CDMA Forward link Waveform Design

CDMA standard specifies a forward link CDMA waveform design that uses a combination of:
- Frequency Division Multiplexing
- Pseudo-random code division
- Orthogonal signal multiple access techniques
CDMA Forward link Waveform Design

- Frequency division is deployed by dividing the available frequency spectrum into nominal 1.25Mhz bandwidth channel.
- Pseudo random binary codes are used to distinguish signals from different base station received at mobile.
- All signal transmitted from a Base station in a particular CDMA radio channel share a common PN code phase. They are distinguished at mobile by using a binary orthogonal code based on Walsh function. It is a 64 PN code chip long and represents 64 orthogonal codes.
CDMA Forward link Waveform Design

Thus a channel in forward link consists of a signal centered on an assigned radio channel, quadruphase modulated by a pair of PN code with an assigned time offset, bi-phase modulated by an assigned orthogonal Walsh function and bi-phase modulated by the encoded, interleaved and scrambled digital information signal.
CDMA Forward link Waveform Design

An important aspect of the Forward link waveform design is that it uses four different kinds of channels:

- Pilot
- Synchronization
- Paging
- Traffic

Broadcast Channels
CDMA Forward Link Channel Format

Walsh fn. (W0= 0…00)

Pilot channel
Walsh Code 32

Sync. channel
Walsh codes (1-7)

Paging ch.
Upto 7 ch.
Walsh code (8-31; 33-63)

Traffic ch.
Upto 55 ch.

Walsh combining
For the purpose of Orthogonal Mux.

I/Q Spreading
FIR LPF & D/A

I/Q Spreading
FIR LPF & D/A

I/Q Spreading
FIR LPF & D/A

PN code spreading for The purpose of multipath Discrimination and Rejection of other cell Interference

Wave shaping for The purpose of Emission bandwidth control

Summation of All the channels For I & Q Ch. formation
CDMA Forward Link Physical Layer

Convolutional Encoder

Rate 1/2

Interleaver

19.2 kbps

1.2288 Mbps

Walsh code

Long code

19.2 kbps

1.2288 Mbps

Vocoded Speech data (20ms block)

9.6 kbps

I short code

FIR

FIR

1.2288 Mbps

I

Q short code

1.2288 Mbps

Q
CDMA Forward link - Pilot

The pilot signal is transmitted by each cell site and is used as a coherent carrier reference for modulation.

Pilot is transmitted at a relatively higher level than others channels to facilitate extremely accurate tracking.

It uses 0 Walsh code (consist of all 0’s).

The signal simply consists of quadrature pair PN code to which mobile can synch. With nearest base station and time offset of this base st. is used for demodulation of other signals.
CDMA Forward link - Pilot

Walsh fn. (W0= 0…00)

Pilot channel all 0’s

I-channel pilot PN sequence with offset
N=15, Rate=1.2288Mcps

Q-channel pilot PN sequence
N=15, Rate=1.2288Mcps

PN chip 1.2288

Baseband filter

Cos\(\omega_t\)

Sin\(\omega_t\)
CDMA Forward link -Pilot

The Pilot channel is transmitted always on the Forward link, on each active Forward CDMA channel.

Every Base station uses a specific time offset for the PN sequence to enable receiver to distinguish between the various BTS Forward channel.

There are 512 time offsets and are numbered 0-512.

The offset for given PN sequence, in terms of chips, is equal to the offset number multiplied by 64.
CDMA Forward link – Synch.

The synch. Channel operates at a fixed bit rate of 1200 bps.

It is used for the mobile to get the:
- System timing and Long code reference from the base station
- PN offset for base station
- System ID/Network ID
- Common Air Interface (CAI) revision level

The synch. Channel is not scrambled and does not carry the power control sub channel.

