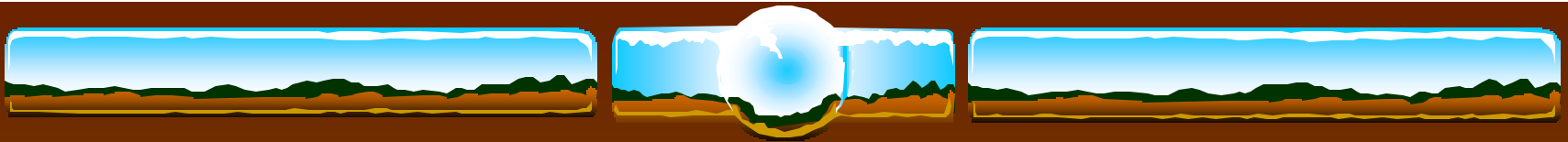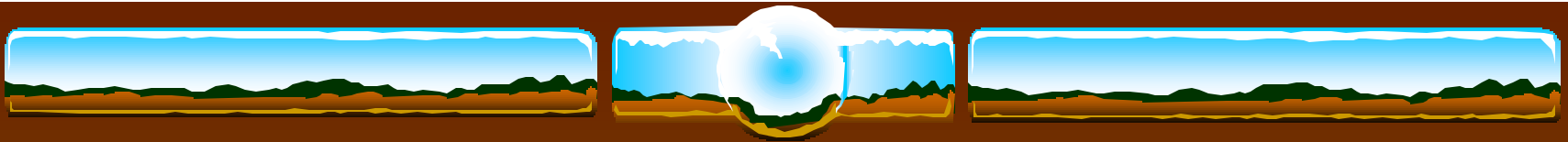# 3G CDMA – WCDMA and cdma2000

Rodger E. Ziemer

IEEE Communications Society

Distinguished Lecturer Program

Outline

- ❖ Multiple access/channel measurement guidelines
- ❖ Current 1G and 2G technology
- ❖ What is Third Generation?
- ❖ WCDMA features
- ❖ cdma2000 features
- ❖ WCDMA and cdma2000 contrasted
- ❖ Summary

Rules for Efficient Multiple Access

❖ Three immutable laws

 ❖ Know the channel

 ❖ Minimize interference to others

 ❖ Mitigate interference received from others

❖ Requirements of wireless multiple access

 ❖ Channel measurement

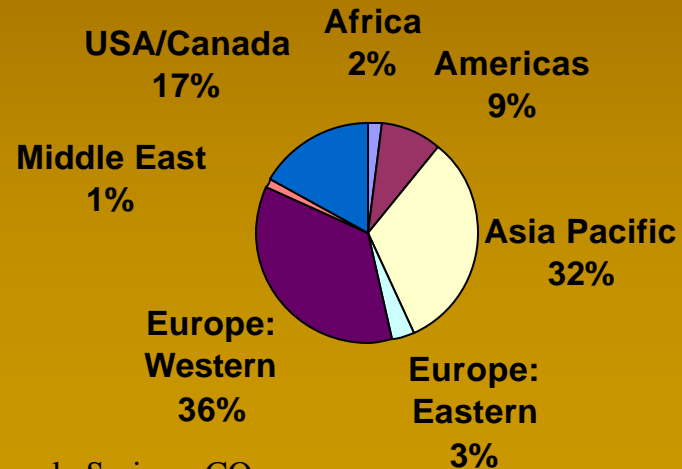 ❖ Channel control and modification

 ❖ Multiple user channel isolation
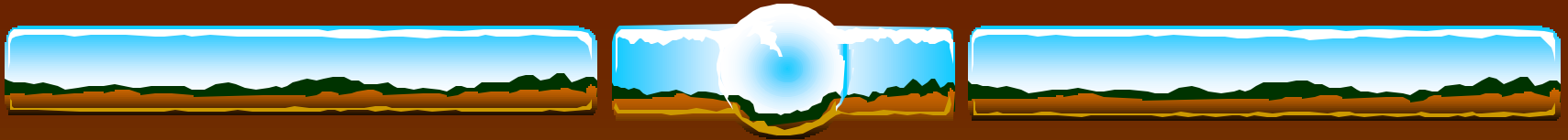
Channel Measurement Guidelines

❖ Wider the bandwidth = better the measurement

  ❖ Limitations on this rule

    ❖ Regulatory (indoor path isolation = 10 ns delay resolution)

    ❖ Complexity (combining more paths = more hardware)

    ❖ Physical limitations (splitting energy over more paths = increasingly inaccurate parameter measurements)

❖ Measure at frequency > rate of change of channel

❖ No other users: good receiver attempts to put together all received multipath components coherently

❖ Other users present: Optimum = multiuser detection; suboptimum = power control; minimize near-far problem
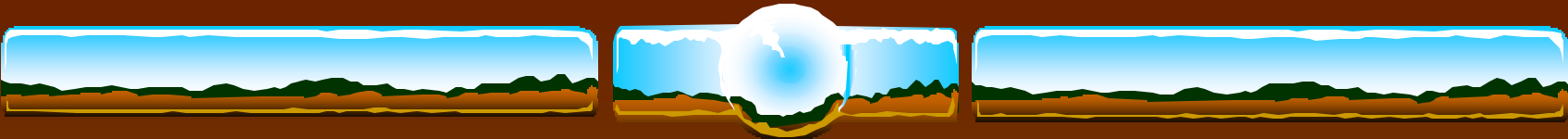
Current 1G and 2G Technology
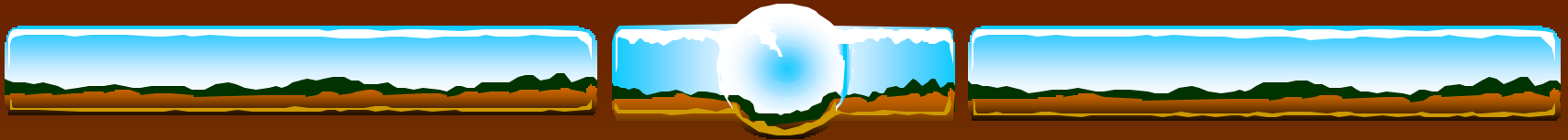
System	Jun-00
Analog	78,339,980
cdmaOne	67,964,980
GSM	337,794,500
PDC	47,739,500
IS-136	48,079,830

PDC 8%

GSM 58%

IS-136 8%

Analog 14%

cdmaOne 12%

USA/Canada 17%

Africa 2%

Americas 9%

Middle East 1%

Asia Pacific 32%

Europe: Western 36%

Europe: Eastern 3%
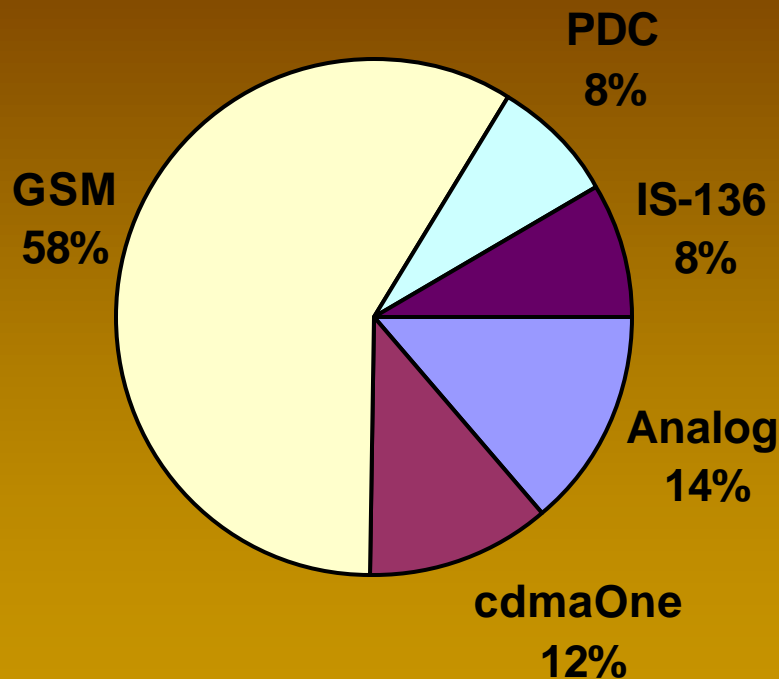
Source: EMC World Cellular Database

Why CDMA?

❖ Higher capacity

❖ Improved performance in multipath by diversity

❖ Lower mobile transmit power = longer battery life

   ❖ Power control

   ❖ Variable transmission rate with voice activity detection

❖ Allows soft handoff

❖ Sectorization gain

❖ High peak data rates can be accommodated

❖ Combats other-user interference = lower reuse factors
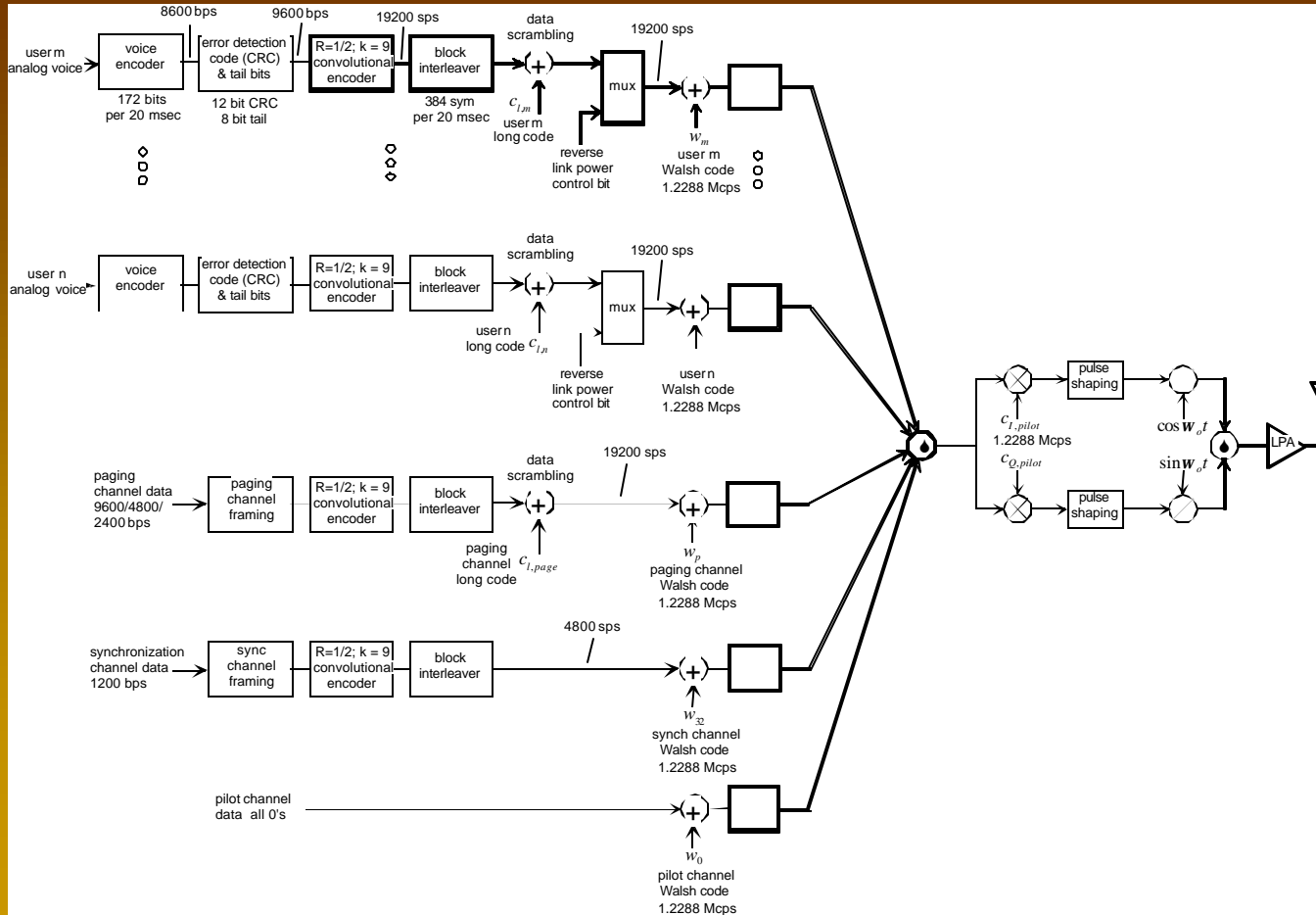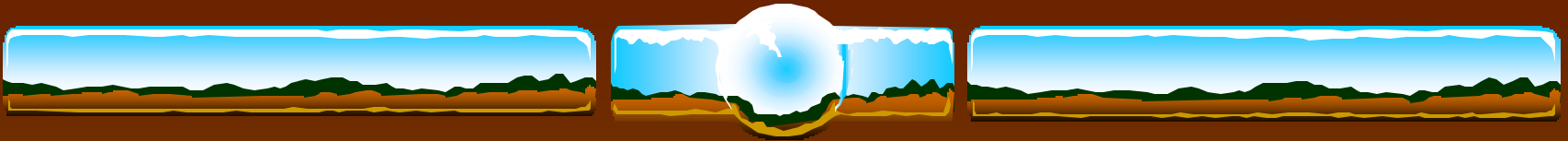
What is Third Generation? [1]

- ❖ Flexible support of multiple services
    - ❖ Voice
    - ❖ Messaging – email, fax, etc.
    - ❖ Medium-rate multimedia – Internet access, educational
    - ❖ High-rate multimedia – file transfer, video
    - ❖ High-rate interactive multimedia – video telecon-ferencing, telemedicine, etc.
- ❖ Mobility: quasi-stationary to high-speed platforms
- ❖ Global roaming: ubiquitous, seamless coverage
- ❖ Evolution from second generation systems

Evolution of Standards [1]

