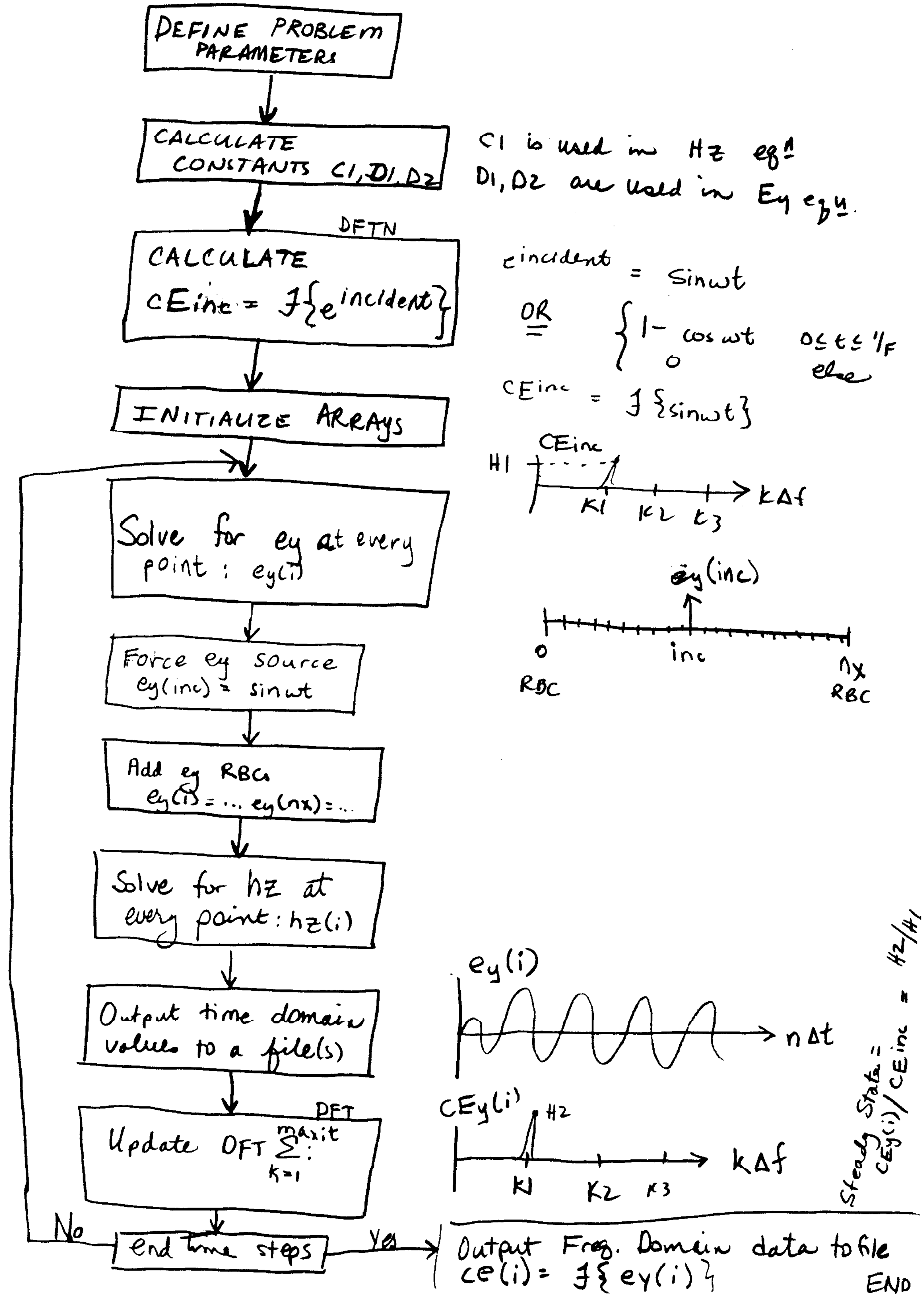
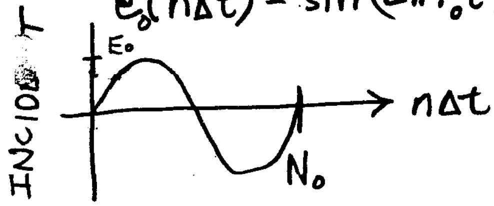
FDTD Flow Chart



