IS-95

ECE 371VV

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IS-95

- Interim Standard 95 – CDMA
- Viterbi, Qualcomm

Outline

- Forward Link
- Reverse Link
- Special Features of IS-95 CDMA
- Brief Comparison to other second-generation standards
- Possible Improvements

Forward Link

- 869 to 894 MHz (each channel is 1.25 MHz wide)

- Subdivided into 4 sub channels

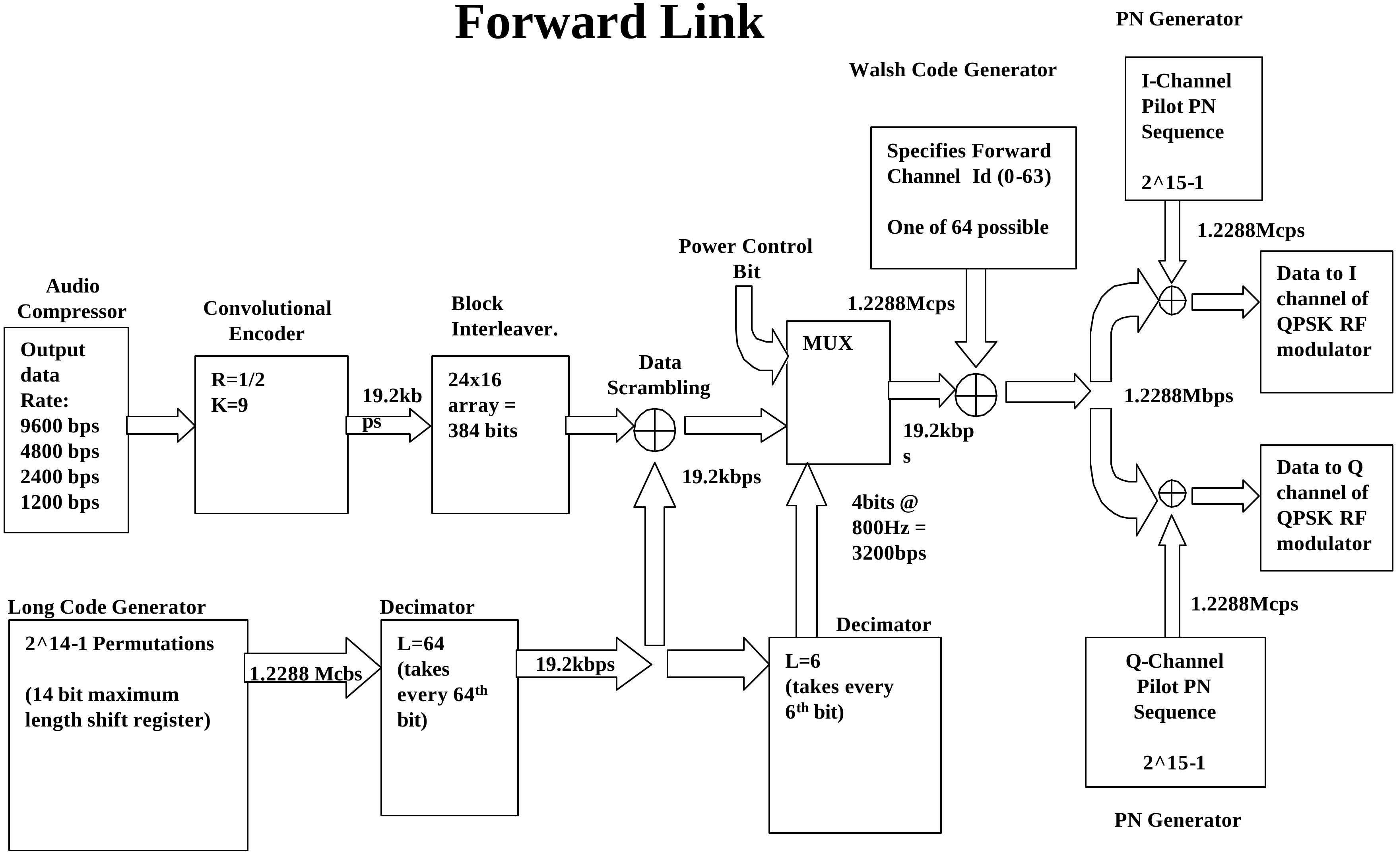
1.Pilot:
a. Timing
b. Phase Reference for Coherent Demodulation
c. Means for Signal Strength Comparison