	2G	2.5G	3G
world	GSM → GPRS → EDGE →		
Japan	PDC		W-CDMA → HSPDA
U.S.	iDEN		
U.S.	IS-136		
U.S./Asia	IS-95A → IS-95B →		cdma2000 → 1xEV-DV / 1xEV-DO
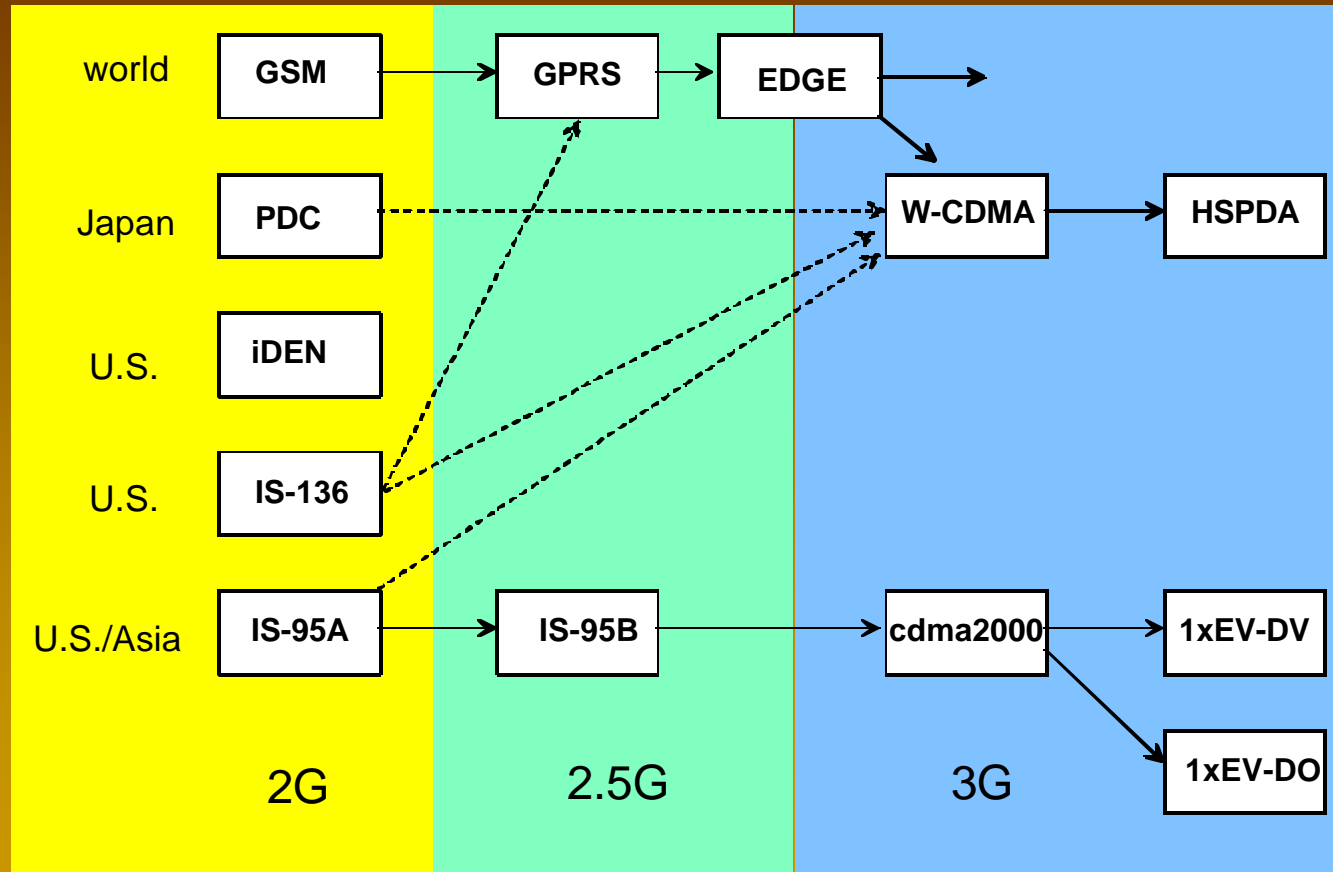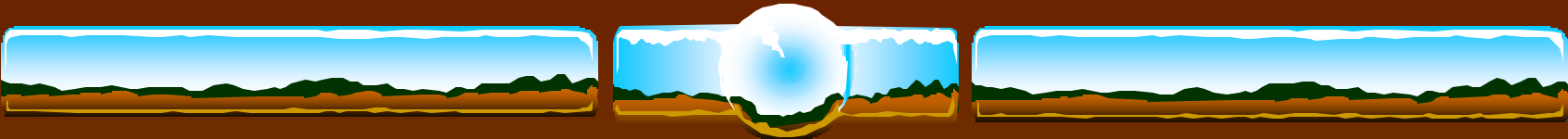
Peak Data Rates [1]
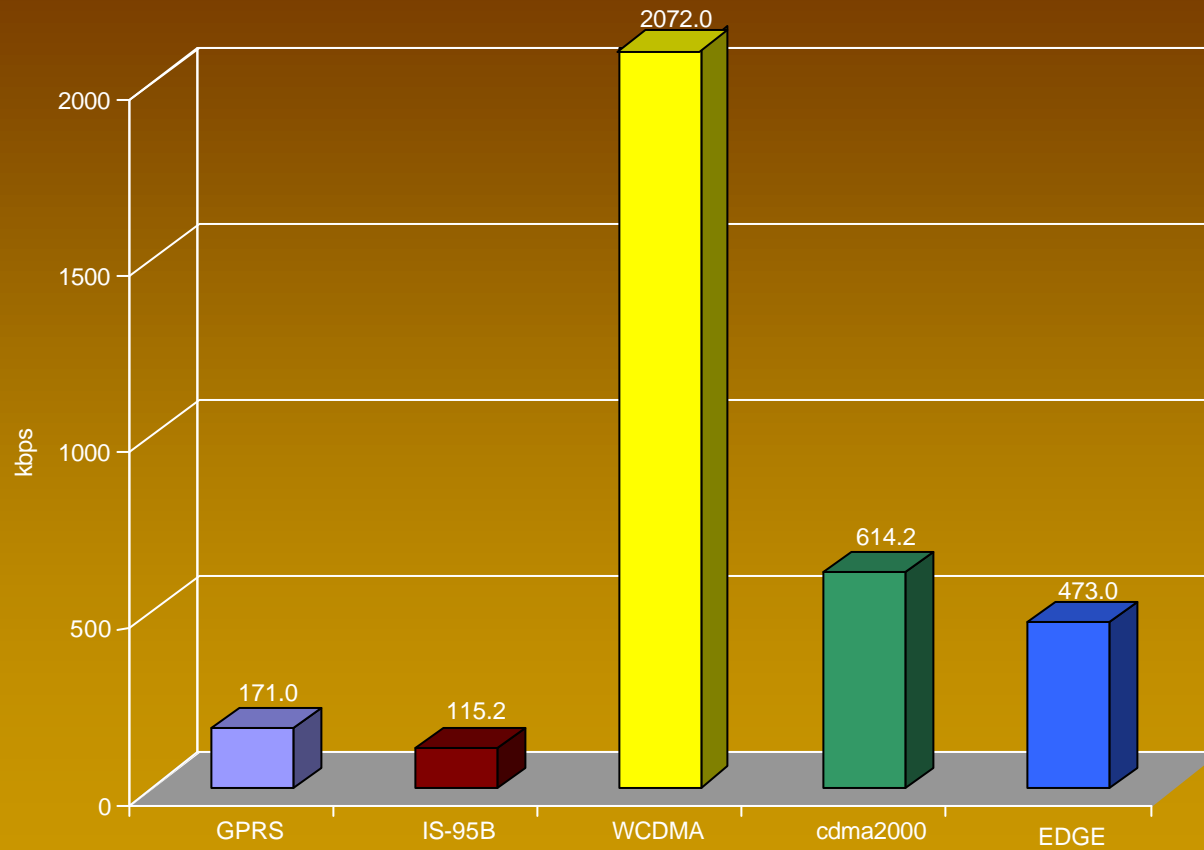
3G Spectrum Availability [2]

ITU

	3G								3G		
		MSS*	MSS		* Region 2				MSS*	MSS	
1885		1930	1980	2010	2025		2110	2120	2170		2200

Japan

PHS	3G					3G		MSS
		MSS						
1885 1895 1918.1		1980	2010	2025	2110	2170		2200

Europe

DCS 1800 DCS 1800 DECT 3G MSS 3G MSS

1710 1785 1805 1880 1900   1996 2010 2025   2110   2186 2200

China

3G		MSS	3G		MSS
1885		2025	2110		2200

USA

PCS		Broadcast Auxiliary	Reserve
A D B E F C	PCS A D B E F C		
1850 1910 1930	1990	2110 2150	2200

All Frequencies in MHz

Main Differences between WCDMA and GSM Air Interfaces [3]

|	WCDMA	GSM
Carrier spacing	5 MHz	200 kHz
Reuse factor	1	1-18
Power control freq	1500 Hz	2 Hz or lower
Quality control	Radio resource management algorithms	Network planning (frequency planning)
Frequency diversity	Wideband with RAKE	Frequency hopping
Packet data	Load based packet scheduling	Time slot base scheduling with GPRS
Downlink diversity	Supported	Not supported

Main Differences between WCDMA and IS-95 Air Interfaces [3]

|	WCDMA	IS-95
Carrier spacing	5 MHz	1.25 MHz
Chip rate	3.84 Mcps	1.2288 Mcps
Power control freq	1500 up- & downlink	800 Hz uplink; slow, DL
Base station synchronization	Not needed	Yes, typically via GPS
Inter-frequency handovers	Yes, measurements with slotted mode	Possible; measurement method not specified
Radio resource management	Yes, provides QoS	Not needed (speech only)
Packet data	Load-based packet scheduling	Packet data xmitted as short circuit switched cells
Downlink transmit diversity	Supported	Not supported

WCDMA Transmission Parameters

❖ Wideband direct-sequence spreading
  - ❖ 3.84 Mcps chip rate
  - ❖ Spreading gains (ratios) from 4 to 512

❖ Complex QPSK spreading

❖ Both frequency- and time-division duplex modes

❖ Both forward and reverse fast power control

❖ Coherent forward and reverse links using both code-division and time-division pilots

❖ Asynchronous cells
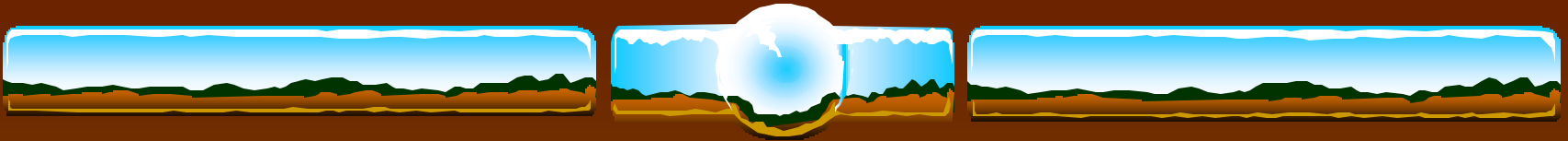
New Features of cdma2000 vs. IS-95

❖ Forward link [4]

  ❖ Quadrature PSK data modulation (doubles avail. Walsh codes)

  ❖ Transmit diversity

  ❖ Fast power control

  ❖ Quasi-orthogonal codes (more codes)

  ❖ Auxiliary pilots (beam forming)

  ❖ New common power control and assignment channels

  ❖ Increased standby time (changes in paging channel)

  ❖ Turbo codes

  ❖ Variable rate

  ❖ Flexible frame length (5, 20, 40, and 80 ms)

  ❖ Multiframe interleaving
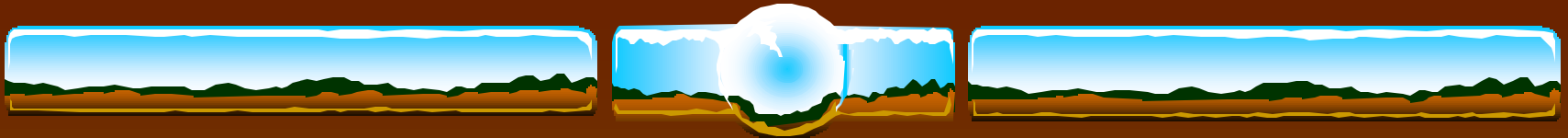
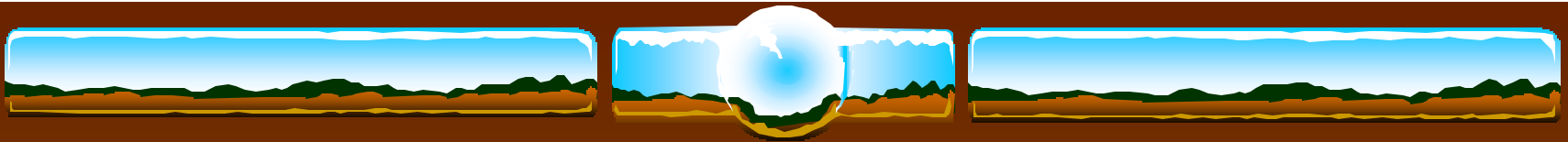# New Features of cdma2000 vs. IS-95

❖ Reverse Link [4]
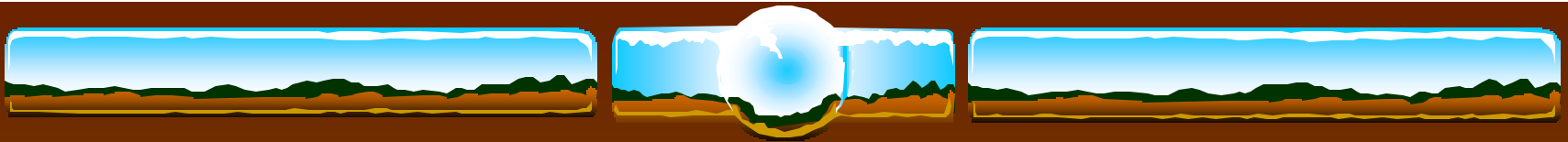
   ❖ Coherent pilot channel assisted

   ❖ Binary PSK data modulation

   ❖ Complex PN spreading

   ❖ Enhanced access channel = decreased setup times for traffic channeless connections (allows power control and slot reservations)

   ❖ Improvements to interfrequency hard handoff to support subframe searches

W-CDMA Versus cdma2000 [2]

	W-CDMA	IS-2000
Chip Rate	4.096 Mcps	3.6864 Mcps
Frame Duration	10 ms	20 ms
Base Stn Sync	Asynchronous	Synchronous
Base Stn Acq/Det	3 step paral code srch for base stn det & slot/frame	Sync through time-shifted PN correlation
Forward Link Pilot	TDM dedicated pilot	CDM common pilot
Antenna Beam Form	TDM dedicated pilot	Auxiliary pilot

Technologies Considered in Arriving at Third Generation

- ❖ Wideband Direct-Sequence Code Division Multiple Access (CDMA)
- ❖ Wideband Time Division Multiple Access (TDMA)
- ❖ Wideband C/TDMA
- ❖ Orthogonal Frequency Division Multiplexing (OFDM)
- ❖ Opportunity Driven Multiple Access (ODMA)

WCDMA Uplink Frame Structure [1]

I: data channel

$$N_{data} = 10 * 2^k \text{ bits } (k = 0,\ominus,6)$$

DPDCH

$$T_{slot} = 2560 \text{ chips}$$

Q: sync & control

| Pilot: N_{pilot} bits | TFCI | FBI | TPC |

DPCCH

0.667 ms

| slot 0 | slot 1 | • • • | slot i | • • • | slot 14 |

radio frame = 10 ms
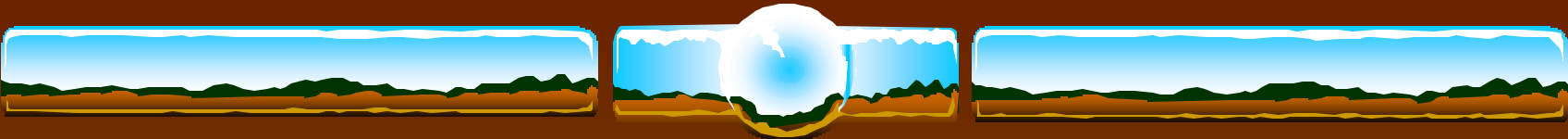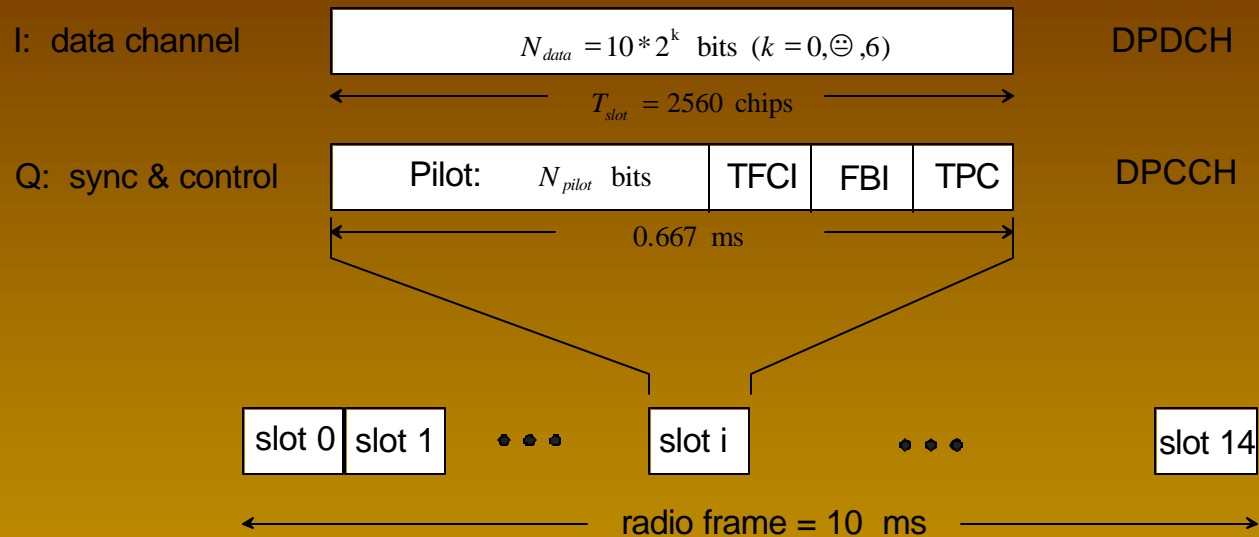
TFCI = transmit format combination indicator
FBI = feedback information
TPC = transmit power control

DPDCH = dedicated physical data channel
DPCCH = dedicated physical control channel

WCDMA Uplink Modulator Structure [1]

