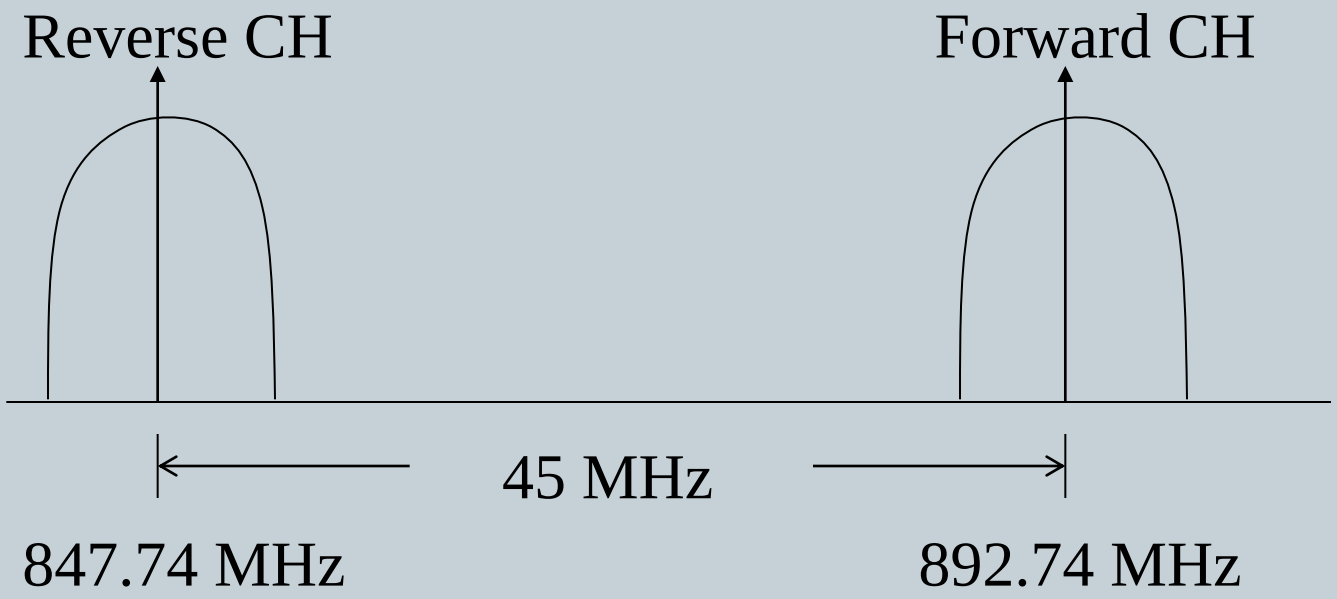
Lecture 19

PRINCIPLES OF SATELLITE COMMUNICATION

IS-95 CDMA

- Direct Sequence Spread Spectrum Signaling on Reverse and Forward Links
- Each channel occupies 1.25 MHz

