High Performance Broadband DS-CDMA via Carrier Interferometry Chip Shaping

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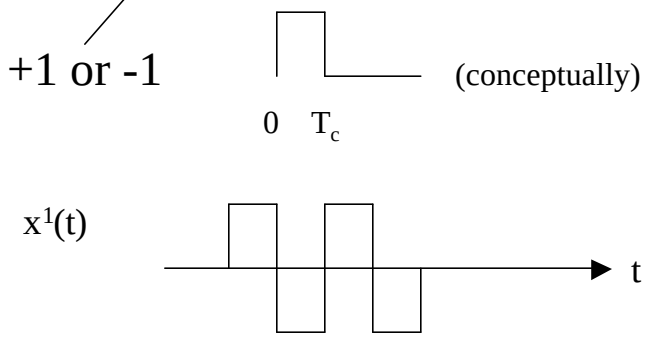
Introduction

- DS-CDMA

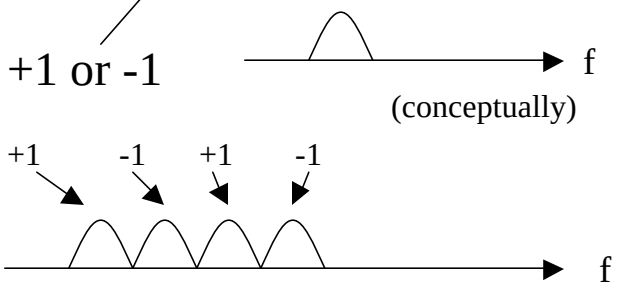
$$x^i(t) = \sum_{n=0}^{N-1} (-1)^{c_n^i} P_{T_c}(t - nT_c)$$



send $s^i(t) = +x^i(t) \text{ or } -x^i(t)$

- MC-CDMA

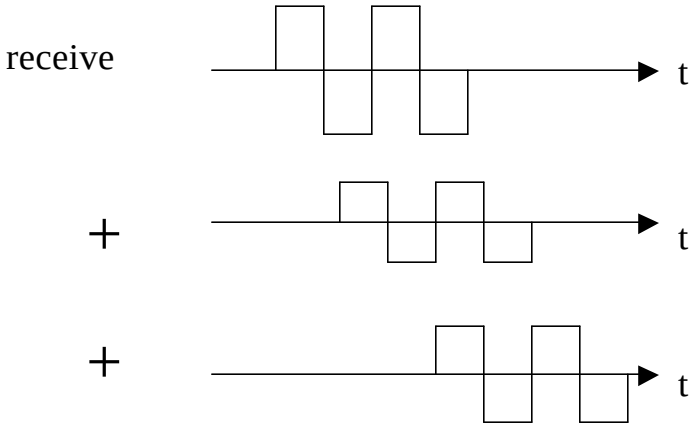
$$x^i(t) = \mathrm{Re}\{\sum_{n=0}^{N-1} (-1)^{c_n^i} e^{j2\pi n \Delta f t}\} P_T(t)$$



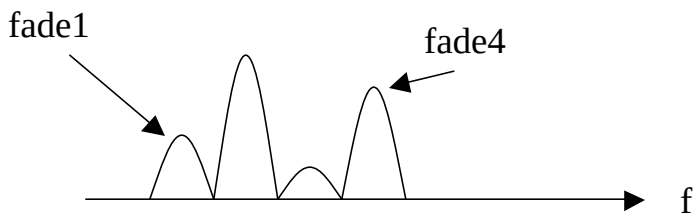
$s^i(t) = +x^i(t) \text{ or } -x^i(t)$

Introduction (2)