2.Sync
a. Broadcasts future state of the long code register

3.Paging
a. Call Control Information

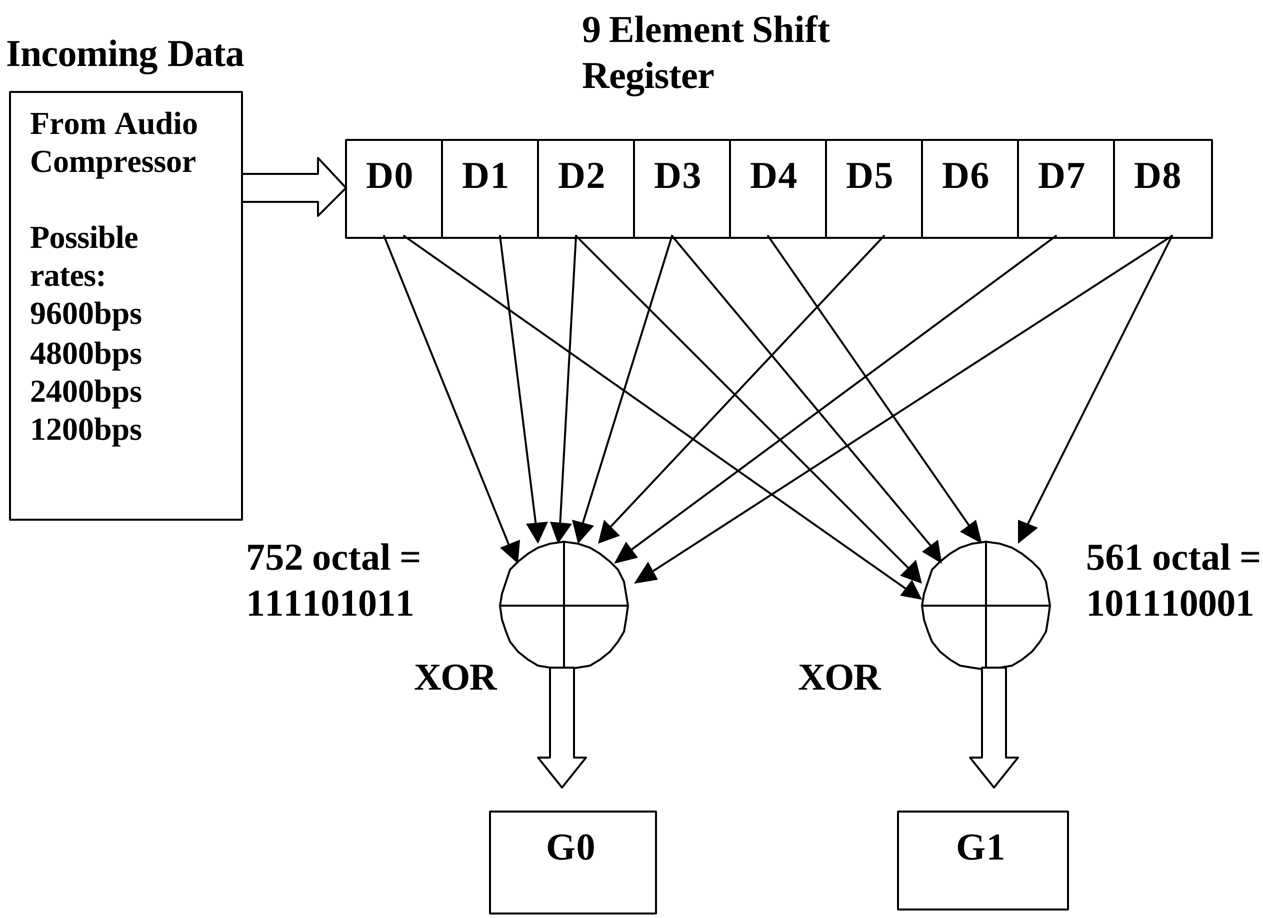
4.Traffic
Voice Data   (includes power control sub channel)

IS-95
Forward Link



Convolutional Encoder and Repetition

- Adds redundancy to data transmitionsfor error robustness.
- Rate, **r=1/2**, where r = input bits / output bits,
- Maintains an output data rate of 19.2kbps regardless of input rate.

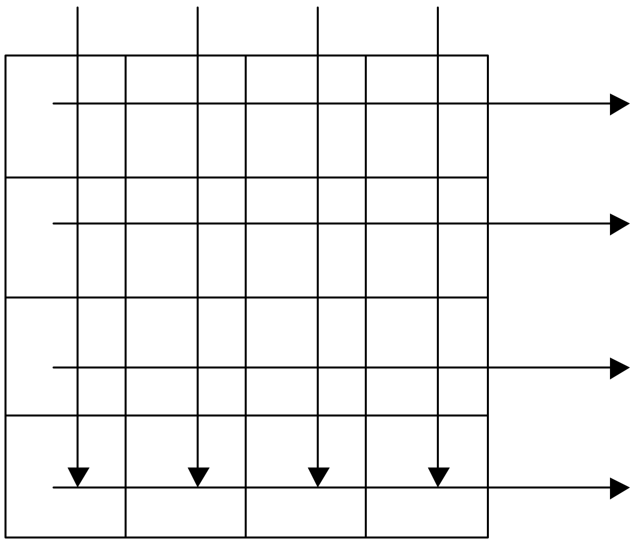


Note, while this is easy to implement at the transmitter, it is nontrivial to undue at the receiver

Block Interleaver

- Separates when consecutive data bits are sent, therefore adding to transmission robustness.