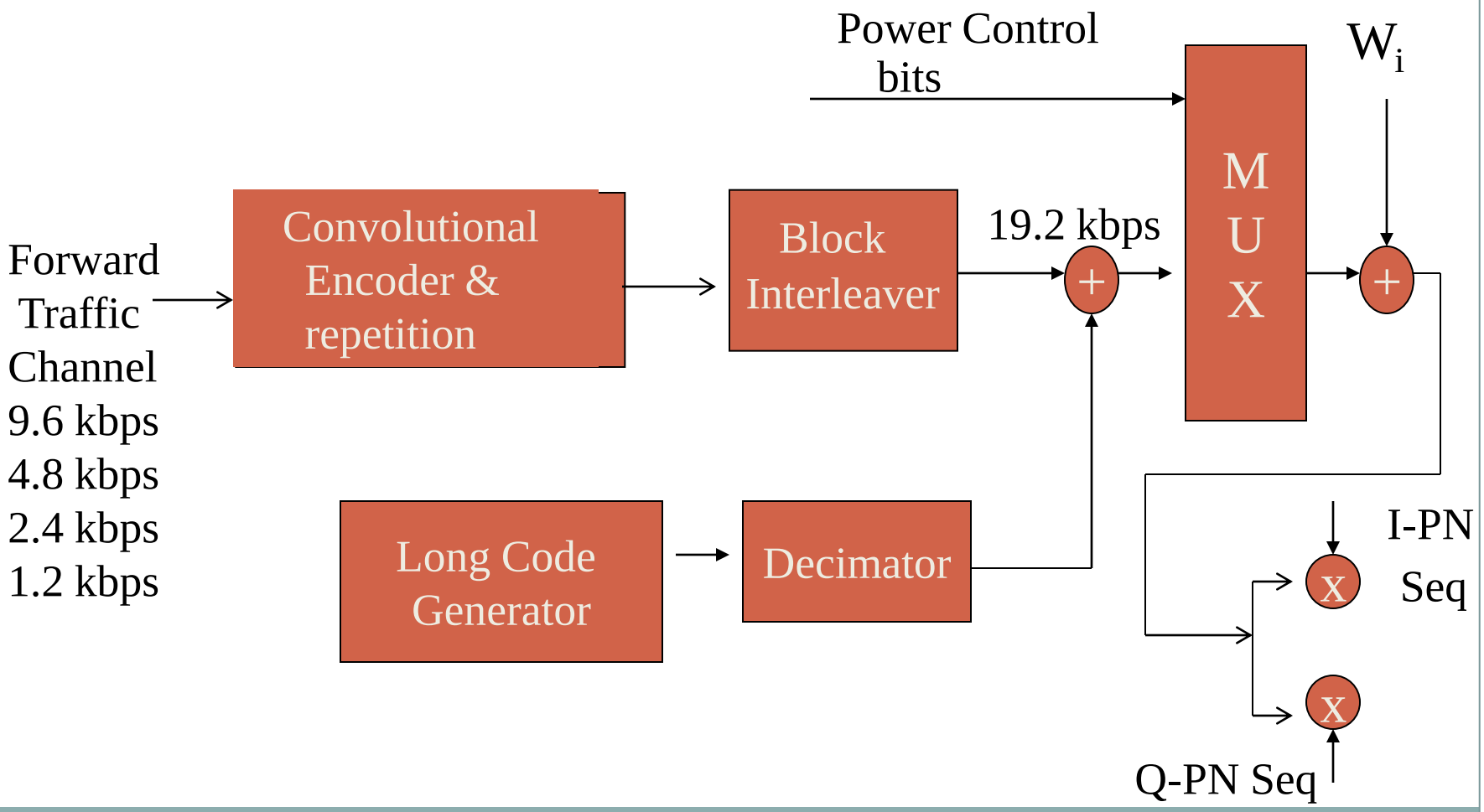


- Fixed chip rate 1.2288 Mcps

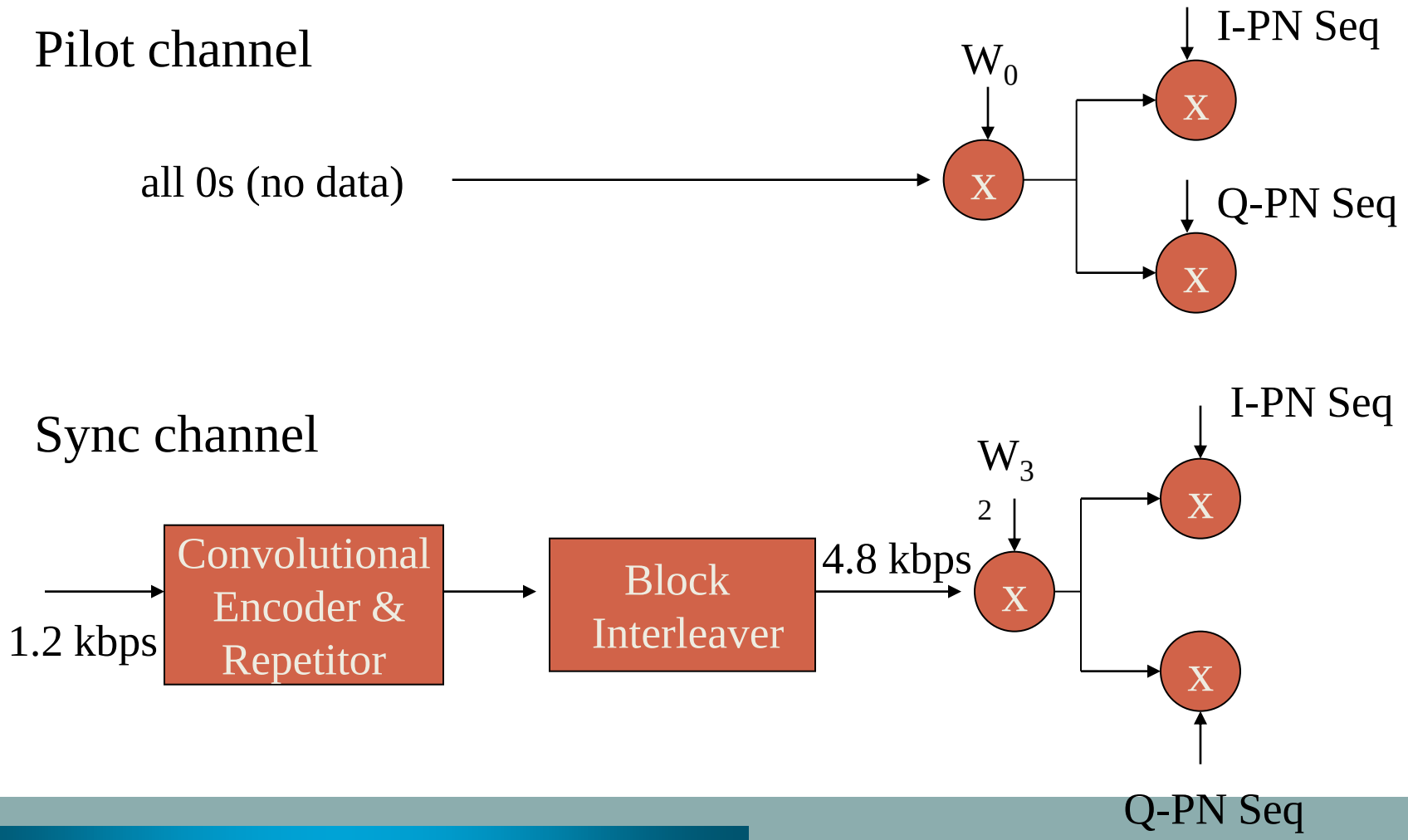
Spreading Codes in IS-95

- Orthogonal Walsh Codes
  - To separate channels from one another on forward link
  - Used for 64-ary orthogonal modulation on reverse link.
- PN Codes
  - Decimated version of long PN codes for scrambling on forward link
  - Long PN codes to identify users on reverse link
  - Short PN codes have different code phases for different base stations