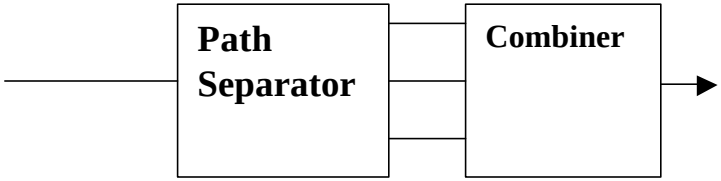
- DS-CDMA

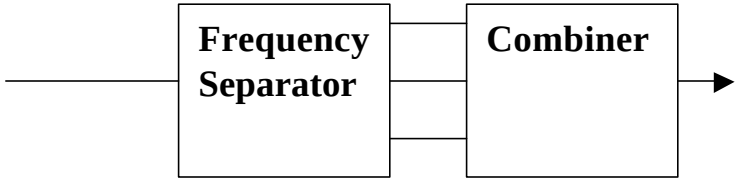


- MC-CDMA

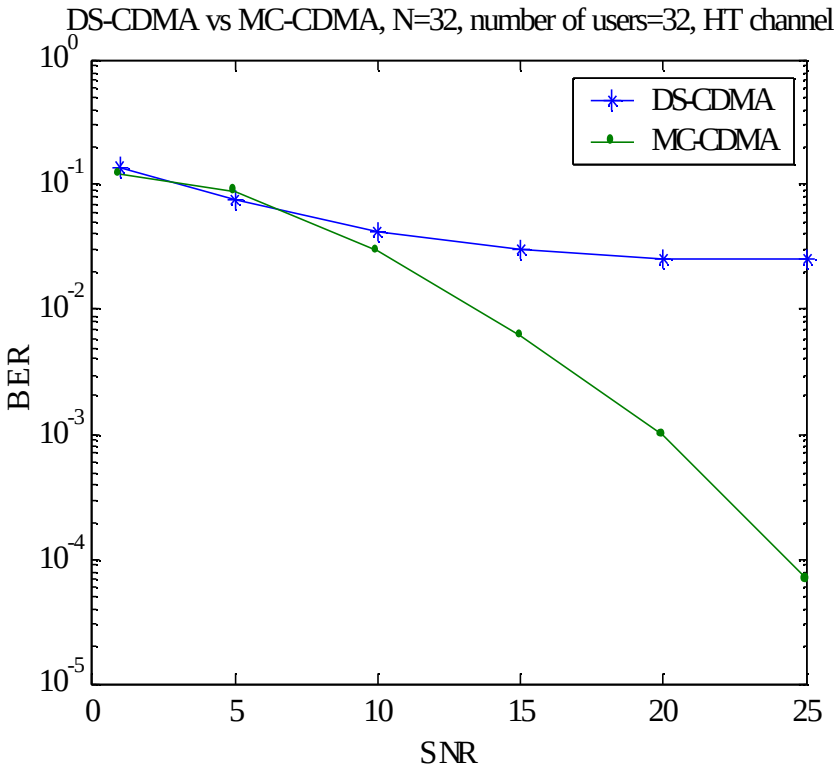


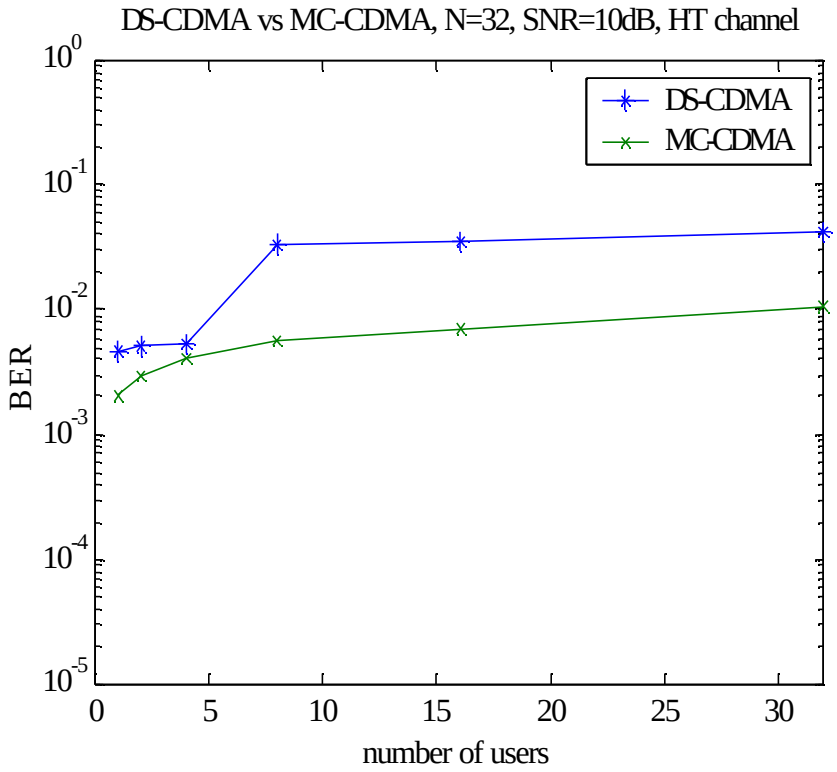
Receiver





Introduction (3)



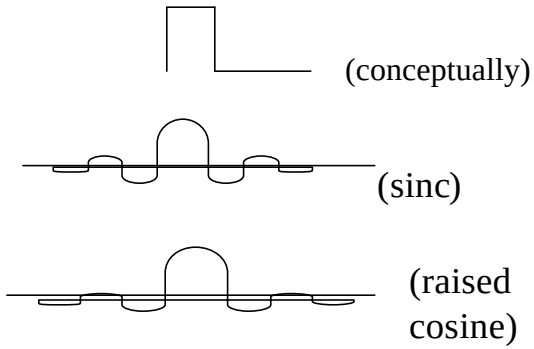


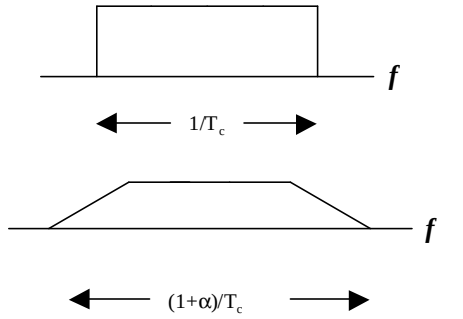
goal: We want DS-CDMA to achieve MC-CDMA performances.