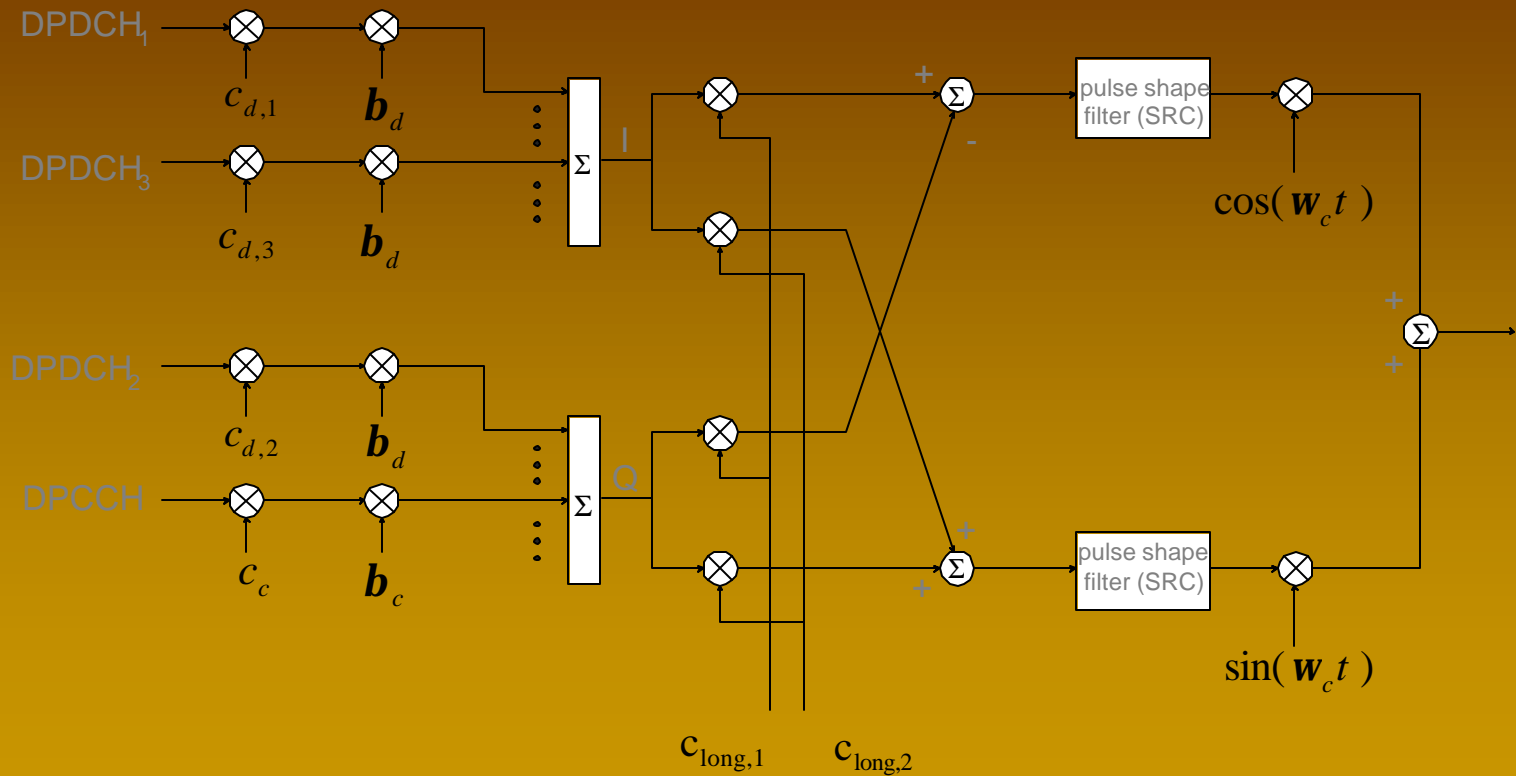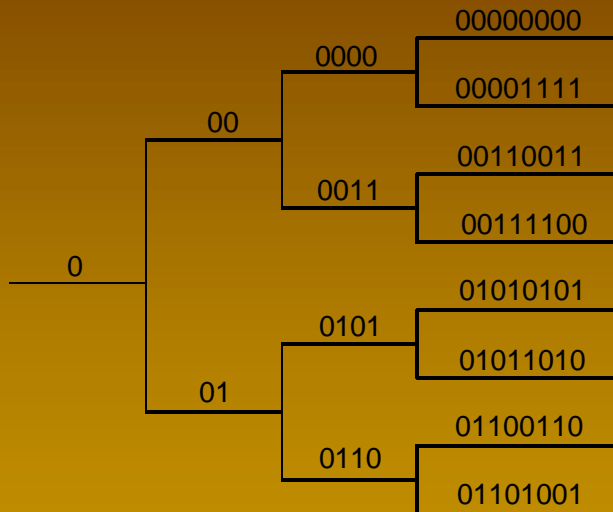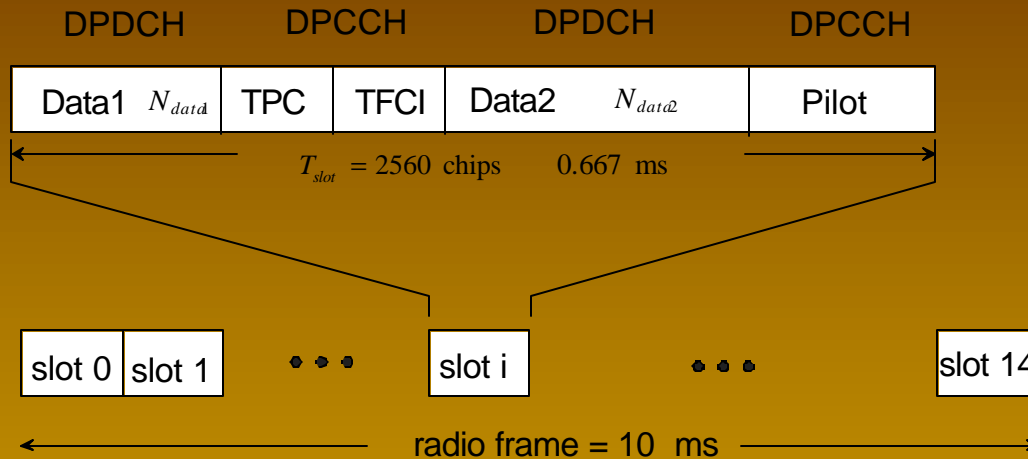# Orthogonal Variable Spreading Factor Codes

$c_{d,i}$ selected from this tree

```
                                              00000000
                                  0000 ───────
                                              00001111
                      00 ─────────
                                              00110011
                                  0011 ───────
                                              00111100
          0 ───────────
                                              01010101
                                  0101 ───────
                                              01011010
                      01 ─────────
                                              01100110
                                  0110 ───────
                                              01101001
```
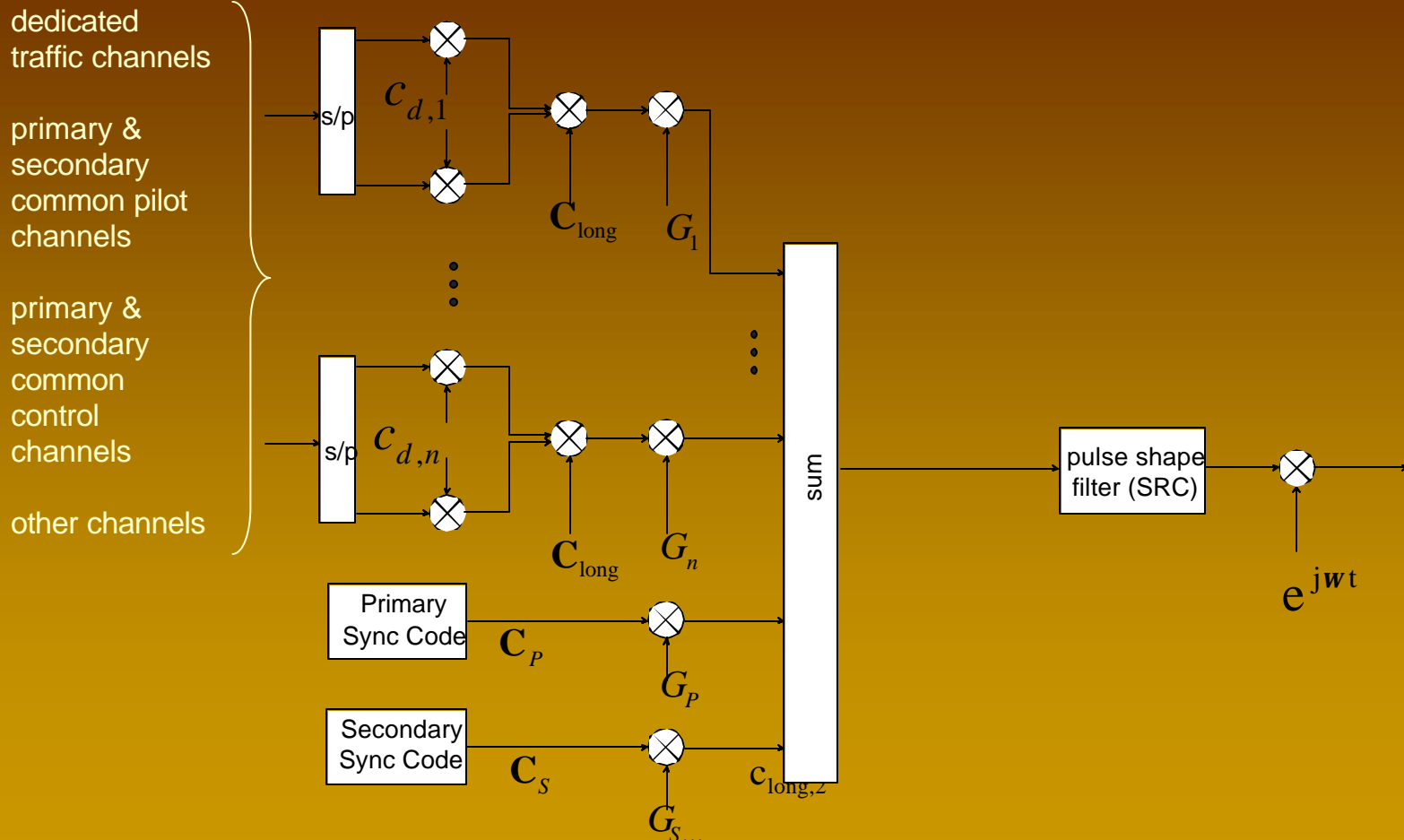
Notes:
1) For fixed chip rate, desired information rate determines length of spreading sequence and therefore processing gain.
2) When a specific code is used, no other code on the path from that code to the root and or on the subtree beneath that code may be used.
3) All the codes at any depth into the tree are the set of Walsh Sequences.
4) Code phase is synchronous with information symbols.
5) FDD UL processing gain between 256 and 4
   FDD DL processing gain between 512 and 4
   TDD UL/DL processing gain between 16 and 1
6) Multicode used only for SF = 4

WCDMA Downlink Frame Structure [1]