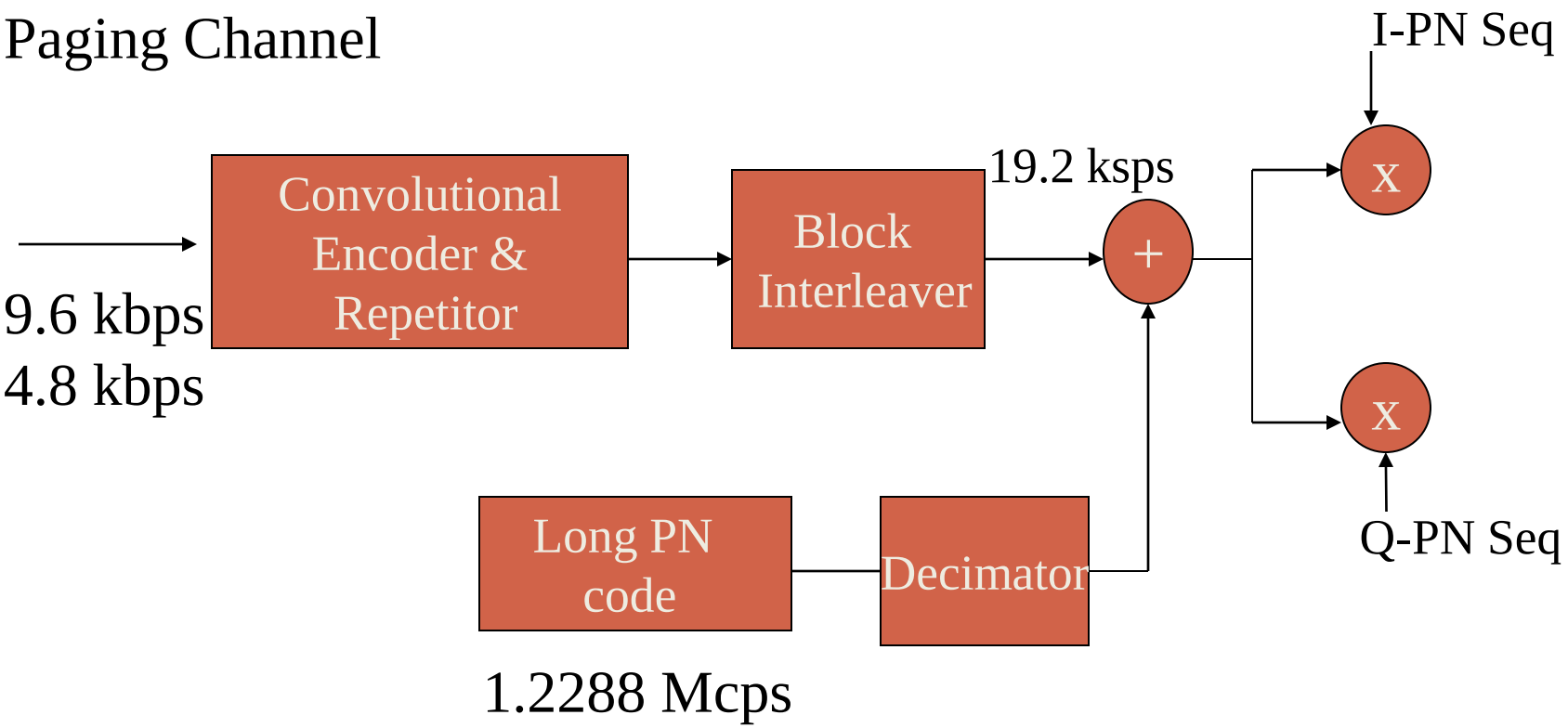
Forward Link Modulation



Forward Link Modulation (contd…)