Uses the same Pilot PN offset as the Pilot chl.
Synch. Channel: Block schematic

Rate 1/2
Convolutional Encoder
Symbol repetition
Interleaver 16x8=128sym.
Walsh Code 32

2400bps 4800bps

Synch. Data 1200bps

I-Channel Pilot PN offset
Q-Channel Pilot PN offset

BPF

I(t)

W32= (0000……1111….)
32 32

1.2288Mbps 1.2288Mbps

Q(t)

I(t)

BPF

1.2288Mbps 1.2288Mbps
Synch. Channel: Structure

- Synch. Channel is sent in 80 msec Super Frames.
- Each Super Frames have got three frames of 26.666msec sync frames.
- First bit of each frame is the SOM (Start of Message) bit.
- No. of Super frames are combined to get a synch. Channel Message Capsule.
Synch. Channel: Structure

- **Sync. Ch. Super frame (80ms, 96 bits)**
- **Sync. Ch. Super frame**

### Synch. Channel Message Capsule
- \( 93 \times N_s \); \( N_s = \text{no. of super frame needed} \)

### Sync Channel Message Table

<table>
<thead>
<tr>
<th>MSG LEN</th>
<th>Message Body</th>
<th>Padding: as needed: 0’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bits</td>
<td>2-1146 bits</td>
<td>30 bits</td>
</tr>
</tbody>
</table>
Paging Channel: Block schematic

- Rate 1/2
- Walsh Code 1-7
- Convolutional Encoder
- 1.2288Mbps
- Symbol repetition
- Interleaver 24x16 = 384 sym
- Code Symbol
- Mod Symbol
- 1.2288Mbps
- I-Channel Pilot PN offset
- Q-Channel Pilot PN offset
- I(t)
- Q(t)
- BPF

Paging data
- 4800 bps / 9600 bps
- Convolutional Encoder
- Decimator 64:1
- Long code generator
- Long paging Code mask
- PCN
- Pilot PN

1100011001101 00000 PCN 000000000000 Pilot_PN

Paging Channel Long Code Mask
Paging Channel

- Operates at 9600 or 4800 kbps
- Use the same PN channel offset as the pilot channel
- Upto 7 paging channels are possible, the first one taking Walsh code number W1.
- Gives system parameter, Neighboring list, CDMA channel list, Access parameter list to sub. Equipment.
- Transmits overhead information.
- Assigns traffic channel to a subscriber station.
Paging channel structure

163.84 sec; 163.84*R bits; R=9600 or 4800 bps
Maximum paging channel slot cycle (2048 slots)

80ms; 0.08*R bits

Slot 0 | Slot 1 | Slot 2 | Slot 2047

4 Frames of 20ms; with two 10 ms half frame per frame
10ms; 0.01*R bits

Paging chl Half Frame | Paging chl Half Frame | Paging chl Half Frame | Paging chl Half Frame

SCI= Synchronized Capsule Indicator

SCI

MSG Length | Message Body | CRC | Padding

Half Frame Body
Paging channel structure

- Paging Channel is sent in 80 ms slots.
- Maximum 2048 slots are possible. This grouping of 2048 slots are called the ‘Maximum slot cycle’
- Each 80 ms slot is divided into 4 sub frames of 20msec.
- Each 20 ms sub frame is divided into two 10 ms halves.
- The first bit of such half frame is the Synchronized Capsule Indicator(SCI) bits.
Paging channel structure

Just like the synch channel, the Paging channel capsule consists of a message body, padding bits and CRC.

The paging channel could be Synch or Asynch. The SCI bit is set for 1 in case Synchronous message.

The paging message to be sent on any paging channel is a synchronous message capsule.
Forward Channel: Traffic

- Transmitted in 20 ms frames.
- Speed up to 9600 kbps
- In band signaling is used to send the message interleaved with speech.
- Carries speech or data.
- Channel assigned dynamically.
Traffic Channel: Block schematic

Rate 1/2
Walsh Code
Convolutional Encoder

1.2288Mbps
2.4kbps
4.8kbps
9.6kbps
19.2kbps

Traffic data 1200/2400/4800 9600bps

Symbol repetition

Code Symbol
2.4kbps
4.8kbps
9.6kbps
19.2kbps

Mod Symbol

Block Interleaver

Symbol repetition

Pwr con. bit

Walsh Code

1.2288Mbps

I(t)

Qt

Decimator

64:1

Decimator

24:1

Long traffic

Long code generator

Code mask

Q-Channel

Pilot PN offset

MUX

Traffic 9600 bps frame structure

CRC Tail bit

172

12

8