Idea

DS-CDMA transmitter

$$x^i(t) = \sum_{n=0}^{N-1} (-1)^{c_n^i} P_{T_c}(t - nT_c)$$





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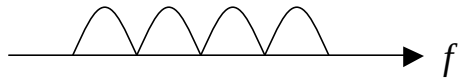


Objectives

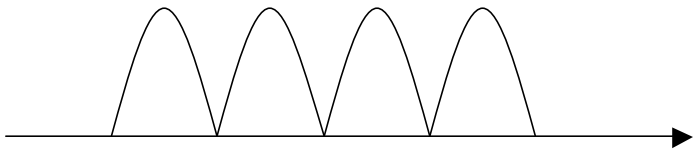
(1) need a chip shape that allows frequency to be decomposed at receiver (multi-carrier chip);

(2) $\int P_{T_c}(t-pT_c)P_{T_c}(t-qT_c)dt=0 \quad for\ p\neq q$ (sinc, raised cosine satisfy this criteria)

Solution

$$P_{T_c}(t) = \sum_{j=0}^{N-1} A\cos(2pj\Delta ft)$$

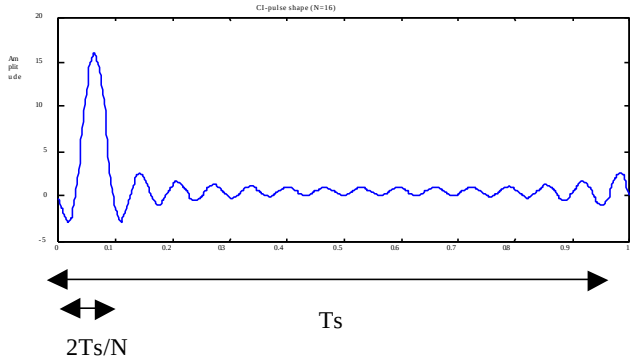
frequency



criteria (1)

time

interferometry pattern

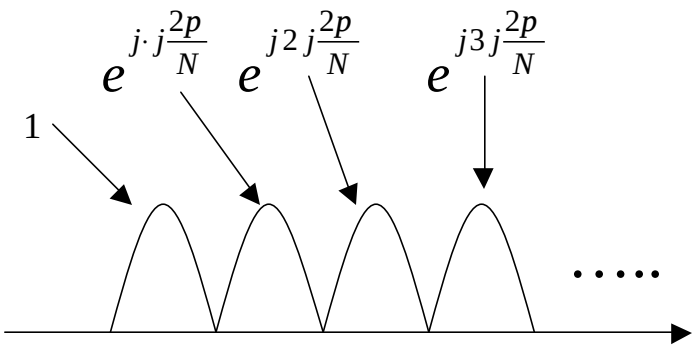


conceptually attractive

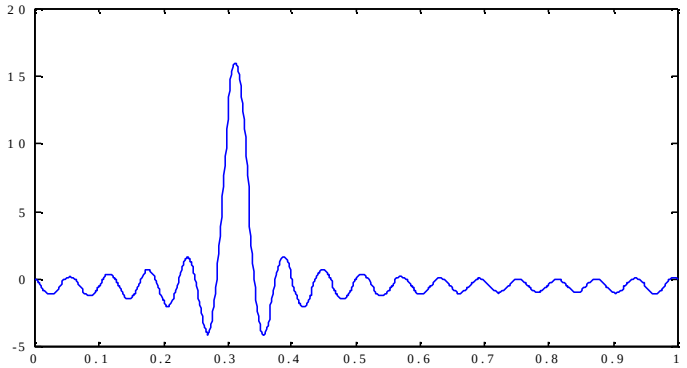
CI (carrier interferometry) chip shape

criteria (2)

frequency



time



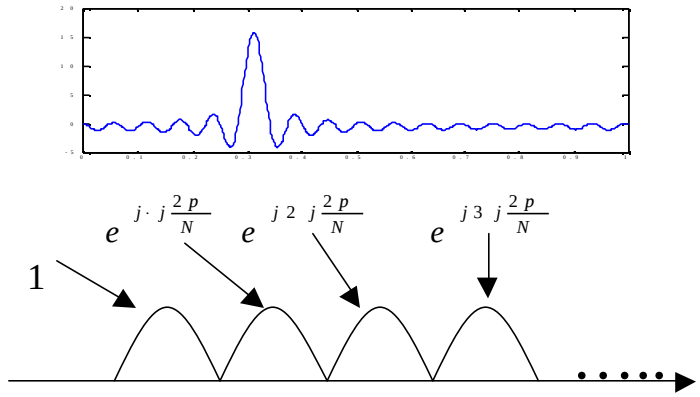
$$x^i(t) = \sum_{n=0}^{N-1} (-1)^{c_n^i} P_{T_c}(t - nT_c) g(t)$$

$$P_{T_c}(t - nT_c) = \sum_{n=0}^{N-1} A\cos(\, 2pn\Delta f\,(t - nT_c\,)$$

$$= \mathrm{Re}\{ \sum_{j=0}^{N-1} A e^{\,j2pj\Delta ft} e^{\,j \cdot jl\frac{2p}{N}} \}$$