Data1 N_{data1}	TPC	TFCI	Data2 N_{data2}	Pilot

DPDCH — DPCCH — DPDCH — DPCCH

$T_{slot} = 2560$ chips 0.667 ms

slot 0	slot 1	• • •	slot i	• • •	slot 14

radio frame = 10 ms

$$N_{data2} + N_{data2} = 10 * 2^k \text{ bits } (k = 0, \odot, 7)$$

dedicated
traffic channels

primary &
secondary
common pilot
channels

primary &
secondary
common
control
channels

other channels

s/p $\quad c_{d,1}$

$\mathbf{C}_{long}$ $\quad G_1$

s/p $\quad c_{d,n}$

$\mathbf{C}_{long}$ $\quad G_n$

Primary
Sync Code $\quad \mathbf{C}_P$

G_P

Secondary
Sync Code $\quad \mathbf{C}_S$

$c_{long,2}$
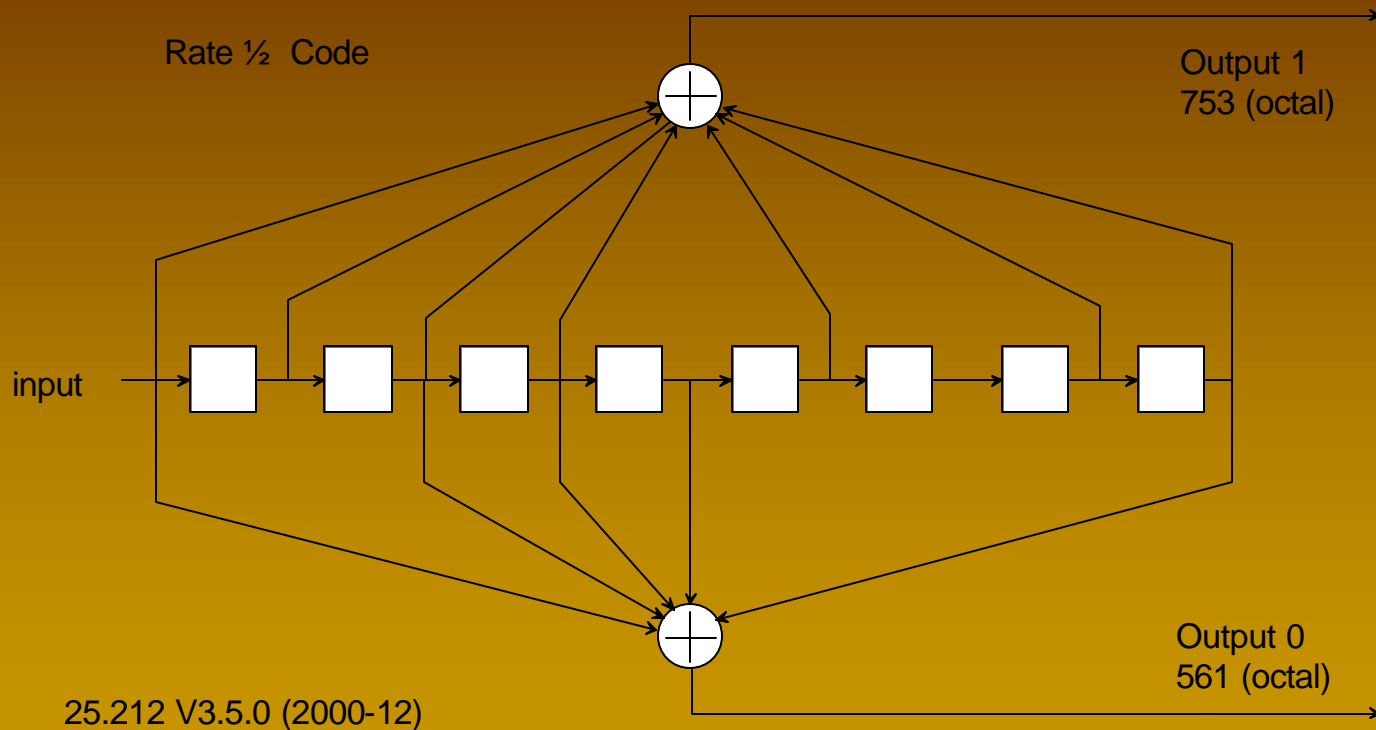
$G_{S...}$

sum

pulse shape
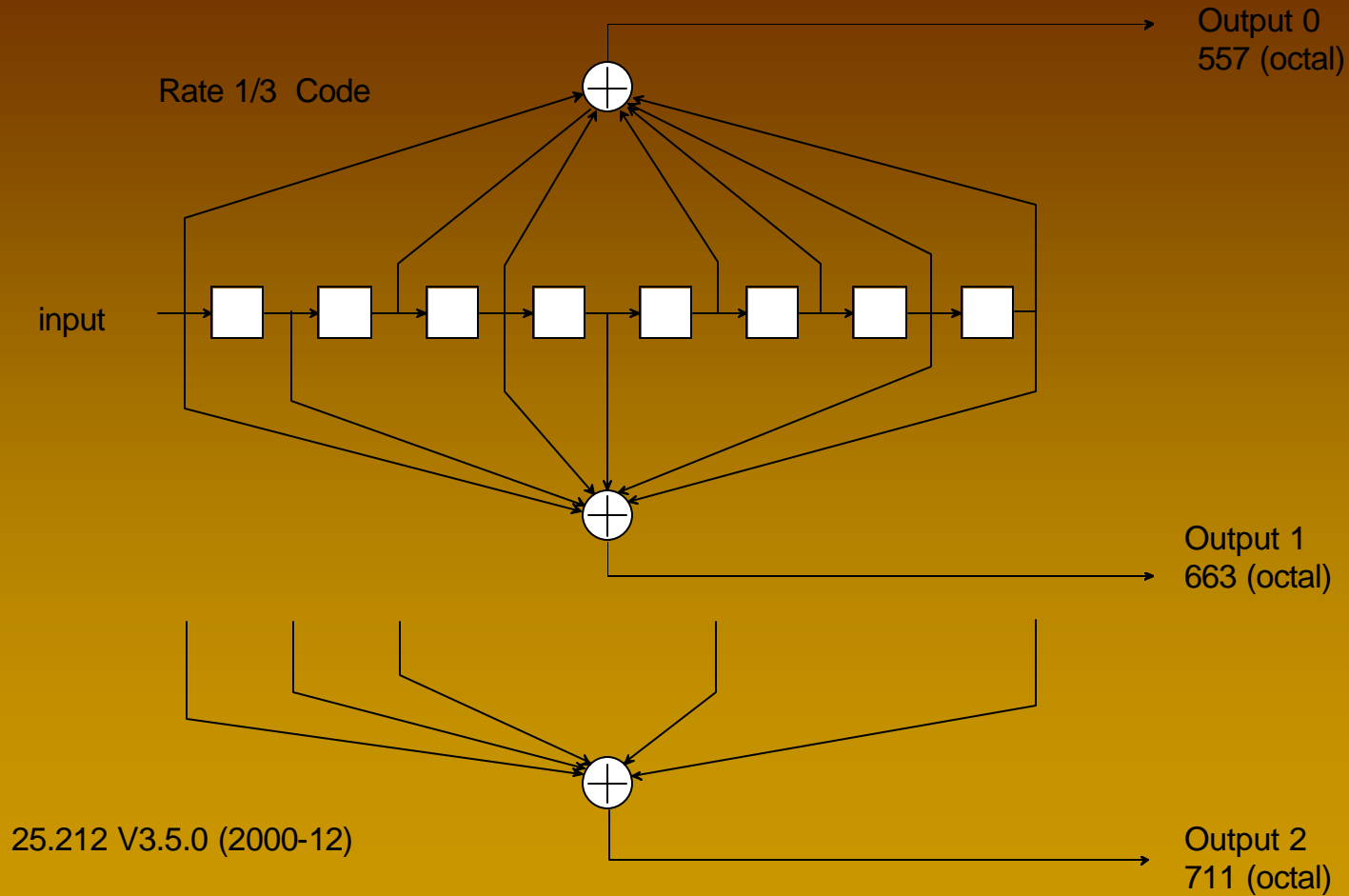filter (SRC)

e^{jwt}

WCDMA Forward Error Control

❖ Convolutional Coding
- ❖ rate 1/2 & rate 1/3
- ❖ 256 state
- ❖ puncture to higher rates
- ❖ interleave over 10, 20, 40 or 80 ms

❖ Turbo Coding
- ❖ parallel coding
- ❖ rate 1/3
- ❖ 8 state codes
- ❖ block lengths 320 to 5114 bits
- ❖ interleaver designed within 3gpp

WCDMA Convolutional Code

Rate ½ Code

Output 1
753 (octal)
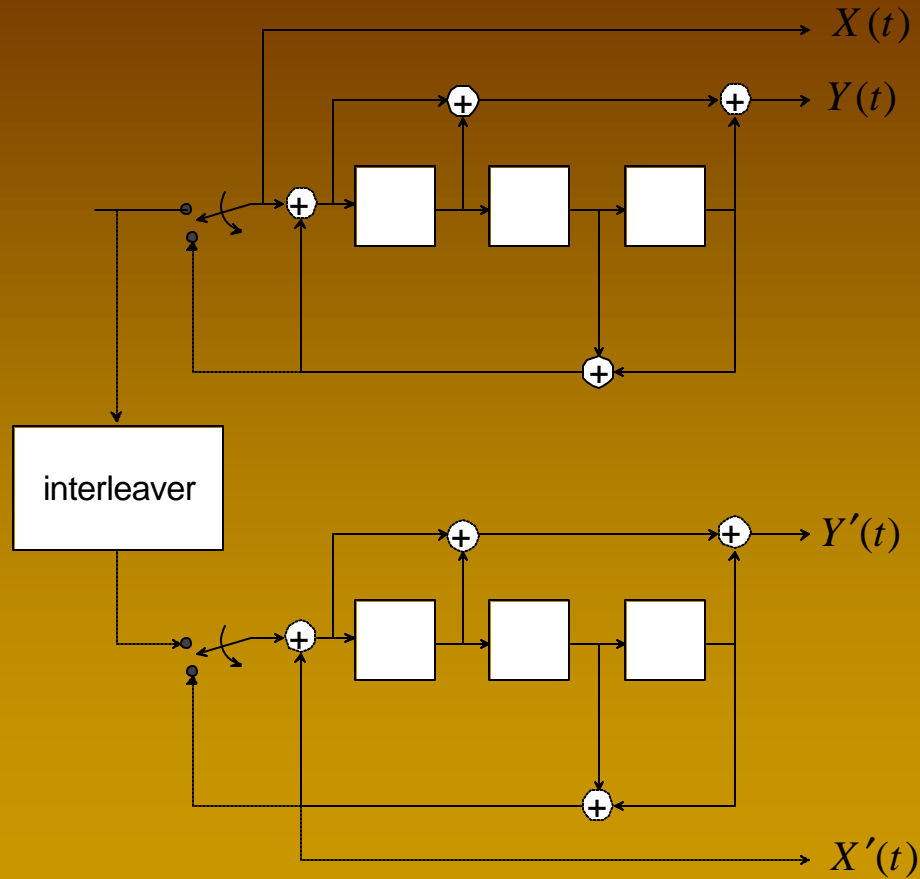
input

Output 0
561 (octal)

25.212 V3.5.0 (2000-12)

WCDMA Convolutional Code

Output 0
557 (octal)

Rate 1/3 Code

input

Output 1
663 (octal)

25.212 V3.5.0 (2000-12)

Output 2
711 (octal)
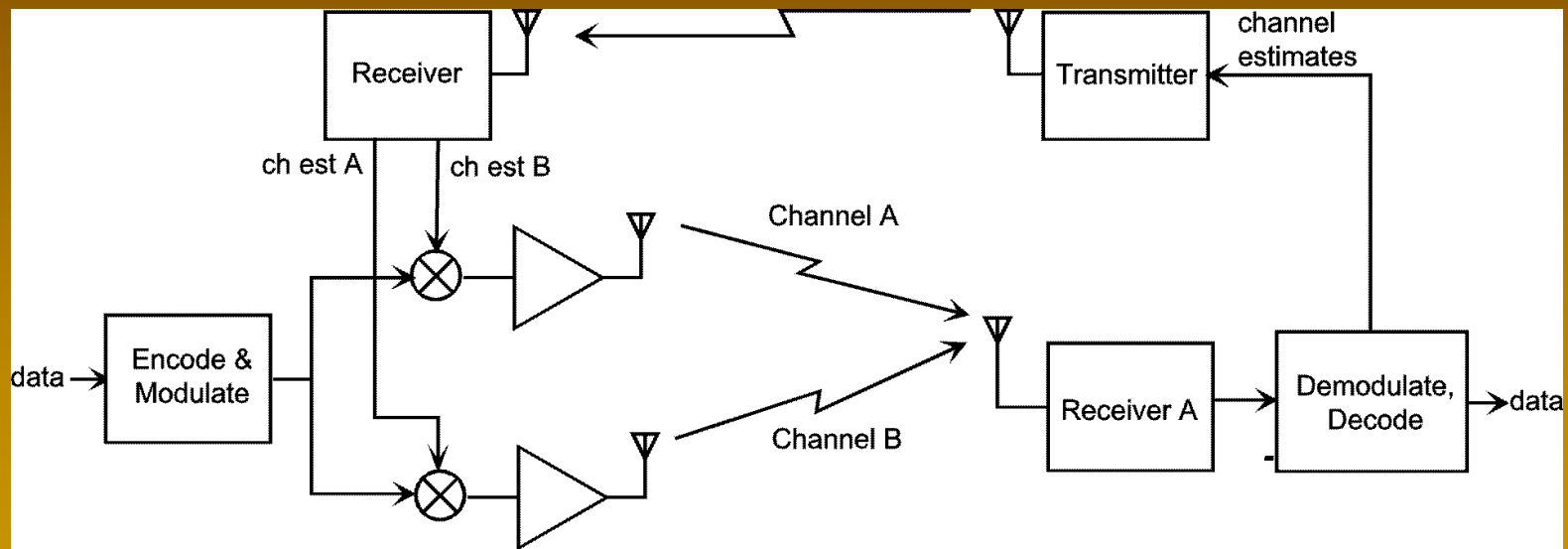
WCDMA Turbo Coding

Codng Performance Compared
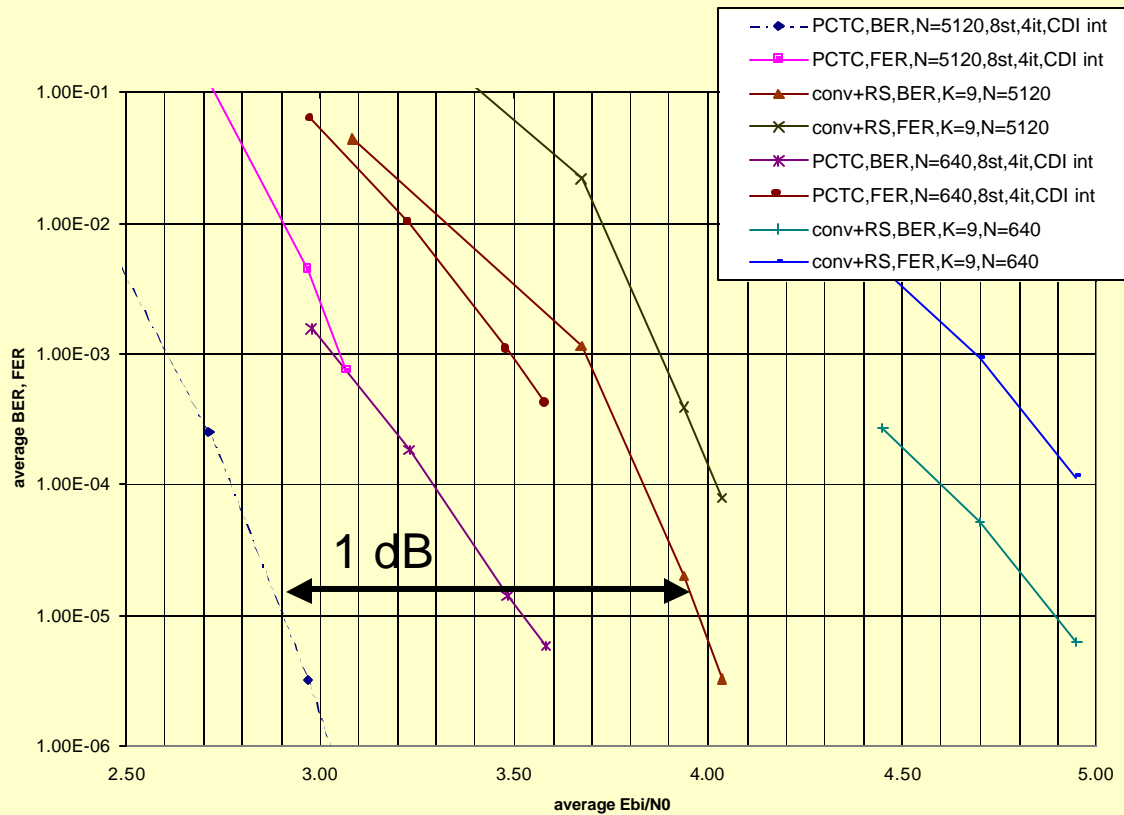
Diversity Strategies for Downlink

Transmit Diversity
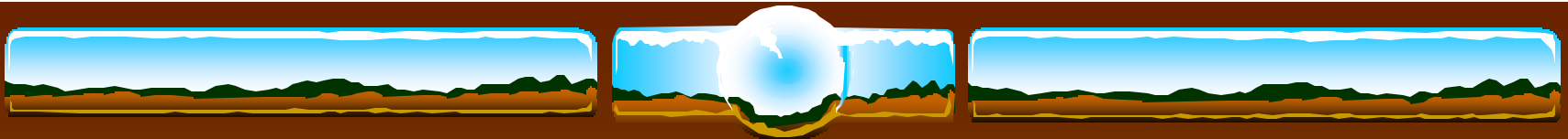
cdma2000 Transmission Parameters

- ❖ Wideband direct-sequence CDMA
  - ❖ uplink chip rates 1.2288 Mcps & 3.686 Mcps
  - ❖ downlink chip rate 1.2288 Mcps
    - ❖ single or 3X multicarrier downlink
  - ❖ spreading factors from TBD to TBD
- ❖ Complex QPSK spreading
- ❖ Frequency Division Duplex
- ❖ Both forward and reverse fast power control (800 Hz)
- ❖ Coherent forward and reverse links using code-division pilots
- ❖ Synchronous cells

cdma2000 Uplink Frame Structure

Radio Configuration 3

channel bits → [CRC] → [encoder tail bits] → [Convolutional or Turbo Coder] → [symbol repetition] → [symbol puncture] → [block interleaver] → (C) modulation symbol
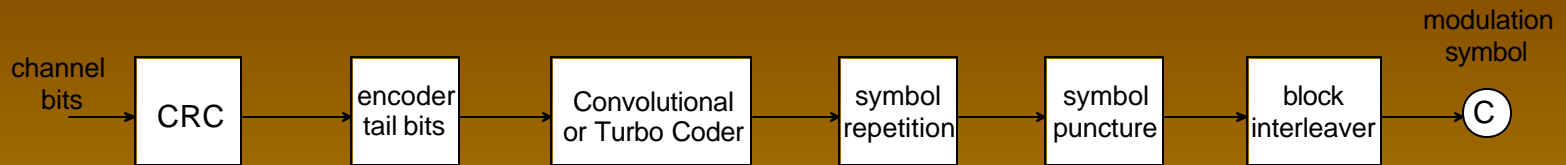
Bits/ Frame	CRC bits	tail bits	Data Rate kbps	Code Rate	Repeats	Delete	Symbols
16	6	8	1.5	1/4	16	1 of 5	1536
40	6	8	2.7	1/4	8	1 of 9	1536
80	8	8	4.8	1/4	4	none	1536
172	12	8	9.6	1/4	2	none	1536
350	16	8	19.2	1/4	1	none	1536
744	16	8	38.4	1/4	1	none	3072
1512	16	8	76.8	1/4	1	none	6144
3048	16	8	153.6	1/4	1	none	12288
6120	16	8	307.2	1/2	1	none	12288