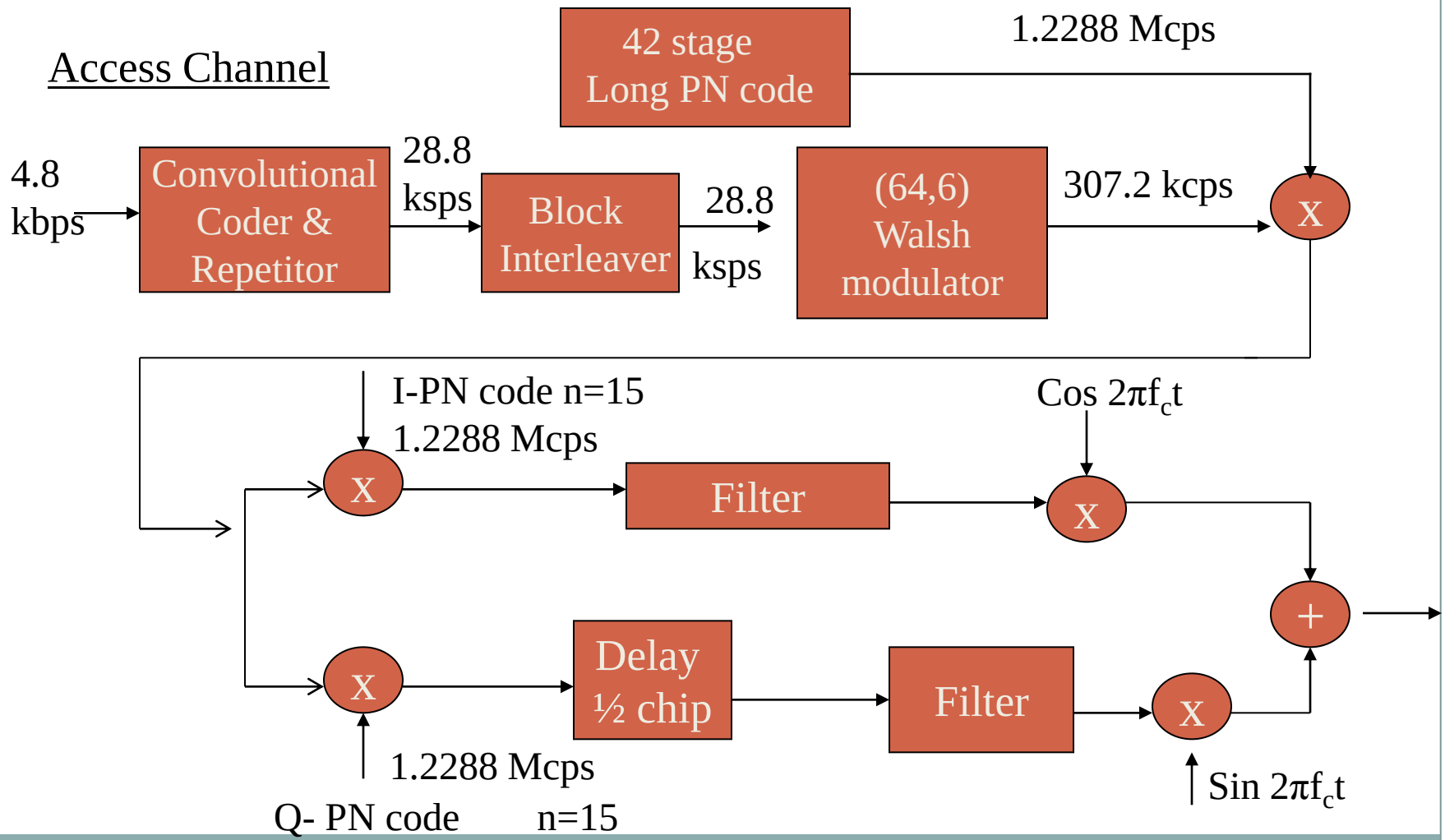
Forward Link Modulation (contd…)



