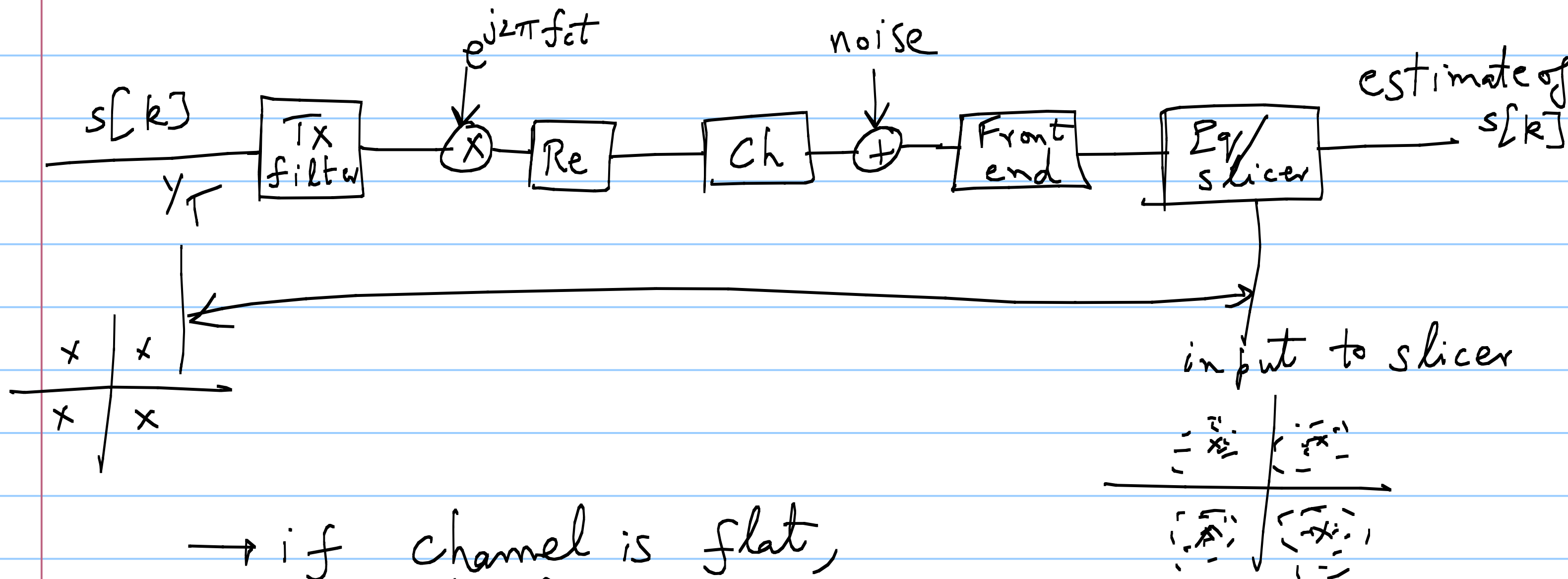
Lecture 39

Note Title 10/28/2008

OFDM:

→ multi-carrier modulation.