C.S.0002-A-1 Fig 2.1.3.1.1.1-8

cdma2000 Uplink Modulator
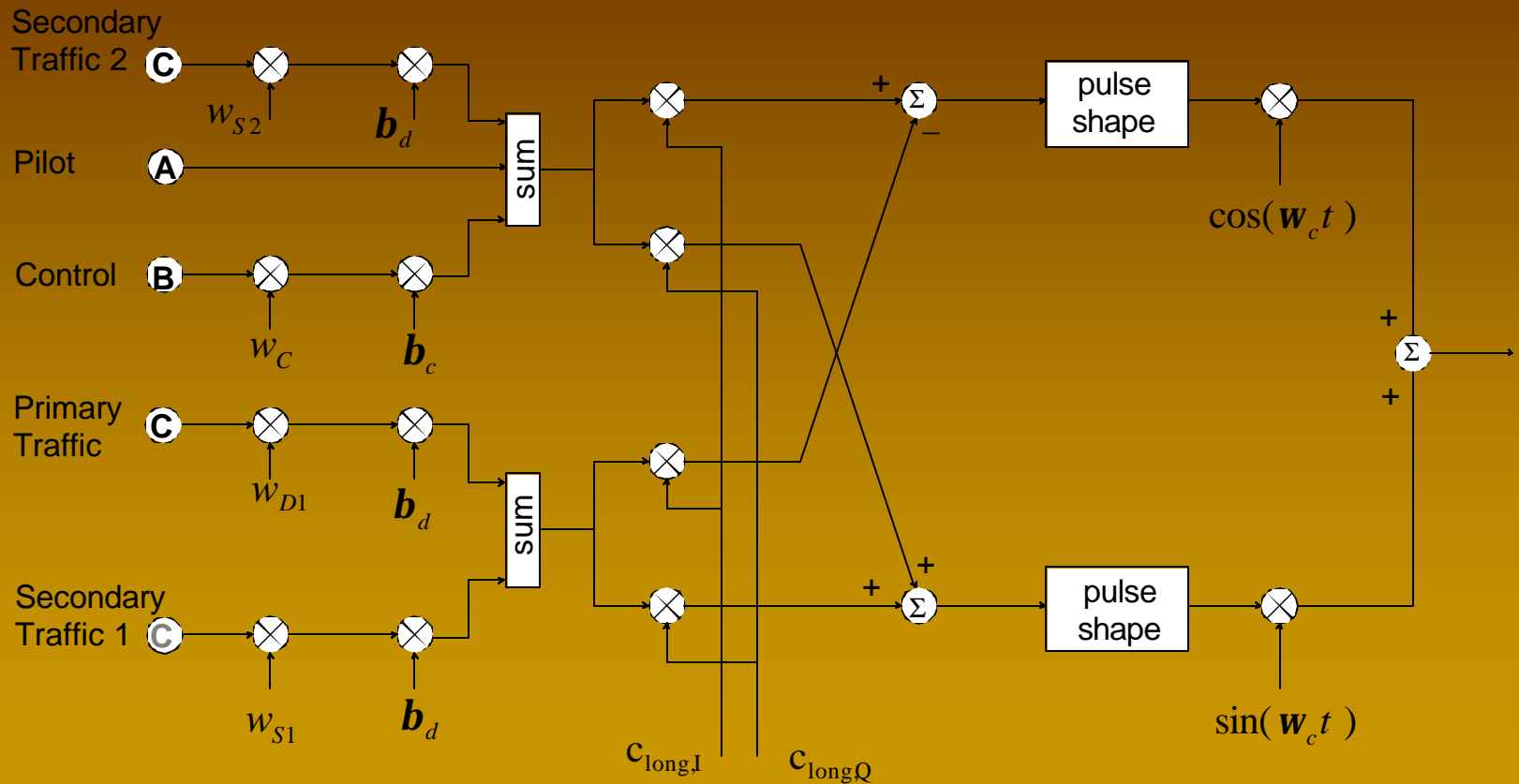
cdma2000 Long Code Generator

X^1

X^{42}

$M_{m,1}$ $M_{m,2}$ $M_{m,3}$

walsh 2
(0 1)

$M_{m,j}$ identifies user

1-chip delay

dec by 2

$$1 + X + X^2 + X^3 + X^5 + X^6 + X^7 + X^{10} + X^{16} + X^{17} +$$

$$X^{18} + X^{19} + X^{21} + X^{22} + X^{25} + X^{26} + X^{27} + X^{31} + X^{33} + X^{35} + X^{42}$$

I-channel PN

Q-channel PN
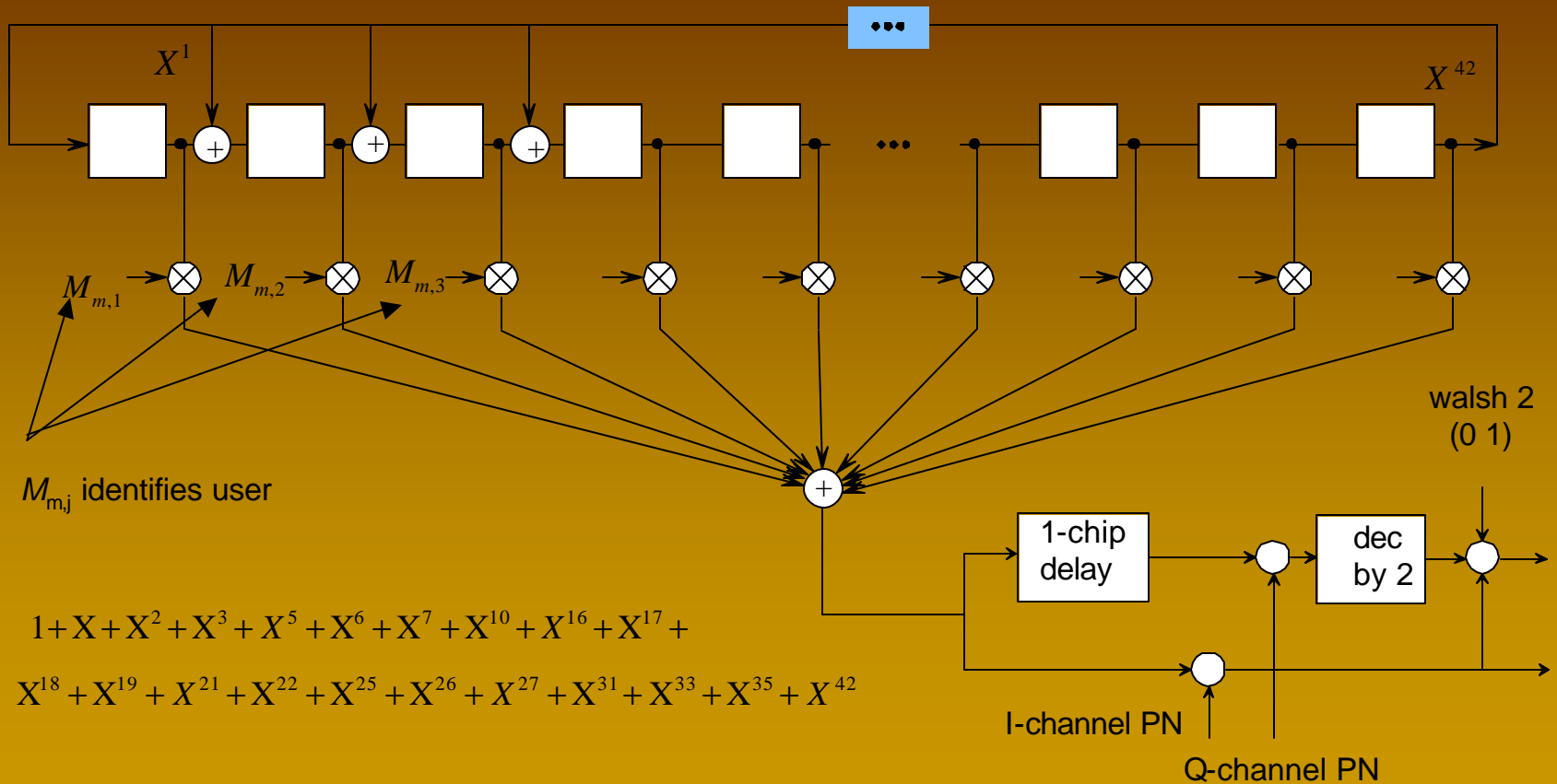
Short PN "Pilot" Sequence: 1.2288 Mcps

inphase PN sequence

insert zero

$$1 + X^5 + X^7 + X^8 + X^9 + X^{13} + X^{15}$$

quadrature PN sequence

insert zero

$$1 + X^3 + X^4 + X^5 + X^6 + X^{10} + X^{11} + X^{12} + X^{15}$$
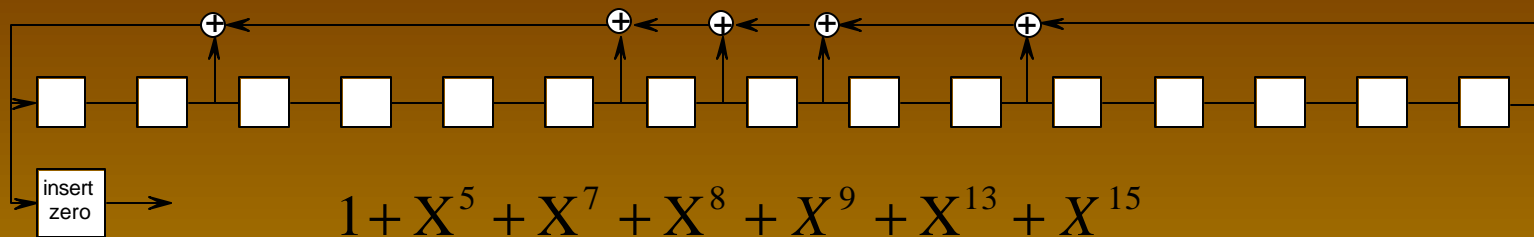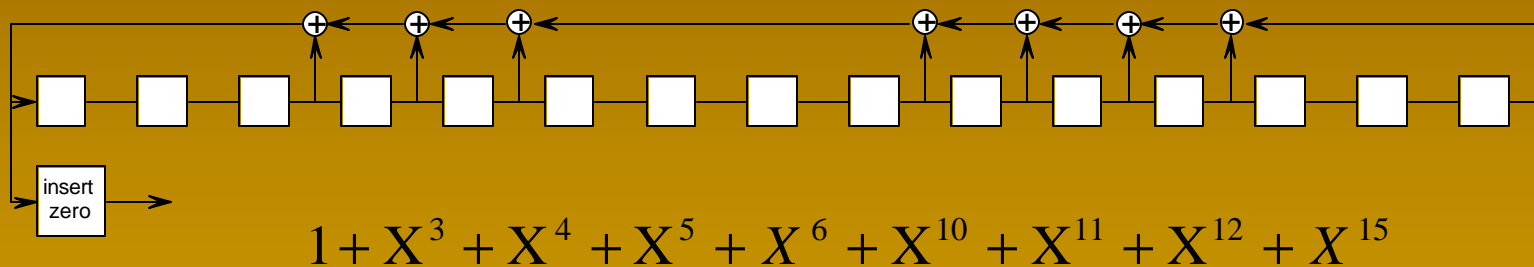
C.S0002-A-1 paragraph 2.1.3.1.12.1

cdma2000 UL Convolutional Codes
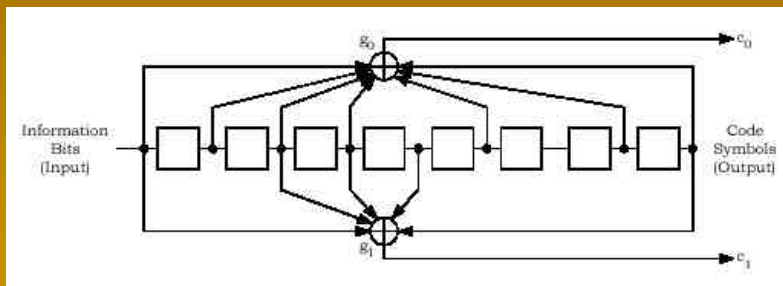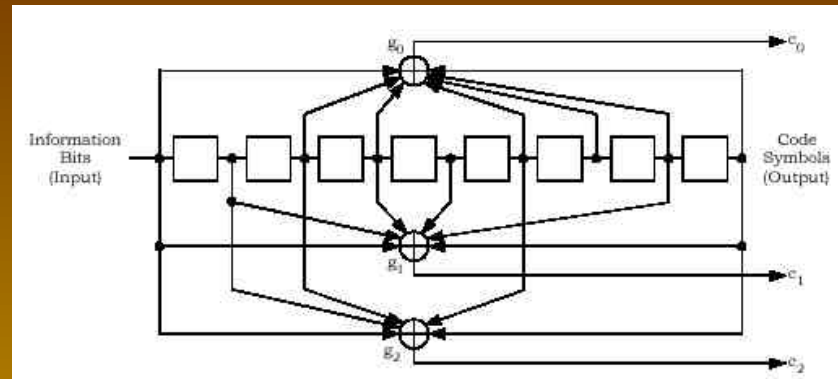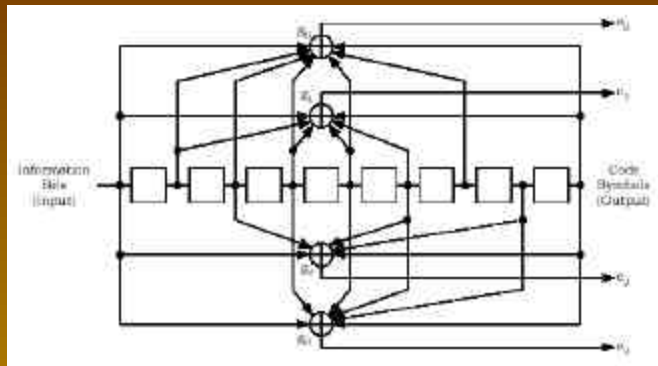
C.S.0002-A-1 Fig 2.1.3.1.4.1.1-1

cdma2000 Turbo Code

input

interleaver

symbol puncture
and repeat

output
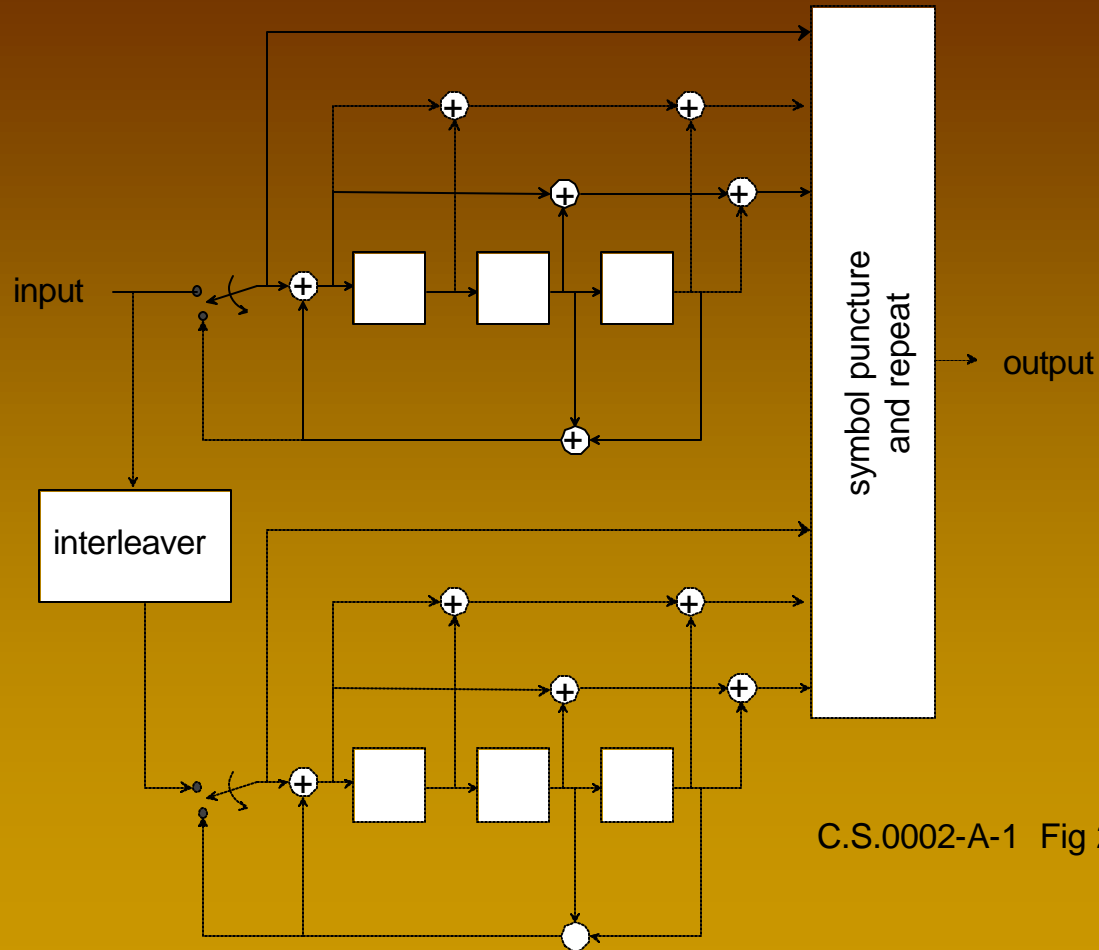
C.S.0002-A-1 Fig 2.1.3.1.4.2.1-1

cdma2000 3X Code Generators

C.S0002-A-1 Fig 2.1.3.1.12-1

1X long code

$\frac{1}{1.2288} \, m_S$

$\frac{1}{1.2288} \, m_S$

MUX

Long Code Generator Output (3.6864 Mcps)
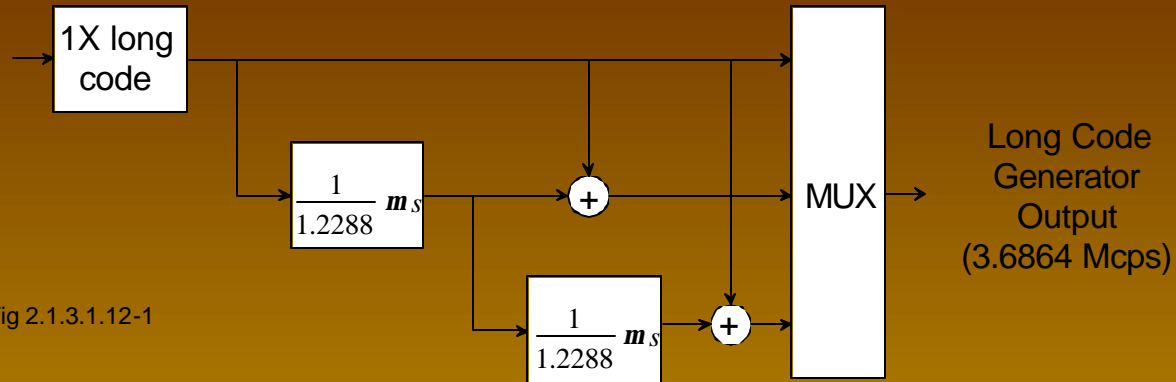
Short "Pilot" Code
Truncate and use delay different segments for I and Q