- Provides Time Diversity



- 2 pages, one is being filled as one is emptied

- Each page contains all the data for one 20ms frame

  24x16 bits = 384 bits
  19.2kps * 20ms per frame = 384 bits!

- Data is read in as rows and out as columns.

Long PN Sequence

- This sequence will be used to scramble the data and to code when to send a power control bit.

- 42 bit maximum length shift register, corresponds to 2^42-1 possible permutations

- Contents of shift register are XOR'd with a public or a private key (depending on the stage of the call) to generate one output bit at a rate of 1.2288Mcps

- Takes a very long time to repeat.

Scrambler

- Used for Data Encryption. Make call more secure.

- Randomizes data. Prevents the transition of a long series of 1's or 0's

Power Control Bit

- Dynamic, Decentralized, closed-loop power control scheme
- Control Scheme: BS decides what to do based on the measured Frame Error Rate

    FER < threshold → decrease mobile power by 1dB
    FER > threshold → increase mobile power by 1dB

- One bit sent every 1.25ms = 800Hz or 16 power control bits per frame.
- The power control bit is sent in one of 16 possible locations coded by the 4 bit output of the second decimator.

    (decimator #2 output = 4bits * 800Hz = 3.2kbps. This was reduced by a factor of 6 from the 19.2kbps at the scrambler)

Orthogonal Covering Via Walsh Codes

- 64 Orthogonal Channels for all users, assuming negligible multi-path delays
- Provides some spreading
- 64 X 64 Walsh Matrix. 1 Row = 1 Walsh Code
- Each row of the matrix is exported at 19.2kHz (one row for each bit that is sent from the scrambler)
- 64 bits per row * 19.2kHz per row = 1.2288Mbps (the output of the Walsh generator)
- Channel 0 is assigned to the pilot and is given more power then the rest of the channels
- Channel 32 is assigned to synchronization.
- Mobile Paging Channels are usually on the lower Walsh ID’s

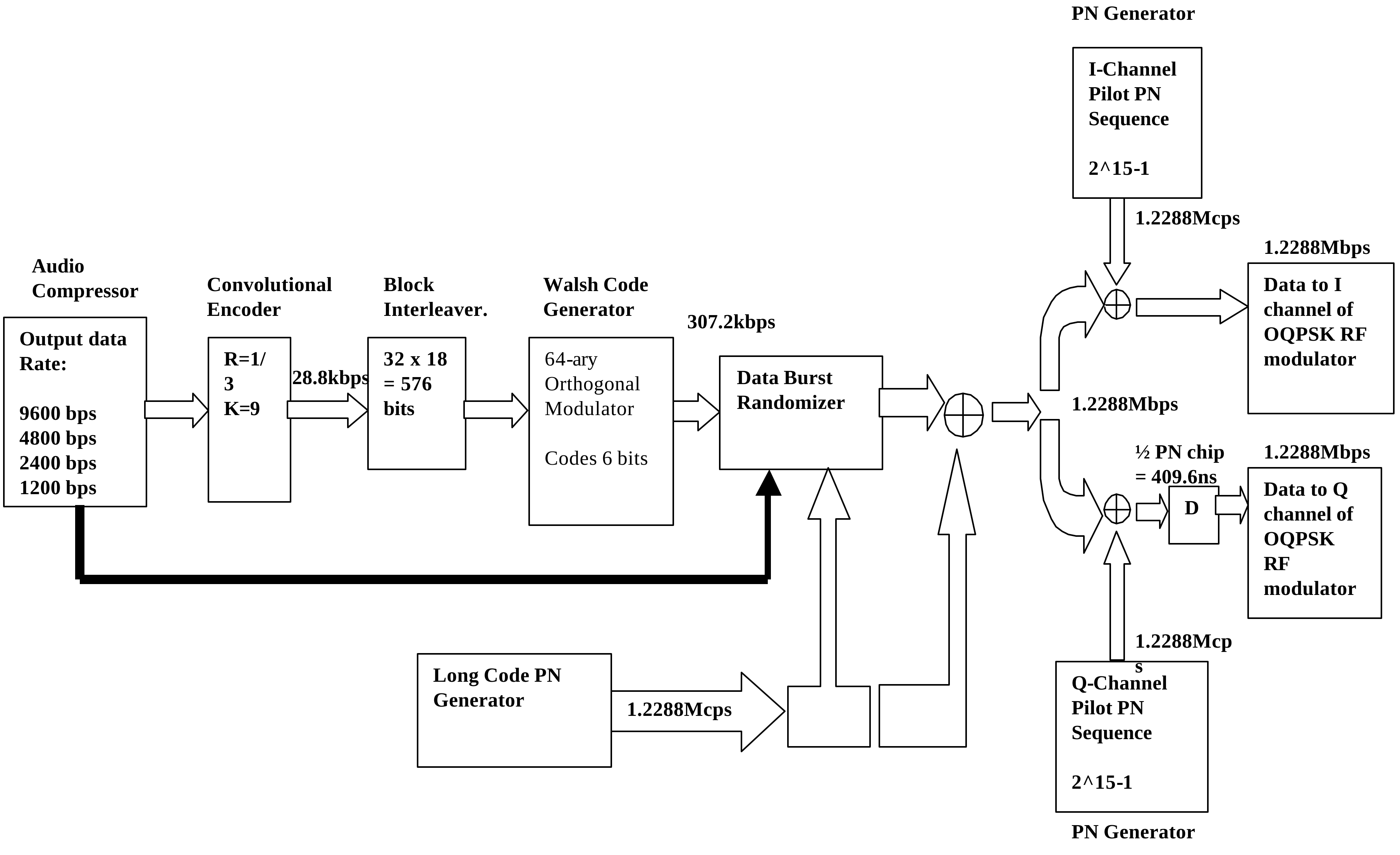
Quadrature Modulation (Short Code)