System Model

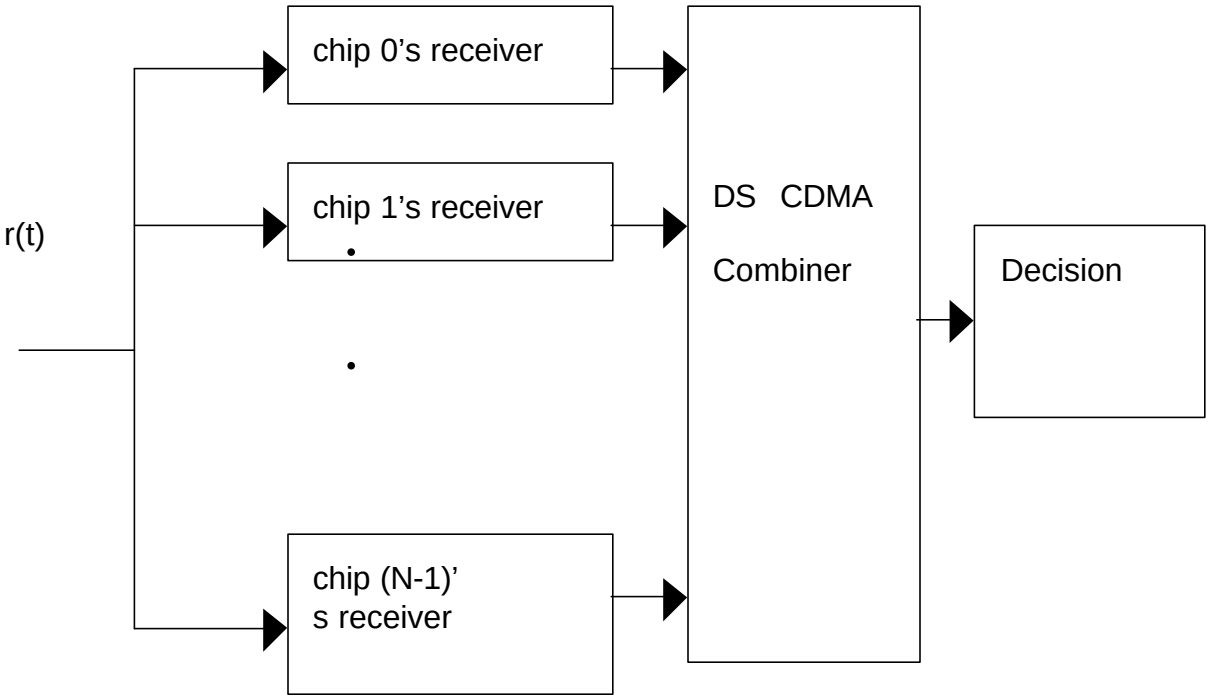
$$x^i(t) = \sum_{n=0}^{N-1} (-1)^{c_n^i} \left(\sum_{j=0}^{N-1} A\cos(2pj\Delta f (t - nT_c) g(t) \right)$$