insert zero

$$1 + X^3 + X^5 + X^9 + X^{20}$$
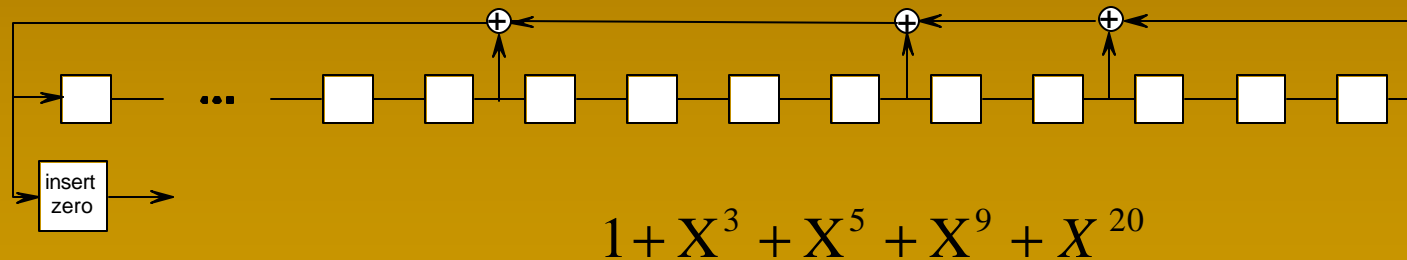
cdma2000 Uplink Data Rates

Table 2.1.3.1-1. Radio Configuration Characteristics for the Reverse CDMA Channel

Radio Config.	Associated Spreading Rate	Data Rates, Forward Error Correction, and General Characteristics
1	1	1200, 2400, 4800, and 9600 bps data rates with R = 1/3, 64-ary orthogonal modulation
2	1	1800, 3600, 7200, and 14400 bps data rates with R = 1/2, 64-ary orthogonal modulation
3	1	1200, 1350, 1500, 2400, 2700, 4800, 9600, 19200, 38400, 76800, and 153600 bps data rates with R = 1/4, 307200 bps data rate with R = 1/2, BPSK modulation with a pilot
4	1	1800, 3600, 7200, 14400, 28800, 57600, 115200, and 230400 bps data rates with R = 1/4, BPSK modulation with a pilot
5	3	1200, 1350, 1500, 2400, 2700, 4800, 9600, 19200, 38400, 76800, and 153600 bps data rates with R = 1/4, 307200 and 614400 bps data rate with R = 1/3, BPSK modulation with a pilot
6	3	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, and 460800 bps data rates with R = 1/4, 1036800 bps data rate with R = 1/2, BPSK modulation with a pilot

Note: For Radio Configurations 3 through 6, the Reverse Dedicated Control Channel and Reverse Fundamental Channel also allow a 9600 bps, 5 ms format.

cdma2000 1X Downlink Common Channels

Pilot Channel
all 0's
$\longrightarrow$ | 0 → 1
 1 → -1 | → | channel gain | $\longrightarrow X_I$

$\longrightarrow X_Q$

Sync Channel → | conv encode | → | 2X repeat | → | interleave | → 4800 ksps → | 0 → 1
 1 → -1 | → | channel gain | $\longrightarrow X_I$

$\longrightarrow X_Q$

Paging Channel → | conv encode | → | repeat | → | interleave | → (+) → | 0 → 1
 1 → -1 | → | channel gain | $\longrightarrow X_I$

$\longrightarrow X_Q$

→ | long code | → | decimate |
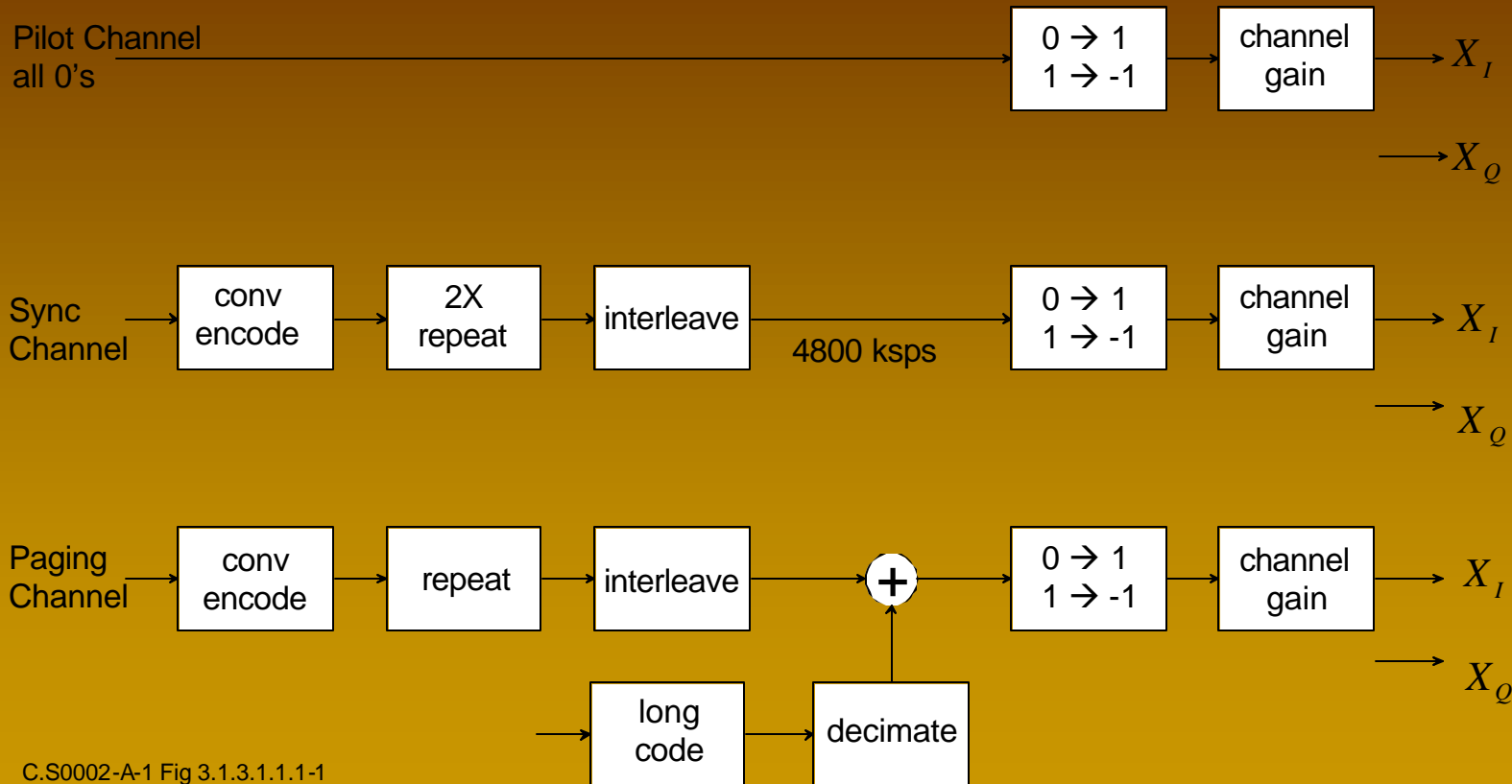
C.S0002-A-1 Fig 3.1.3.1.1.1-1

cdma2000 1X DL Modulation Processing
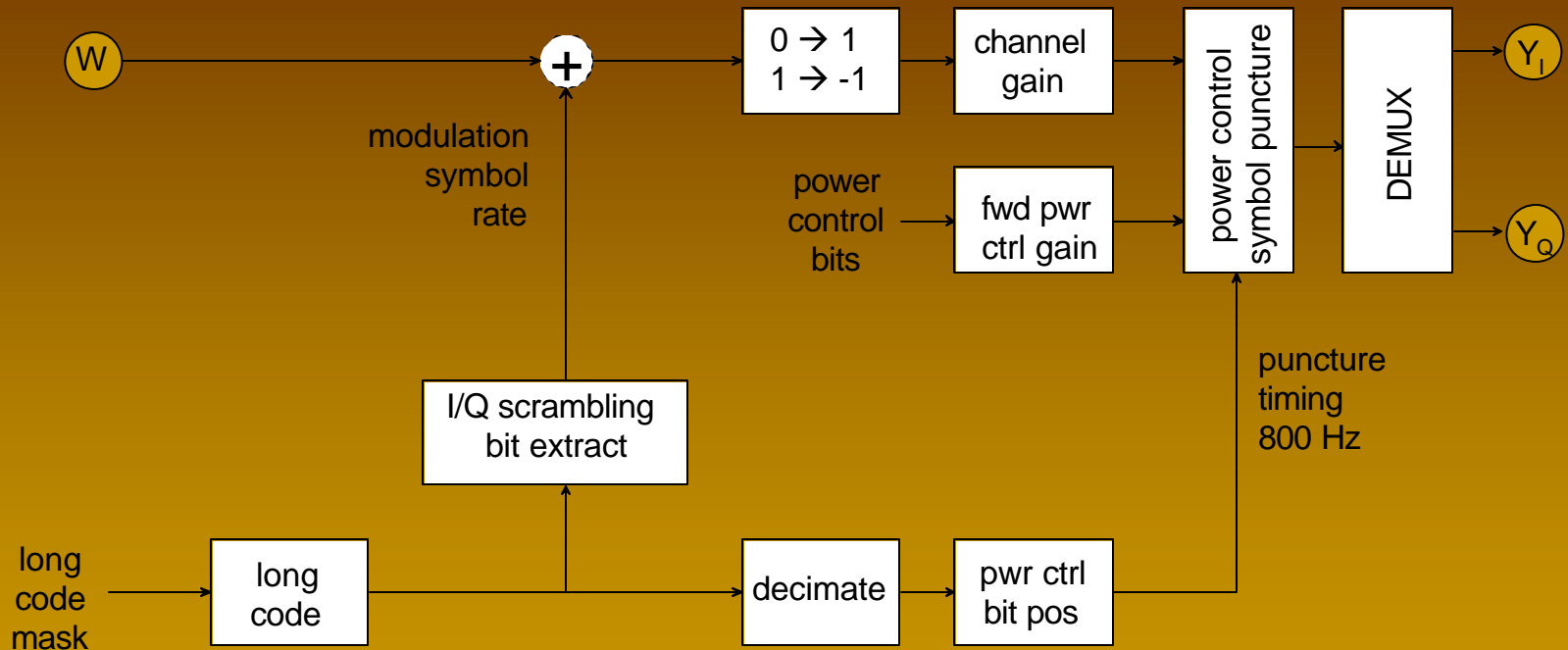
W

$0 \rightarrow 1$
$1 \rightarrow -1$

channel gain

modulation symbol rate

power control bits

fwd pwr ctrl gain

power control symbol puncture

DEMUX

Y_I

Y_Q

puncture timing 800 Hz

I/Q scrambling bit extract

long code mask

long code

decimate

pwr ctrl bit pos

C.S.0002-A-1 Fig 3.1.3.1.1.1-18

cdma2000 Downlink Convolutional Codes

Figure 3.1.3.1.4.1.4-1. K = 9, Rate 1/2 Convolutional Encoder

Figure 3.1.3.1.4.1.2-1. K = 9, Rate 1/4 Convolutional Encoder

Figure 3.1.3.1.4.1.3-1. K = 9, Rate 1/3 Convolutional Encoder

Figure 3.1.3.1.4.1.1-1. K = 9, Rate 1/6 Convolutional Encoder

cdma2000 3X Downlink Common Channels

Pilot Channel
all 0's

$$\longrightarrow \boxed{\begin{array}{c} 0 \rightarrow 1 \\ 1 \rightarrow -1 \end{array}} \longrightarrow \boxed{\begin{array}{c} \text{channel} \\ \text{gain} \end{array}} \longrightarrow X_I$$

$$\longrightarrow X_Q$$

Sync
Channel

$$\longrightarrow \boxed{\begin{array}{c} \text{conv} \\ \text{encode} \end{array}} \longrightarrow \boxed{\begin{array}{c} \text{2X} \\ \text{repeat} \end{array}} \longrightarrow \boxed{\text{interleave}} \underset{\text{4800 ksps}}{\longrightarrow} \boxed{\begin{array}{c} 0 \rightarrow 1 \\ 1 \rightarrow -1 \end{array}} \longrightarrow \boxed{\begin{array}{c} \text{channel} \\ \text{gain} \end{array}} \longrightarrow X_I$$

$$\longrightarrow X_Q$$
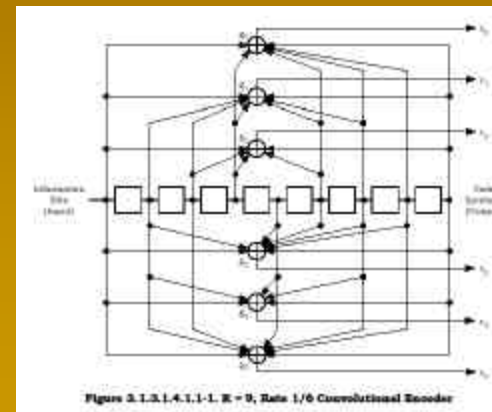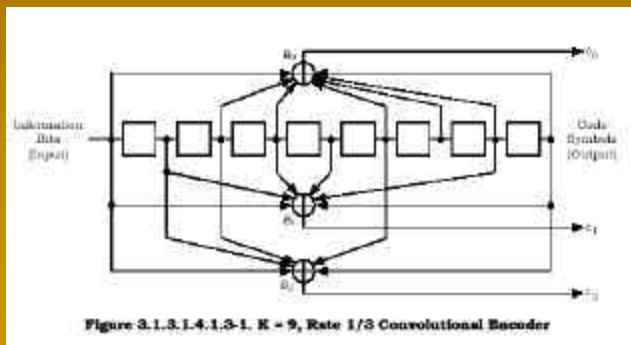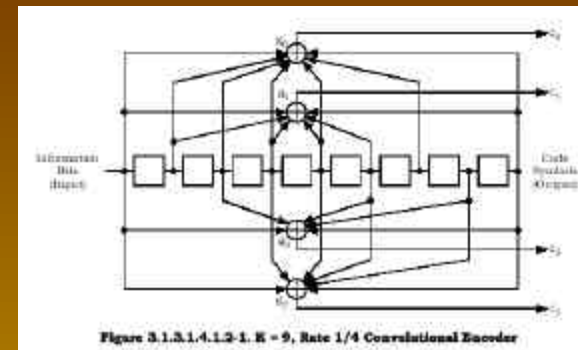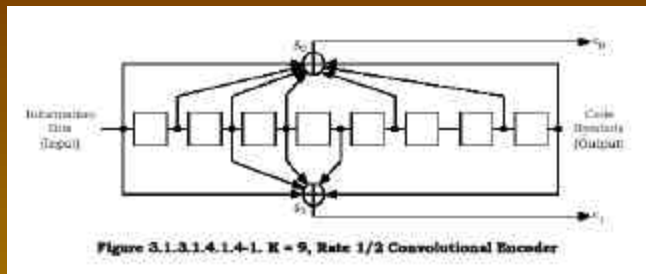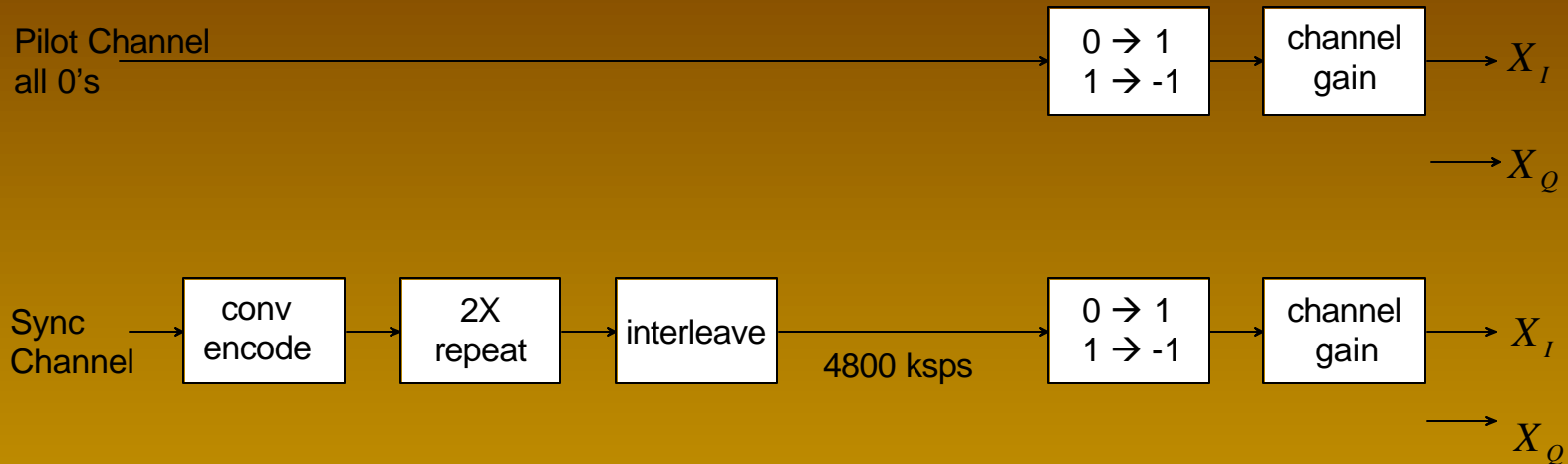
C.S.0002-A-1 Fig 3.1.3.1.1.2-1