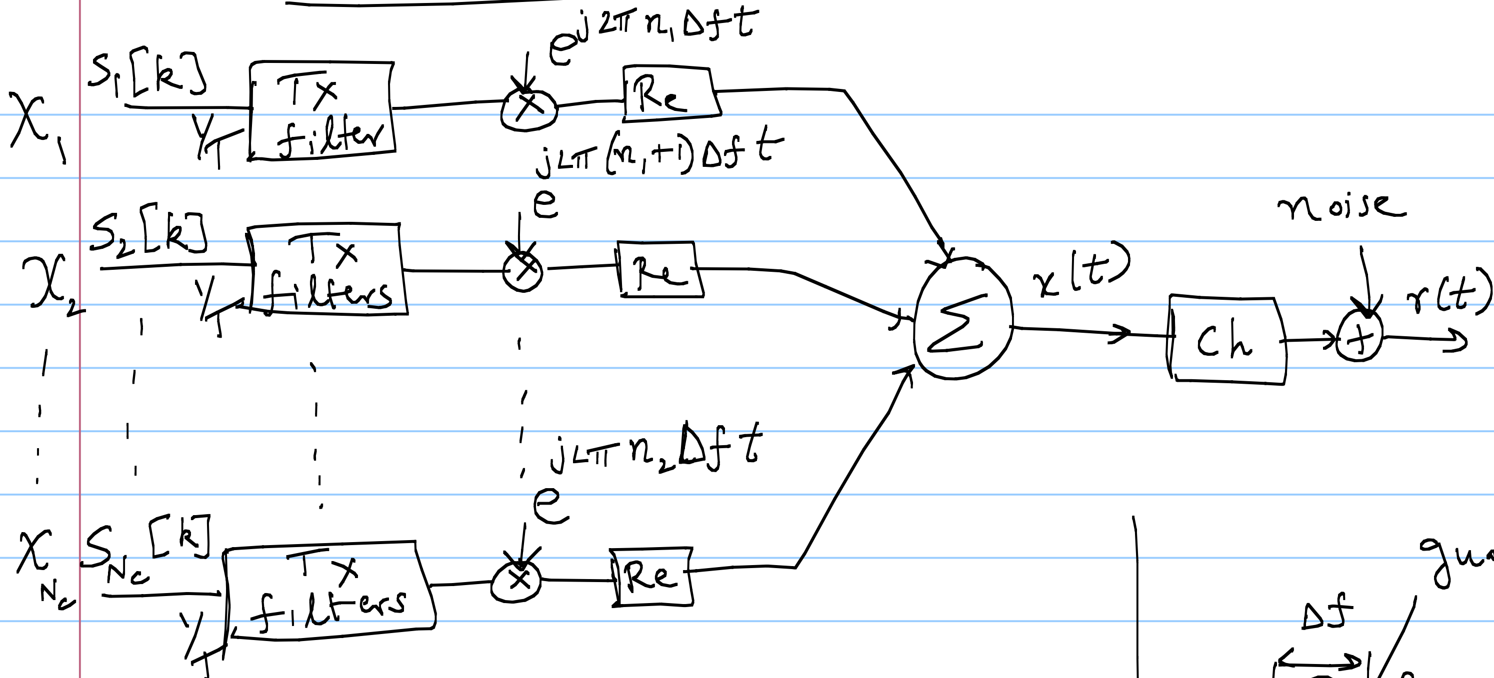
→ if channel is flat, good performance

Towards multiple carriers:

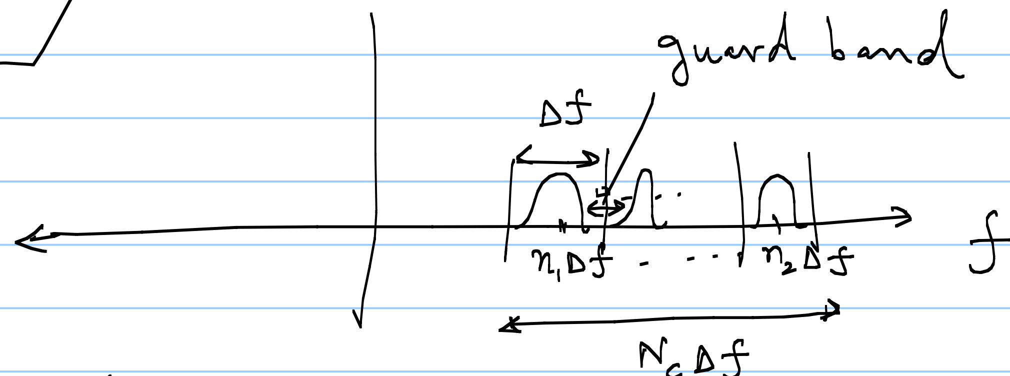
→ channel is flat in a small BW around each carrier

→ better control over sub-bands.

Multi-carrier modulation



$$N_c = n_2 - n_1 + 1$$



Frequency Division Multiplexing:

Treat each channel individually →

symbol rate / carrier $= \frac{1}{T} = f_s \leq \Delta f$

Advantages

1) Simple equalization
2) No noise enhancement
3) immune to time-impulsive distortions
4) Control over power of sub-bands

Disadvantages

1) Guard bands result in wastage of BW.
2) Bank of up-converters and BPFs.

OFDM: best of both worlds!

1) Set $\frac{1}{T} = f_s = \Delta f$

2) Tx filter: rectangular pulse of width $T = 1/\Delta f$

→ Baseband processing to separate carriers.

→ Use FFT/IFFT to simplify Tx/Rx.