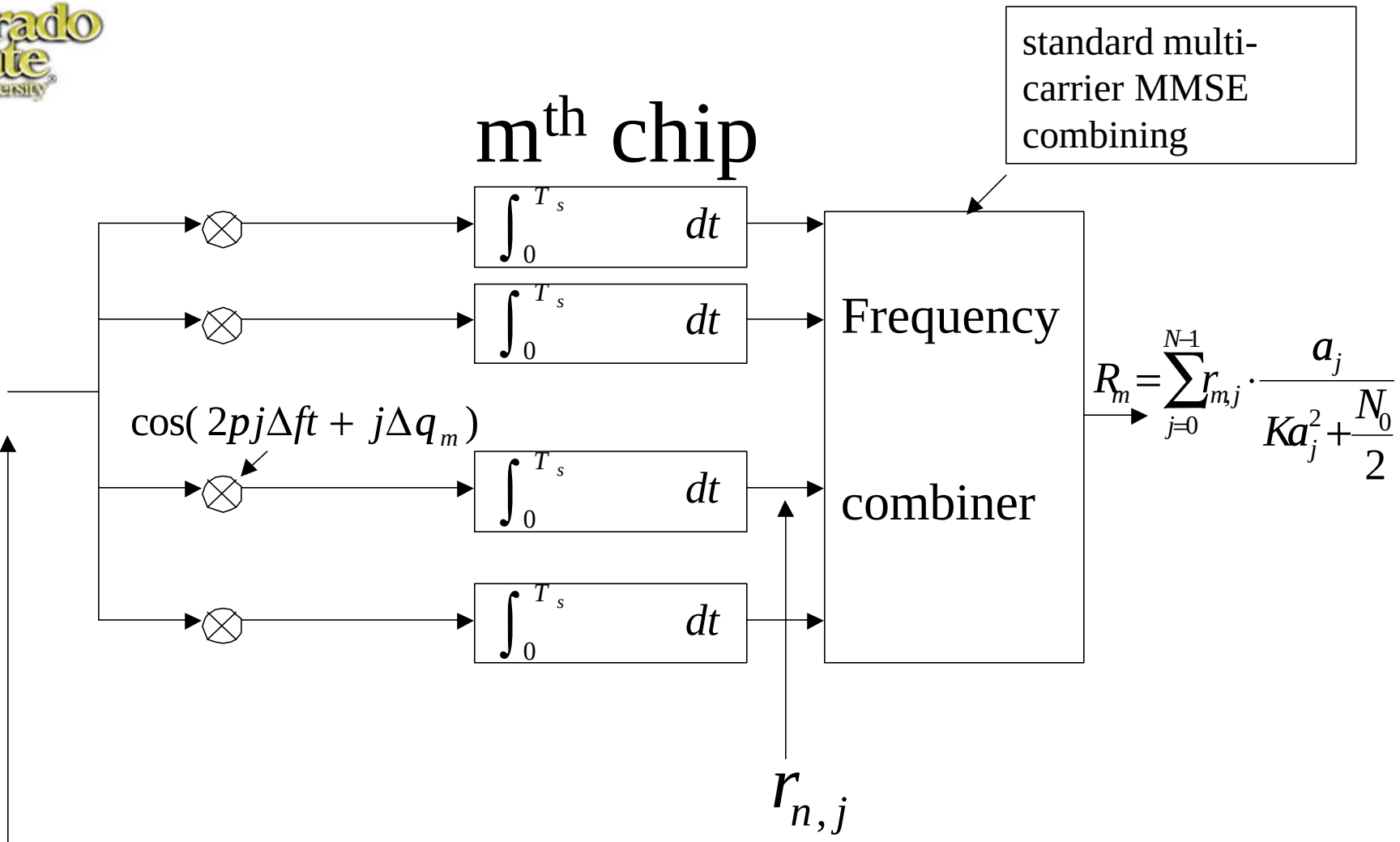


$$s^i(t) = b_i \left(\sum_{n=0}^{N-1} (-1)^{c_n^i} \left(\sum_{j=0}^{N-1} A\cos(2pj\Delta f (t - nT_c) \right) g(t) \right)$$

$$S(t) = \sum_{i=0}^{K-1} b_i \left(\sum_{n=0}^{N-1} (-1)^{c_n^i} \left(\sum_{j=0}^{N-1} A\cos(2pj\Delta f (t - nT_c) \right) g(t) \right)$$

Receiver Structure





$$r(t) = \sum_{i=0}^{K-1} b_i \left(\sum_{n=0}^{N-1} (-1)^{c_n^i} \left(\sum_{j=0}^{N-1} a_j A \cos(2pj\Delta ft - jn\frac{2p}{N} + f_j) \right) \right) + n(t)$$

$$r_{m,j} = \sum_{i=0}^{K-1} b_i \sum_{n=0}^{N-1} (-1)^{c_n^i} \cos\left(j(m-n)\frac{2p}{N} \right) + n_{m,j}$$

Desired chip m at carrier j

other chip's interference

$$r_{m,j} = b_l (-1)^{c_m^l} a_j + b_l a_j \sum_{\substack{n=0 \\ n \neq m}}^{N-1} (-1)^{c_n^l} \cos\left(j(m-n)\frac{2p}{N}\right)$$

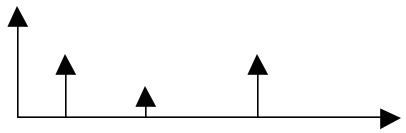
noise

$$+ \sum_{\substack{i=0 \\ i \neq l}}^{K-1} b_i (-1)^{c_m^i} a_j + \sum_{\substack{i=0 \\ i \neq l}}^{K-1} b_i a_j \sum_{\substack{n=0 \\ n \neq m}}^{N-1} (-1)^{c_n^i} \cos\left(j(m-n)\frac{2p}{N}\right) + n_{m,j}$$

Performance Results

Channel Model: HT(hilly terrain) (COST-207 GSM)

time



frequency

$$(\Delta f)_c \cong \frac{1}{5 s_t}$$

s_t : *rms delay spread*

DS-CDMA benchmark:

HW code, N=32, number of users=32, synchronous downlink, RAKE receiver

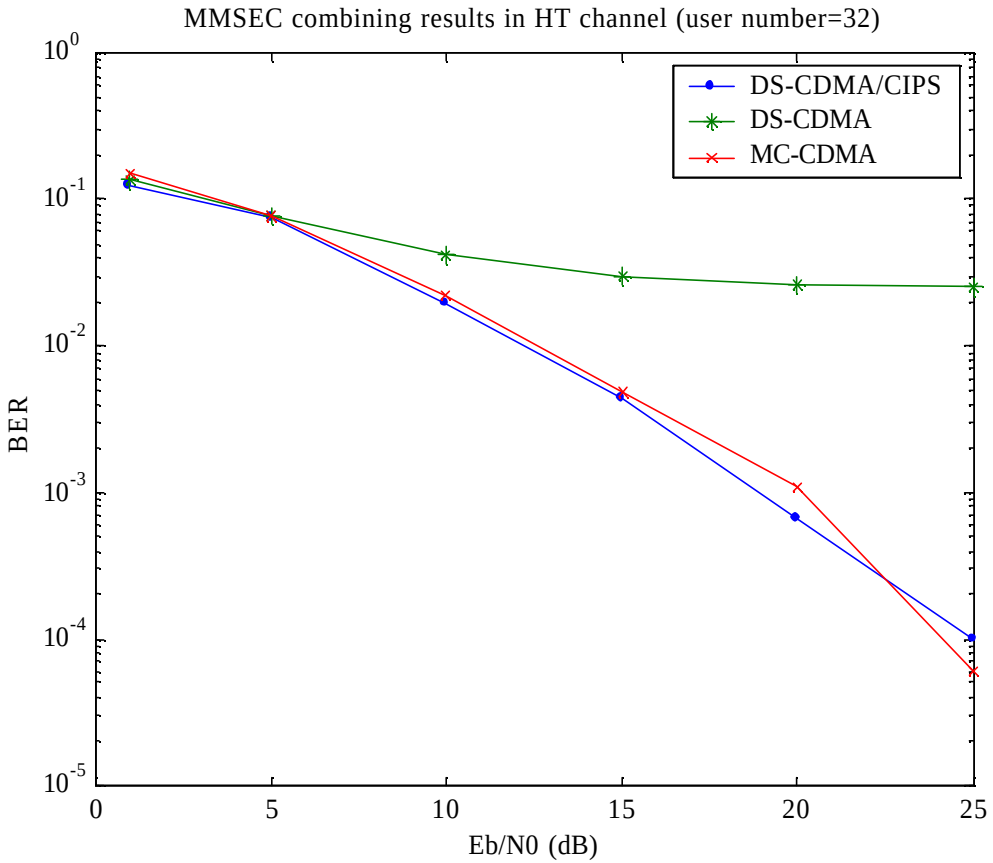
MC-CDMA benchmark

HW code, N=32, number of users=32, synchronous downlink, MMSEC receiver

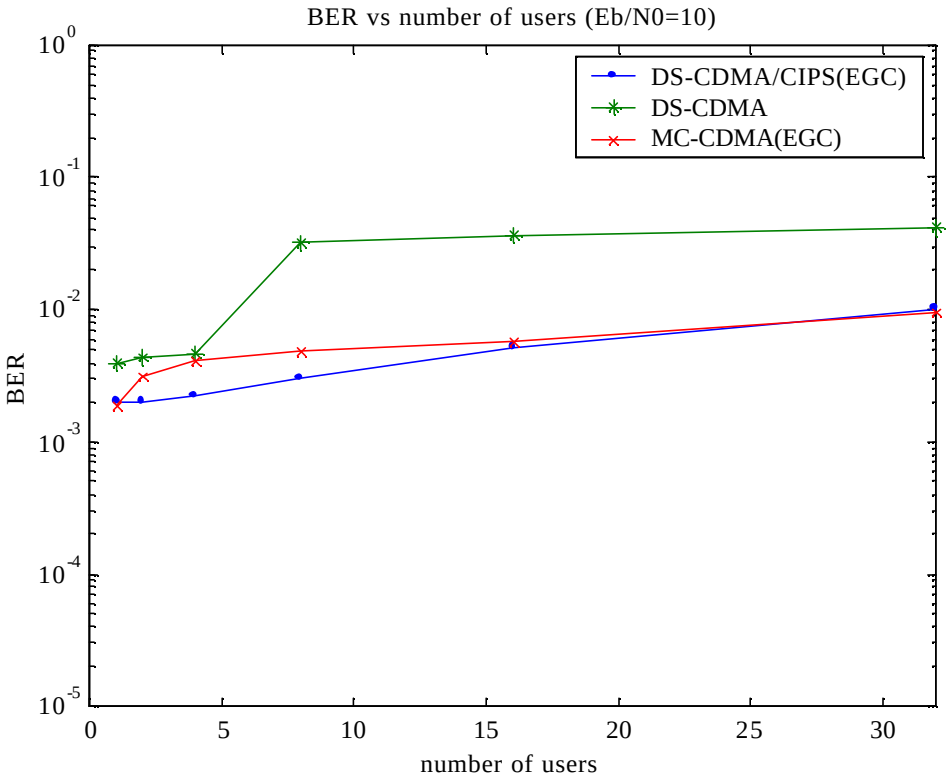
CI/DS-CDMA:

HW code, N=32, number of users=32, synchronous downlink, proposed receiver

Performance

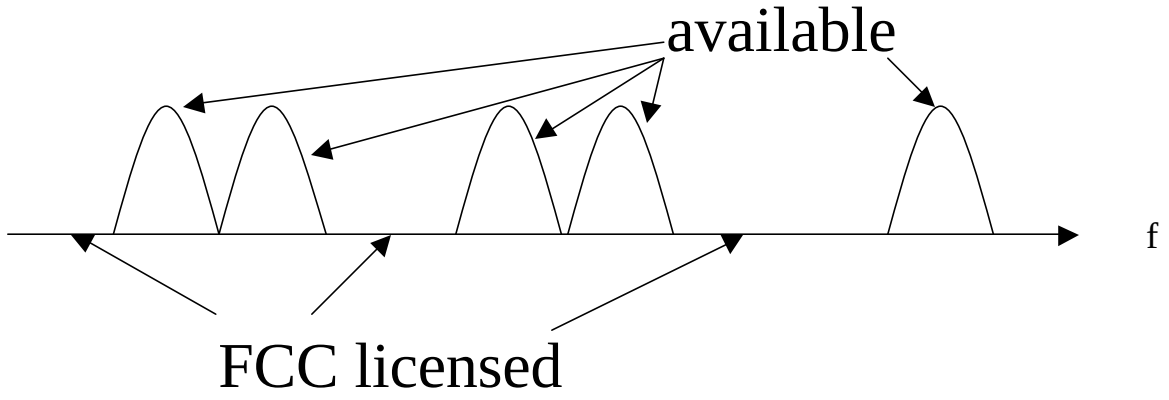


Performance (2)