cdma2000 1X Downlink Modulation
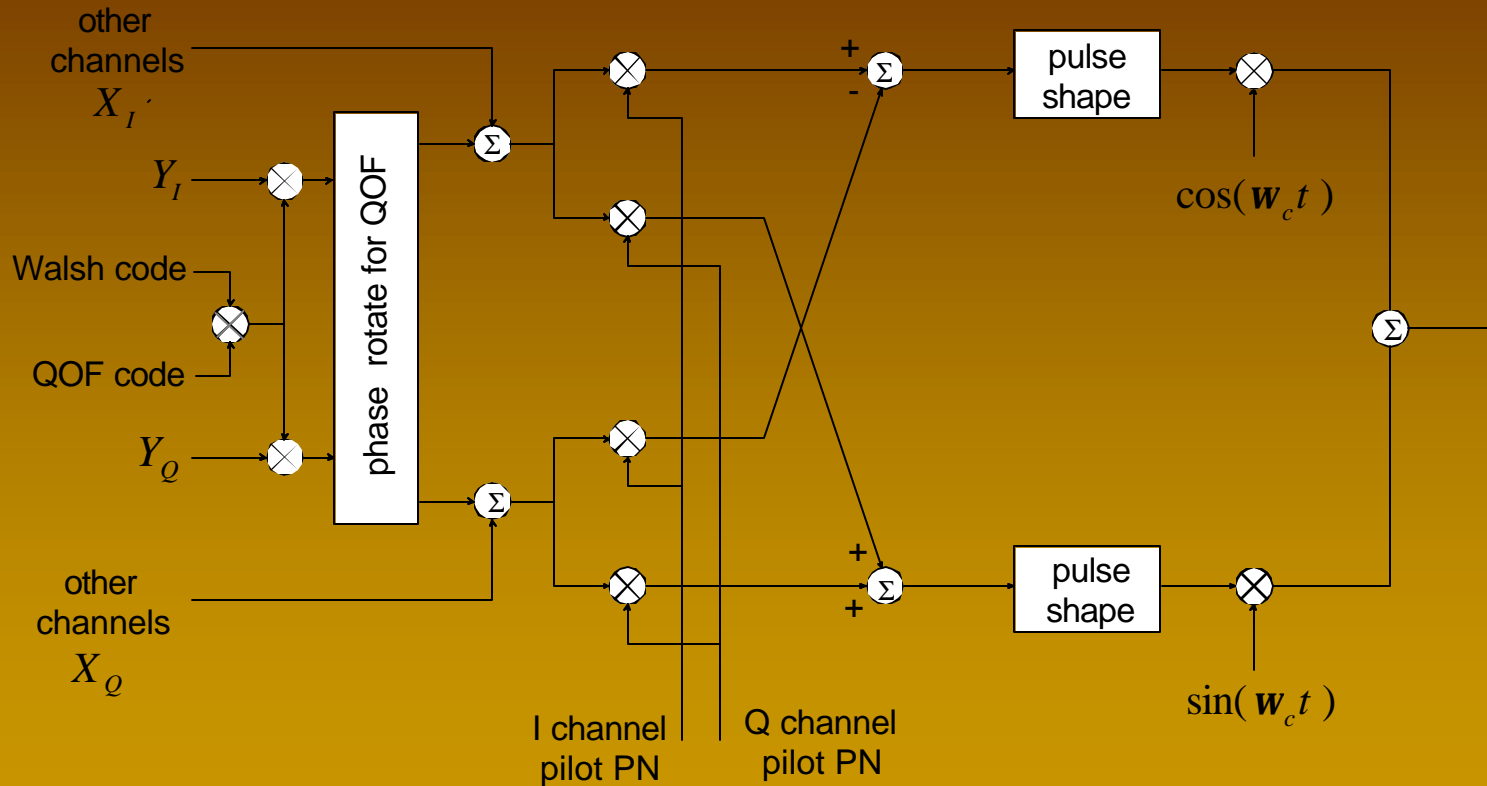
cdma2000 Downlink Frame Structure

Radio Configuration 3

channel bits → | CRC | → | encoder tail bits | → | Convolutional or Turbo Coder | → | symbol repetition | → | symbol puncture | → | block interleaver | → Ⓦ modulation symbol

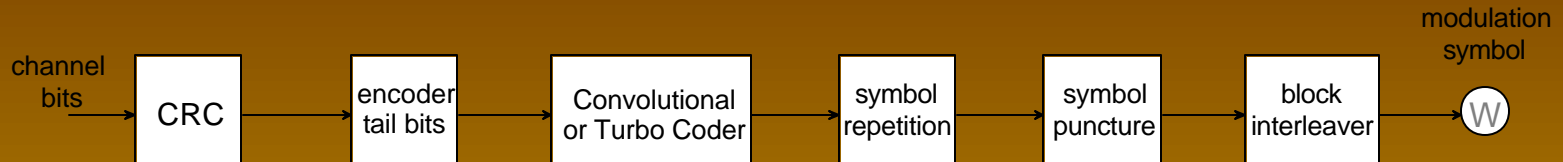| Bits/ Frame	CRC bits	tail bits	Data Rate kbps	Code Rate	Repeats	Delete	Symbols
16	6	8	1.5	1/4	8	1 of 5	768
40	6	8	2.7	1/4	4	1 of 9	768
80	8	8	4.8	1/4	2	none	768
172	12	8	9.6	1/4	1	none	768
360	16	8	19.2	1/4	1	none	1536
744	16	8	38.4	1/4	1	none	3072
1512	16	8	76.8	1/4	1	none	6144
3048	16	8	153.6	1/4	1	none	12288

Other similar tables in specification.
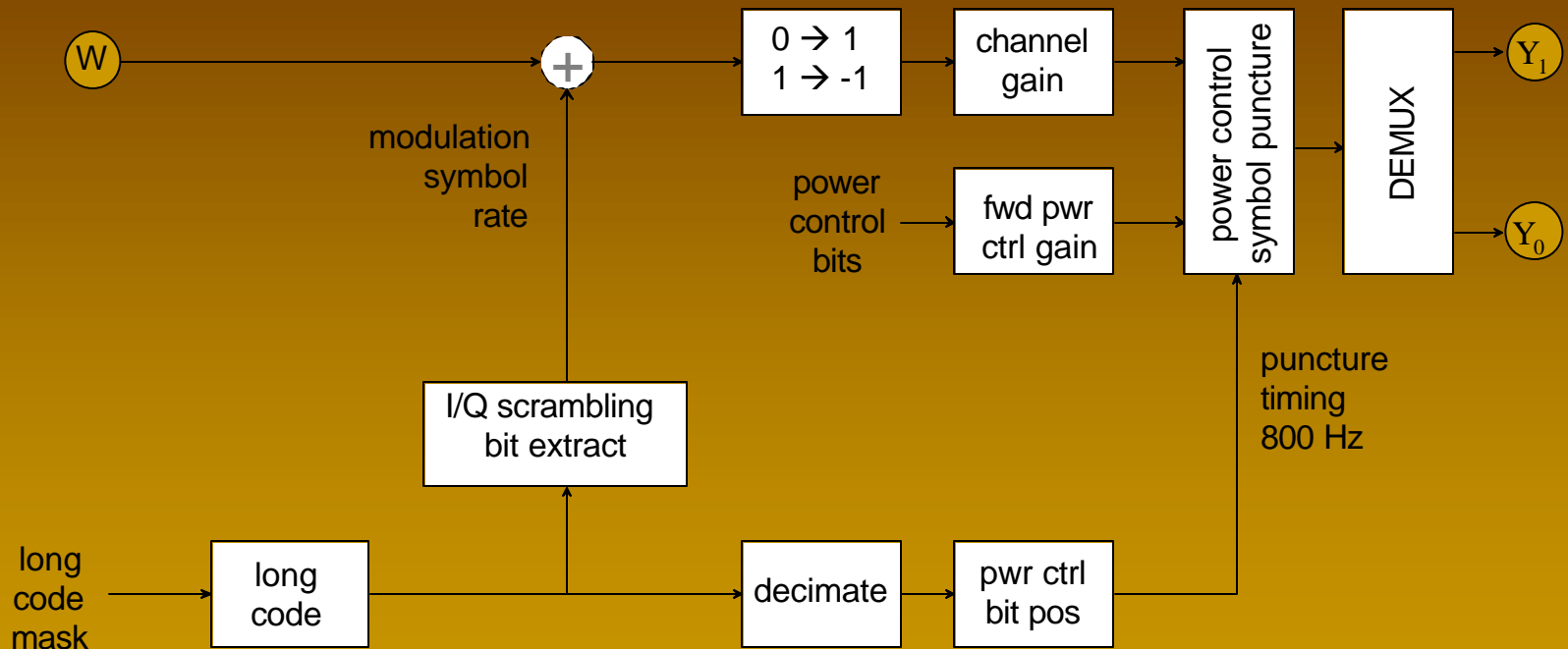
cdma2000 3X DL Modulation Processing

W → (+)

modulation symbol rate

0 → 1
1 → -1 → channel gain → power control symbol puncture → DEMUX → Y_1

power control bits → fwd pwr ctrl gain → power control symbol puncture

→ Y_0

puncture timing 800 Hz

I/Q scrambling bit extract

long code mask → long code → decimate → pwr ctrl bit pos

cdma2000 3X Downlink Common Channels

Pilot Channel
all 0's ────────────────────────────→ | 0 → 1
 1 → -1 | → | channel gain | → X_I

$\longrightarrow X_Q$

Sync Channel → | conv encode | → | 2X repeat | → | interleave | 4800 ksps → | 0 → 1
 1 → -1 | → | channel gain | → X_I

$\longrightarrow X_Q$

cdma2000 Downlink Frame Structure

Radio Configuration 9

modulation symbol

channel bits → CRC → encoder tail bits → Convolutional or Turbo Coder → symbol repetition → symbol puncture → block interleaver → (W)
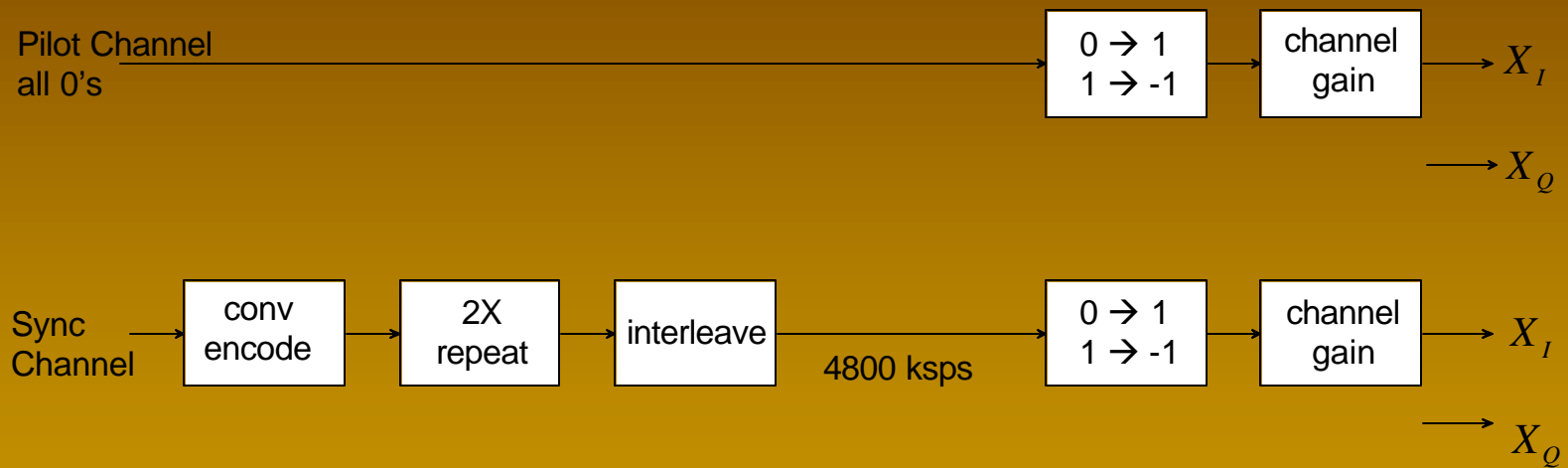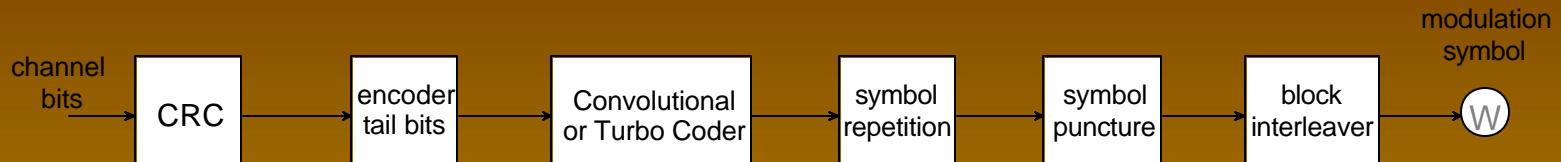
Bits/ Frame	CRC bits	tail bits	Data Rate kbps	Code Rate	Repeats	Delete	Symbols
21	6	8	1.8	1/2	8	none	576
55	8	8	3.6	1/2	4	none	576
125	10	8	7.2	1/2	2	none	576
267	12	8	14.4	1/2	1	none	576
552	16	8	28.8	1/2	1	none	1152
1128	16	8	57.6	1/2	1	none	2304
2280	16	8	115.2	1/2	1	none	4608
4584	16	8	230.4	1/2	1	none	9216
9192	16	8	460.8	1/2	1	none	18432
20712	16	8	1036.8	1/2	1	2 of 18	36864

Other similar tables in specification.