IFFT at Tx:

$$x(t) = \mathrm{Re}\left\{ \sum_{i=1}^{N_c} s_i[k]\, e^{j2\pi(n_1+i-1)\Delta f t} \right\}$$

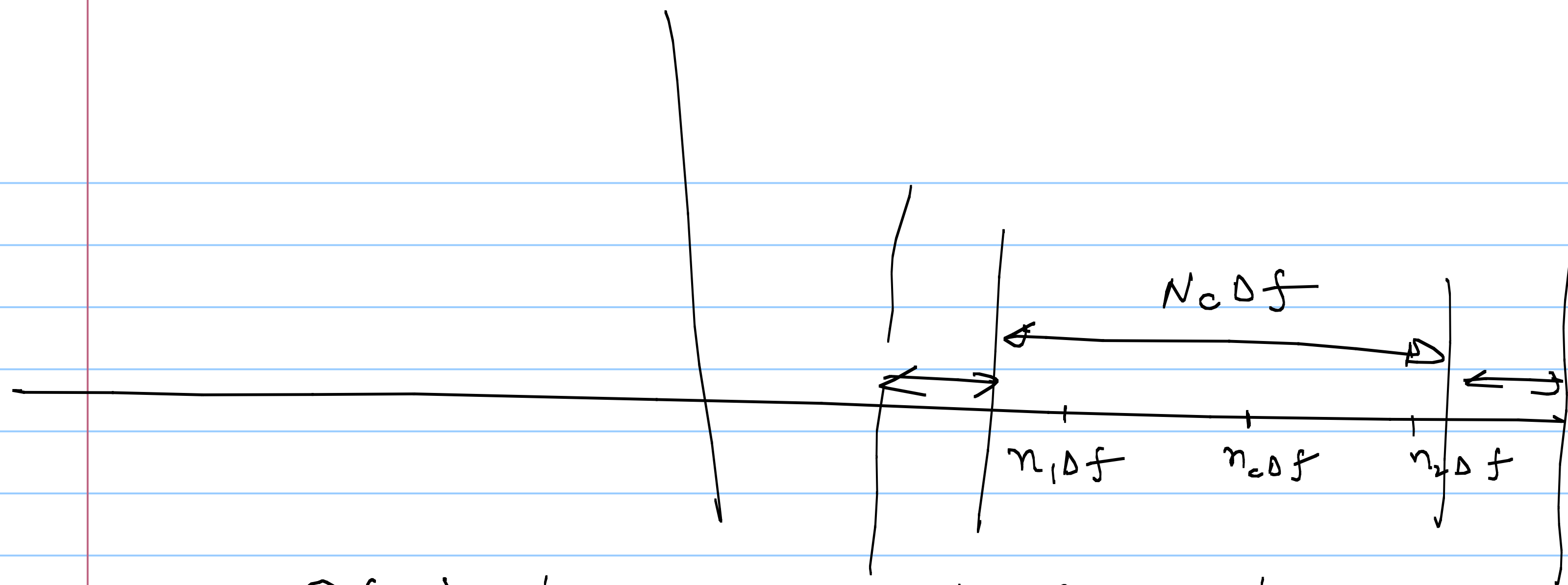
$0 \leq t \leq T = \frac{1}{\Delta f}$

$$= \mathrm{Re}\left\{ e^{j2\pi n_c \Delta f t} \underbrace{\sum_{l=0}^{N_c-1} s_{l+1}[k]\, e^{j2\pi\left(l - \frac{N_c-1}{2}\right)\Delta f t}}_{\tilde{x}(t)} \right\}$$

$\left(n_c = \frac{n_1+n_2}{2} \right)$

$e^{j2\pi n_c \Delta f t}$ → Carrier

$\tilde{x}(t)$ → Complex baseband Signal



$\tilde{x}(t)$ has BW $= \frac{N_c \Delta f}{2}$ + extra sinc lobes

→ Sample $\tilde{x}(t)$ at $N_{tot} \Delta f$ $\quad (N_{tot} > N_c)$

$$\tilde{x}[n] = \tilde{x}(n T_{samp}) = \sum_{l=0}^{N_c - 1} S_{l+1}[k] \, e^{j 2\pi \left(l - \frac{N_c - 1}{2}\right) \frac{n}{N_{tot}}}$$

Set $N_c \overset{?}{\neq} N_{tot} = N$

$$S_\ell[k] = \begin{cases} 0 & \text{for } \ell = n_1 - \Delta_1, \ldots, n_1 - 1 \\ \text{Tx symbols} & \text{for } \ell = n_1, \ldots, n_2 \\ 0 & \text{for } \ell = n_2 + 1, \ldots, n_2 + \Delta_2 \end{cases}$$

$$\tilde{x}[n] = \sum_{\ell=0}^{N-1} S_\ell[k] \, e^{j \frac{2\pi \ell n}{N}}$$

$\downarrow$

IFFT