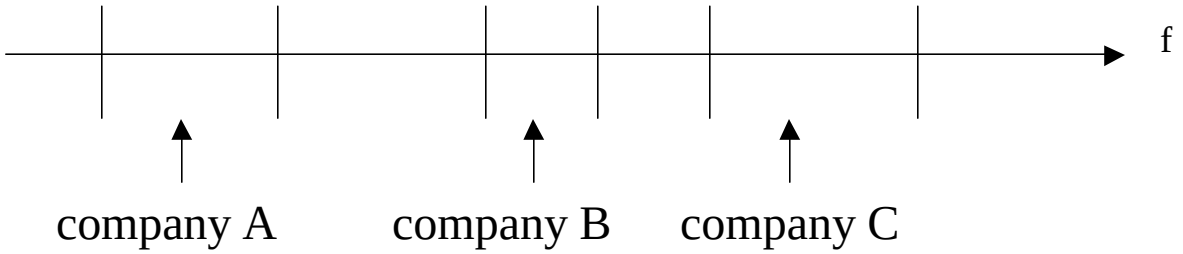


Ultra-wideband DS-CDMA and Wireless Exchange DS-CDMA

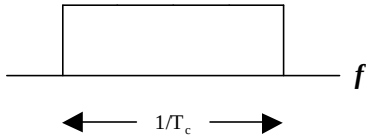
Ultra-wideband DS-CDMA

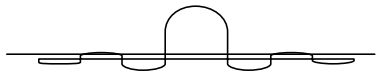


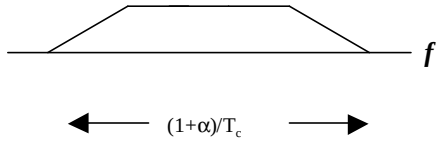
Wireless Exchange DS-CDMA



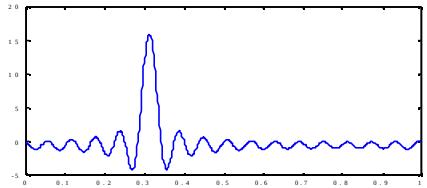
Conventional
DS-CDMA

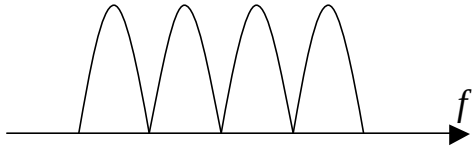




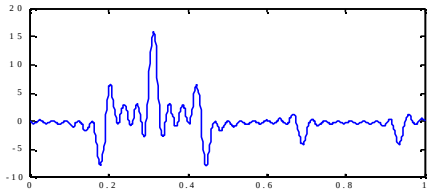


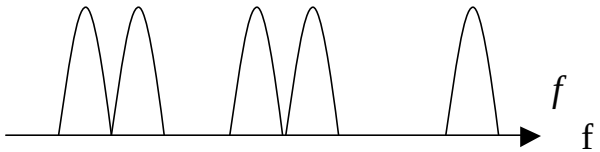
CI/DS-CDMA



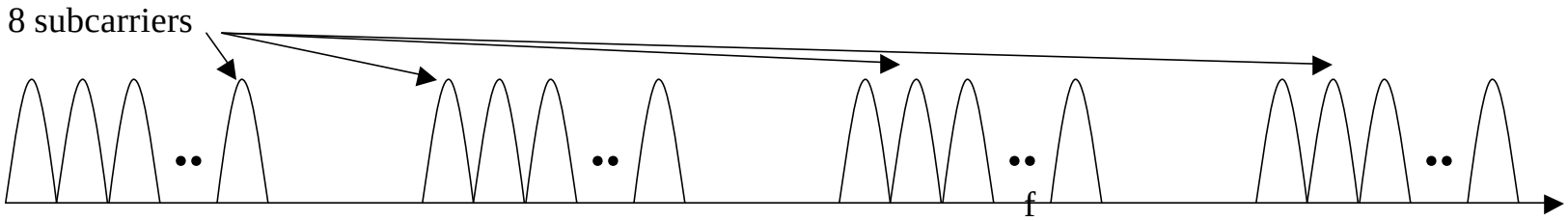


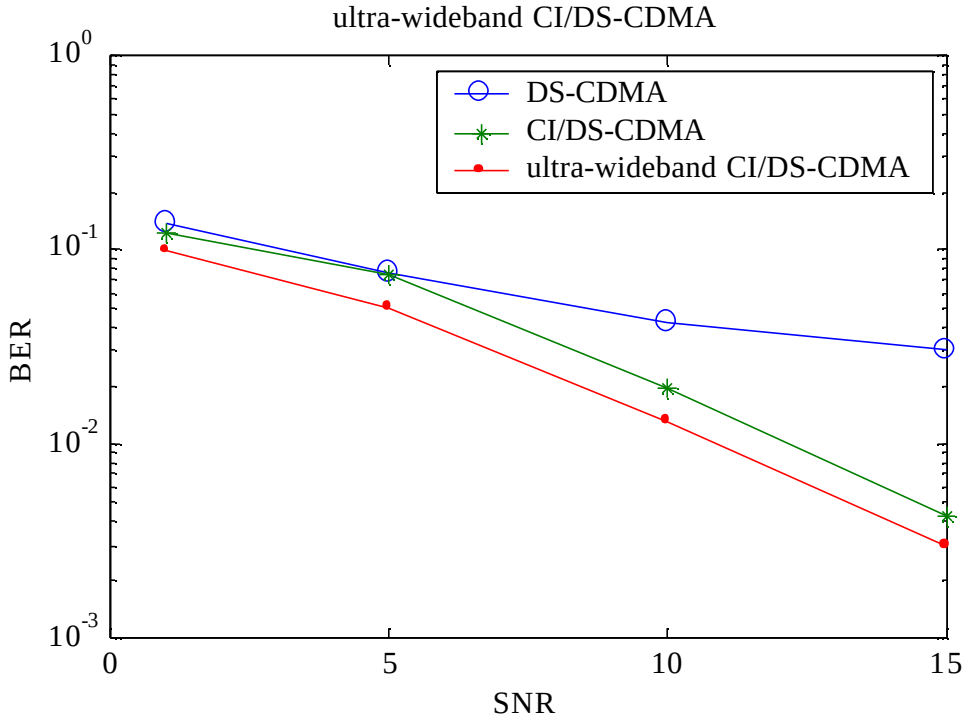
New Idea





Preliminary Results

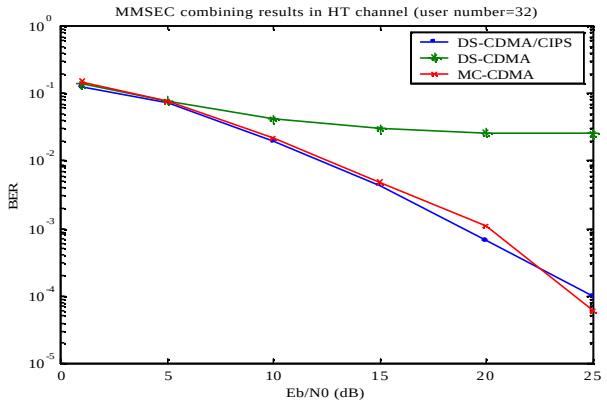




Conclusion

Novel DS-CDMA chip shape

* high performance benefits



*high bandwidth capability