cdma2000 3X DL Modulation Processing

W → (+) → | 0 → 1
 1 → -1 | → channel gain → power control symbol puncture → DEMUX → Y_{I1} Y_{Q1} Y_{I2} Y_{Q2} Y_{I3} Y_{Q3}

modulation symbol rate

power control bits → fwd pwr ctrl gain

I/Q scrambling bit extract

puncture timing 800 Hz

long code mask → long code → decimate → pwr ctrl bit pos
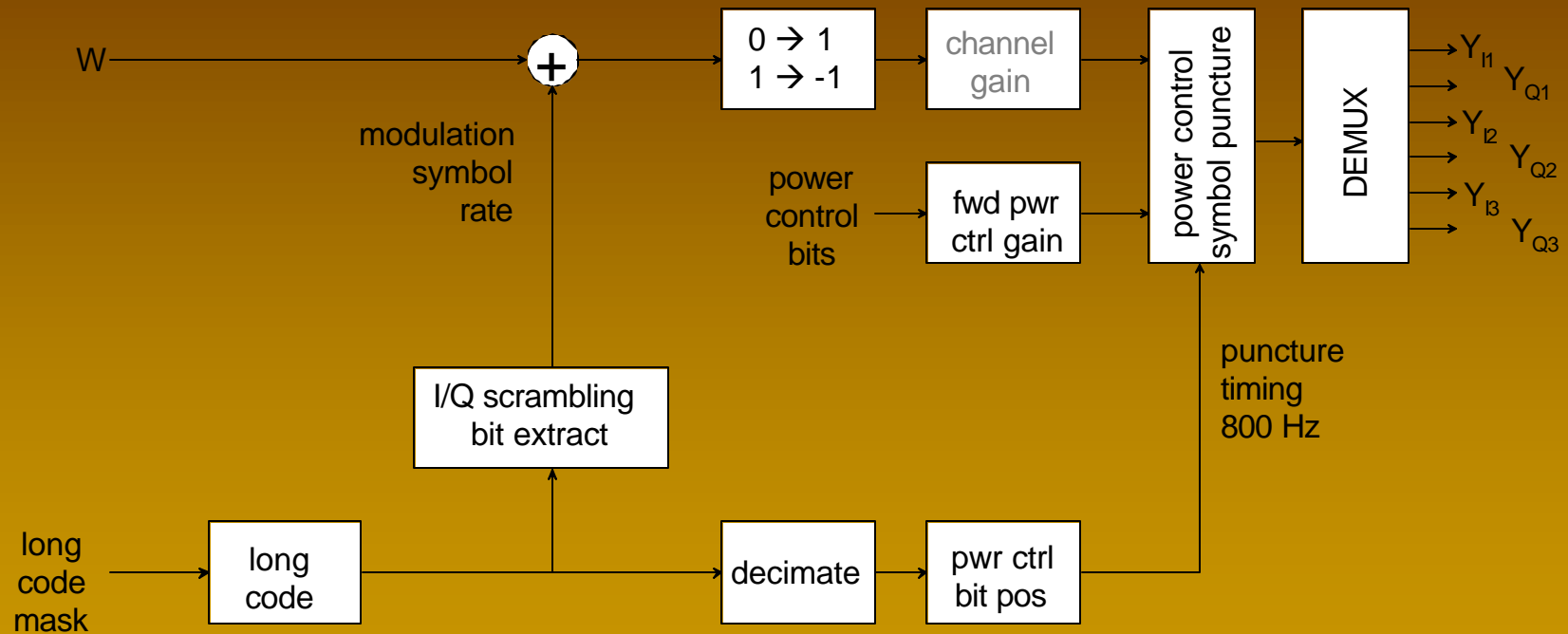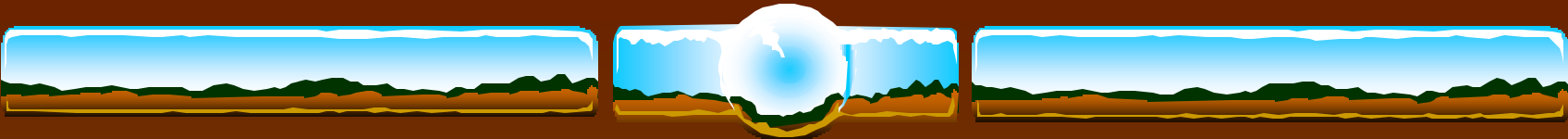
cdma2000 3X Downlink Modulation

Y_{I1} → | same as below | → output carrier 1

Y_{Q1} →

Y_{I2} → | | → output carrier 2

Y_{Q2} →

Y_{I3} → | same as above | → output carrier 3
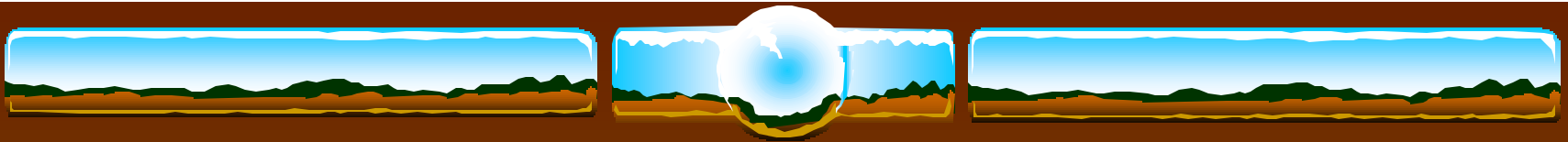
Y_{Q3} →
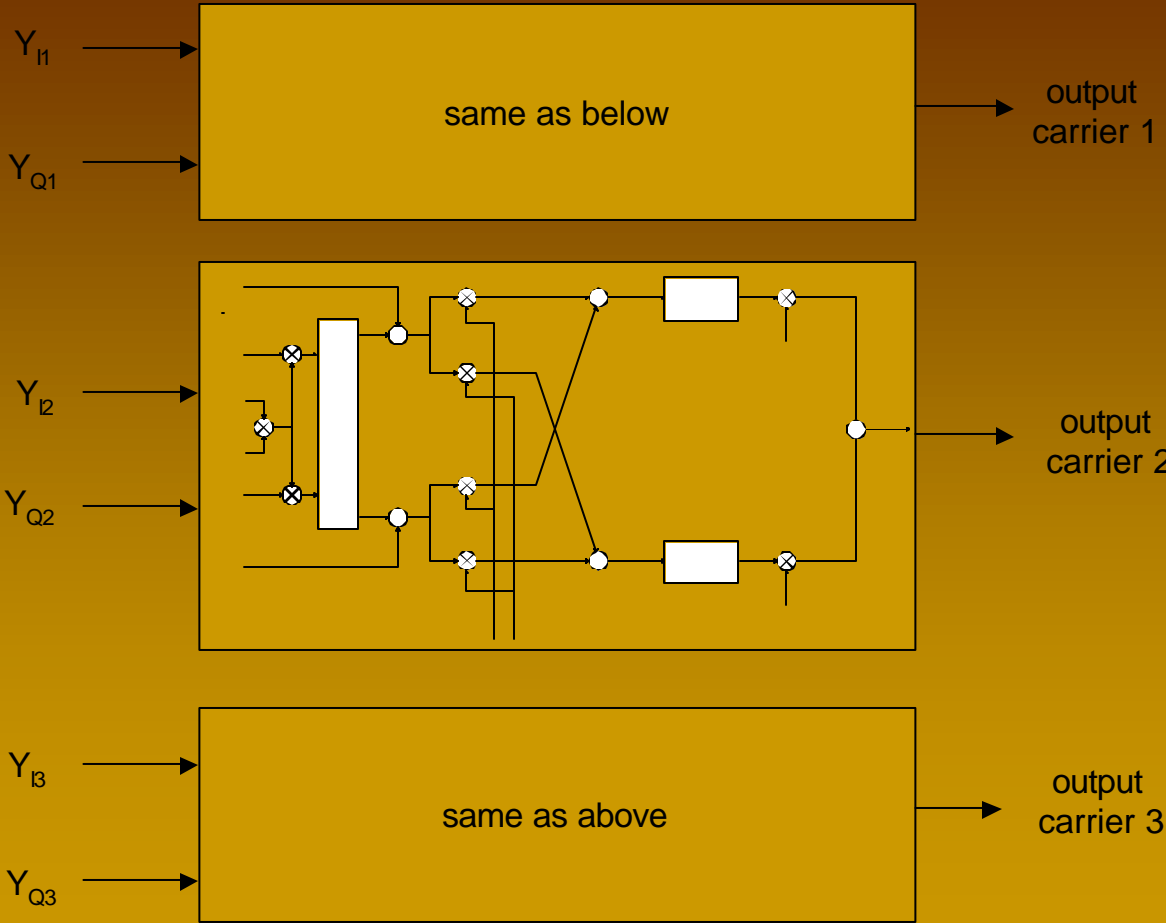
cdma2000 Downlink Data Rates

Table 3.1.3.1-1. Radio Configuration Characteristics for the Forward Traffic Channel

Radio Configuration	Associated Spreading Rate	Data Rates, Forward Error Correction, and General Characteristics
1	1	1200, 2400, 4800, and 9600 bps data rates with R = 1/2, BPSK pre-spreading symbols
2	1	1800, 3600, 7200, and 14400 bps data rates with R = 1/2, BPSK pre-spreading symbols
3	1	1200, 1350, 1500, 2400, 2700, 4800, 9600, 19200, 38400, 76800, and 153600 bps data rates with R = 1/4, QPSK pre-spreading symbols, TD allowed
4	1	1200, 1350, 1500, 2400, 2700, 4800, 9600, 19200, 38400, 76800, 153600, and 307200 bps data rates with R = 1/2, QPSK pre-spreading symbols, TD allowed
5	1	1800, 3600, 7200, 14400, 28800, 57600, 115200, and 230400 bps data rates with R = 1/4, QPSK pre-spreading symbols, TD allowed
6	3	1200, 1350, 1500, 2400, 2700, 4800, 9600, 19200, 38400, 76800, 153600, and 307200 bps data rates with R = 1/6, QPSK pre-spreading symbols.
7	3	1200, 1350, 1500, 2400, 2700, 4800, 9600, 19200, 38400, 76800, 153600, 307200, and 614400 bps data rates with R = 1/3, QPSK pre-spreading symbols.
8	3	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, and 460800 data rates with R = 1/4 (20 ms) or 1/3 (5 ms), QPSK pre-spreading symbols.
9	3	1800, 3600, 7200, 14400, 28800, 57600, 115200, 230400, 259200, 460800, 518400, and 1036800 bps data rates with R = 1/2 (20 ms) or 1/3 (5 ms), QPSK pre-spreading symbols.

# cdma2000 vs WCDMA

❖ Chip rate

❖ Coherent Pilot Channels

❖ Transmit Diversity

❖ Underlying Network

❖ Single Carrier versus Multicarrier Spreading

❖ Cell Site Synchronization
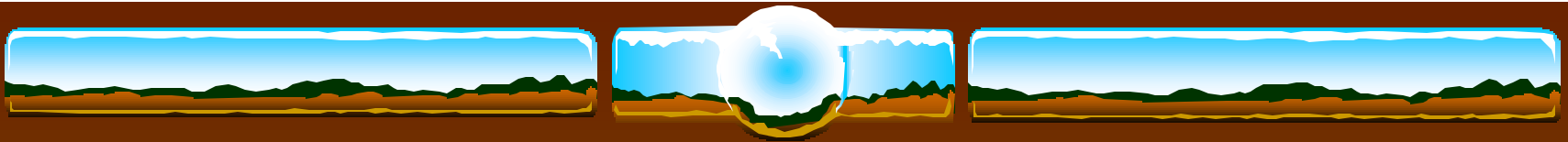
References

[1] R. L. Peterson, "Third Generation Personal Communications: Physical Layer Status," Presentation at Clemson University, Feb. 1, 2001

[2] Manjit Singh and Manoneet Singh, "3G Wireless with Respect to IMT-2000 and Beyond," Telecom 99

[3] Harri Holma and Antti Toskala, *WCDMA for UMTS: Radio Access for Third Generation Mobile Communications*, New York: Wiley, 2000

[4] "CDMA Evolution from IS-95, IS-2000, to 1XTREME," Technology Transfer Training Class, Motorola, Inc., July 2000

[5] R. Ziemer and R. Peterson, *Introduction to Digital Communications*, Upper Saddle River, NJ: Prentice Hall, Chapter 10, 2001
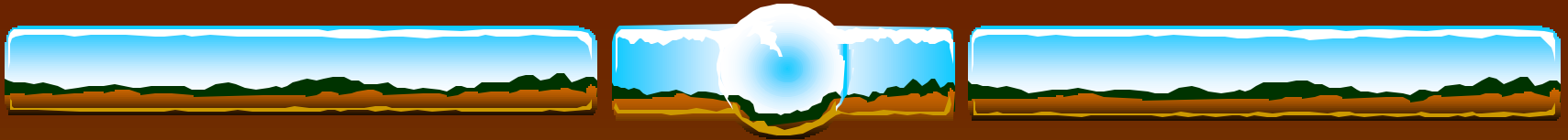
WCDMA: More Information?

❖ http://www.3gpp.org
- ❖ 21.101 → guide to all other documents
- ❖ 25.XXX series → radio access network (RAN)
  - ❖ 25.211 → frame structure etc.
  - ❖ 25.212 → channel coding etc.
  - ❖ 25.213 → spreading and modulation
  - ❖ 25.214 → physical layer procedures (tx diversity, etc.)
  - ❖ 25.321 → medium access control (MAC)
  - ❖ 25.322 → radio link control (RLC)
- ❖ 26.XXX series → voice coding
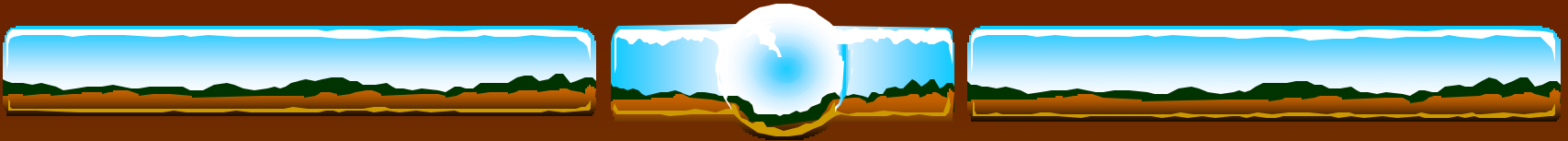
GSM/GPRS/EDGE: More Information?

❖ http://www.3gpp.org

3GPP	ETSI	description
45.001	05.01	general description
45.002	05.02	multiple access, logical channels, etc
45.003	05.03	channel coding
45.004	05.04	modulation
45.005	05.05	radio transmission and channel models
45.008	05.08	radio link control
45.009	05.09	link adaptation
44.060	04.60	RLC/MAC

cdma2000: More Information?

❖ http://www.3gpp2.org

  ❖ Technical Specification Group C → cdma2000

  ❖ C.S0002-A-1 → Physical Layer Standard

  ❖ C.S0003-A-1 → Medium Access Control (MAC)

  ❖ C.S0004-A-1 → Signaling Link Access Control

  ❖ C.S00024   → 1XEV-DO (high speed packet)

  ❖ C.S0005   → Upper Layer Signaling (L3)
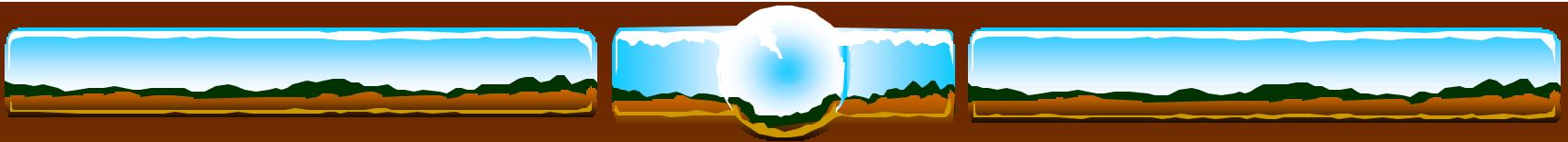
3G Information Sources

❖ Third Generation Partnership Projects
  - ❖ **http://www.3gpp.org**
  - ❖ **http://www.3gpp2.org**
❖ CDMA Development Group (CDG)
  - ❖ **http://www.cdg.org**
❖ International Mobile Telecommunications for the year 2000
  - ❖ **http://www.tiaonline.org/standards/sfg/imt2k/**
❖ Japan ARIB IMT-2000 proposal
  - ❖ http://www.arib.or.jp/IMT-2000/ARIB/Document/