- Provides more spreading, as not all Walsh codes have sufficient spreading.
- Based on a 15 bits maximum length shift register (2^15-1 possible permutations)
  -This is the pilot sequence if it's modulated by Walsh code 0.
- PN generator outputs data at 1.2288Mbps. (The same rate as the Walsh code generator)
- Different cells use different time offsets of the short code as to identify themselves so that Walsh codes can be reused.
- The PN sequence for the I channel is based on a different polynomial then the Q channel and they therefore evolve differently.
- The output I and Q channels are converted to analog and are modulated by an RF carrier -> QPSK

Reverse Link

- 824 to 849 MHz (each channel is 45 MHz away from the forward counterpart)
- Access channel
  - 4800 bps
  - Initiate communication
  - Respond to paging channel message
- Reverse voice traffic channel
  - 9600, 4800, 2400, 1200 bps
- Very similar to forward link, but there are important differences.

IS-95 Reverse Link



- **Orthogonal Modulation**
  - 64-ary orthogonal modulation using the same Walsh function in the forward link
  - Contrary to the forward link, used for orthogonal data modulation
  - One Walsh function is transmitted for six coded bits
  - Modulated symbol rate
    - 28.8 kbps*64 chips /6 coded bits = 307.2 kcps
  - Increase interference tolerance (refer to ECE459)

- **Data burst randomizer**
  - Turns off the Transmitter when the data rate falls below 9.6kbps so that each redundant bit is sent only once.
  - Used to reduce interference to other users
  - Each 20ms frame is divided into 16 1.25ms slots which are selected as a function of the long PN code

Special Features of IS-95 CDMA System

- Bandwidth Recycling
  - →Enhancing the system capacity due to the increase of reuse efficiency.
  - →Achieving higher bandwidth efficiency (interference limited) and simplifying the system planning.
  - →Achieving flexibility due to the bandwidth on demand.

- Power Control
  - →Reducing the interference and increasing the talk time of mobile station by using the efficient power control scheme.

- Soft handoffs
  - →Contributing to the achievement of the diversity and reduce the chance of loss of link midway through the conversation.

Special Features of IS-95 CDMA System (cont'd)

- Diversity
  - →Taking advantage of multiple levels of diversity: frequency diversity (spreading), spatial diversity (multiple antennas), path diversity (rake receiver) and time diversity (block interleaver), all of which reduce the interference and improve speech quality.

- Variable Rate Vocoder
  - →Offering high speed coding and reducing background noise and system interference based on the detection of the voice activity.

- Coding Technique
  - →Enhancing the privacy and security.

A Comparison between IS-95 and other 2nd Generation Cellular Phone Systems

IS-54/136 GSM	**IS-95**
TDMA/FDMA	**CDMA**
Hard Handoff	Soft Handoff
Open-loop and Slow Power Control	Close-loop and Faster Power Control
Fixed Rate Vocoder	Variable Rate Vocoder

Possible Improvements on IS-95

- Increasing the channel bandwidth beyond 1.25MHz.
- Directional antennas on mobile stations.
- Better power control algorithms.
- Using MANET technology.
- Adaptive filtering.

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