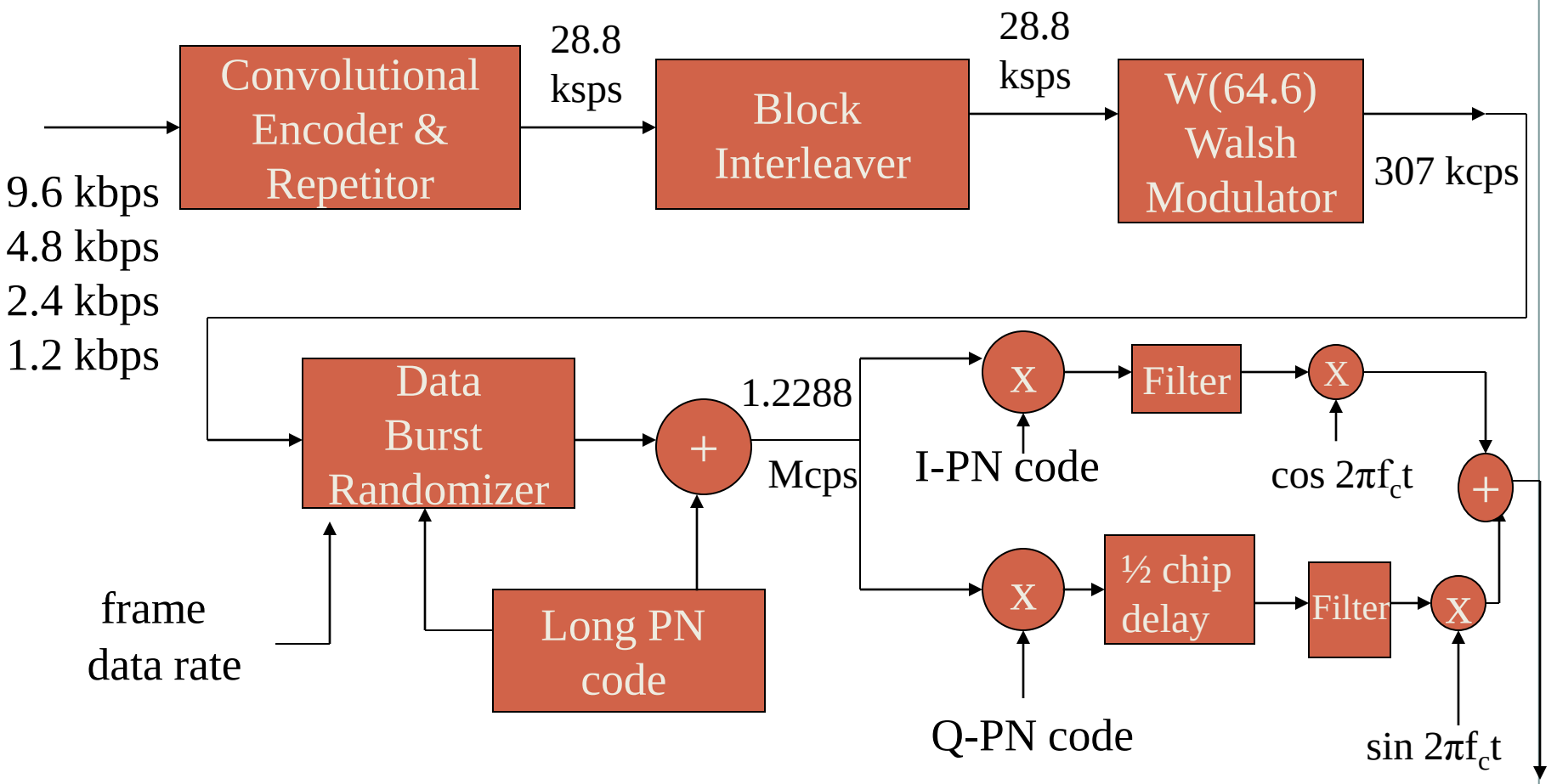
Reverse Link Modulation

- The signal is spread by the short PN code modulation (since it is clocked at the same rate)
- Zero offset code phases of the short PN code are used for all mobiles
- The long code PN sequence has a user distinct phase offset.

Reverse Link Modulation



Traffic Channel



Power Control in CDMA

- CDMA goal is to maximize the number of simultaneous users
- Capacity is maximized by maintaining the signal to interference ratio at the minimum acceptable
- Power transmitted by mobile station must be therefore controlled
  - Transmit power enough to achieve target BER: no less no more

Two factors important for power control

- Propagation loss
  - due to propagation loss, power variations up to 80 dB
  - a high dynamic range of power control required
- Channel Fading
  - average rate of fade is one fade per second per mile hour of mobile speed
  - power attenuated by more than 30 dB
  - power control must track the fade

Power Control on Forward Link and Reverse Link

- On Forward Link
  - to send just enough power to reach users at the cell edge
- On Reverse Link
  - to overcome the ‘near-far’ problem in DS-CDMA

Types of Power Control

- Open Loop Power Control (on FL)
  - Channel state on the FL estimated by the mobile
    - measuring the signal strength of the pilot channel
  - RL transmit power made inversely proportional to FL power measured
  - Mobile Power = Constant – Received power
    (dBm) (dBm) (dBm)
  - Works well if FL and RL are highly correlated
    - slowly varying distance and propagation losses
    - not true for fast Rayleigh Fading.

Closed Loop Power Control (on RL)

- Measurement of signal strength on FL as a rough estimate
- Base station measures the received power on RL
- Measured signal strength compared with the target Eb/No (power control threshold)
- Power control command is generated
  - asking mobile to increase/decrease
- Must be done at fast enough a rate (approx 10 times the max Doppler spread) to track multi-path fading

Outer Loop Power Control

- Frame error rate (FER)is measured
- Power control threshold is adjusted at the base station

Power Control in IS-95A

- At 900 MHz and 120 km/hr mobile speed Doppler shift =100Hz
- In IS 95-A closed loop power control is operated at 800 Hz update rate
- Power control bits are inserted (‘punctured’) into the interleaved and encoded traffic data stream
- Power control step size is +/- 1 dB
- Power control bit errors do not affect performance much

Diversity Techniques in CDMA

Rationale for Diversity:-

if ‘p’ is the probability that a given path in a multi-path environment is below a detection threshold, then the probability is ‘p^L’ that all ‘L’ paths in an L-path multi-path situation are below the threshold

Diversity Techniques

- Frequency Diversity
  - transmission of signal on two frequencies spaced further apart than the coherence bandwidth
  - inherent in spread spectrum system if the chip rate is greater than the coherence bandwidth
- Time Diversity
  - transmission of data at different times
  - repeating the data ‘n’ times
  - interleaving and error correcting codes used in IS-95
- Space Diversity
  - Multi-path tracking (Path Diversity)
  - Transmission space diversity
    - Signal can be emitted from multiple antennas at a single cell site