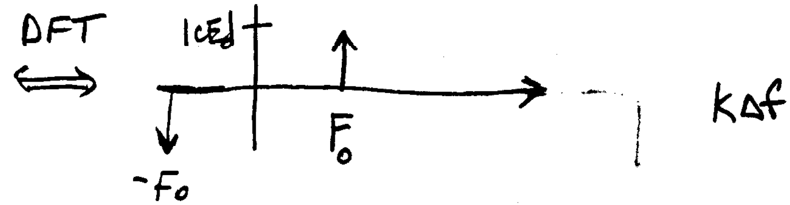
CW EXAMPLE

$e_o(n\Delta t) = \sin(2\pi F_o t)$



DFT $\Longleftrightarrow$

$cE_o(k\Delta f)$



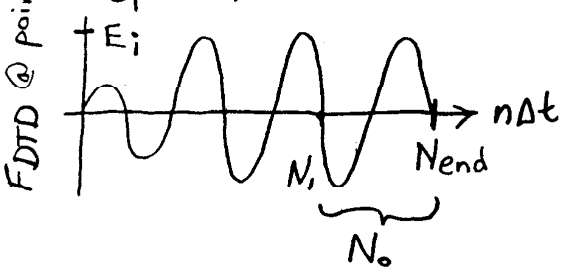
$T_o = 1/F_o \qquad N_o = \frac{T_o}{\Delta t}$

Let $\Delta f = F_o$
$k = 1$

Calculate; $$cE_o(1 * F_o) = \Delta t \sum_{n=0}^{N_o-1} e_o(n\Delta t) \exp\left[\frac{-j2\pi k n}{N_o}\right]$$

$$= |cE_o|\, e^{j\phi_{Eo}}$$

$e_i(n\Delta t)$



$$cE_i(1 * F_o) = \Delta t \sum_{n=N_1}^{Nend-1} e_i(n\Delta t) * \exp\left[\frac{-j2\pi k(n-N_1)}{N_o}\right]$$

$$= |cE_i|\, e^{j\phi_{Ei}}$$

Nend = last FDTD timestep + 1

$N_1 = Nend - N_o + 1$

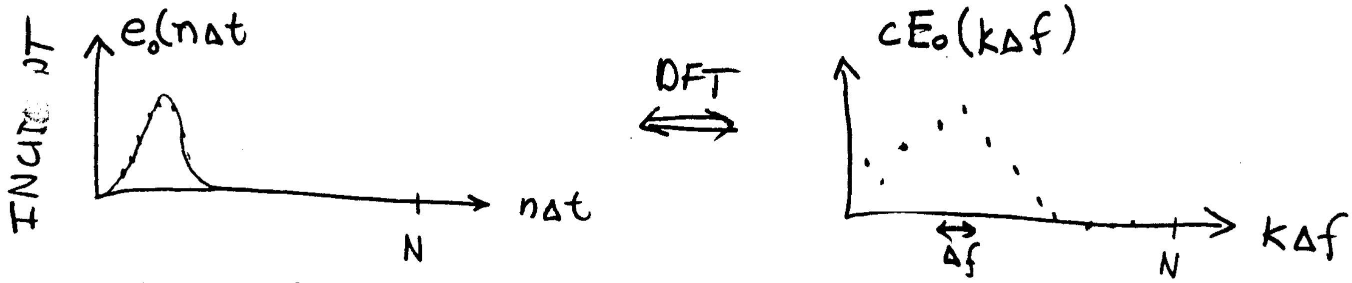
E_i = steady state magnitude of field @ point i $= \left|\frac{cE_i(F_o)}{cE_o(F_o)}\right|$

ϕ_i = steady state phase $= \operatorname{atan}\left[\frac{\operatorname{imag}(cE_i/cE_o)}{\operatorname{real}(cE_i/cE_o)}\right]$

PRACTICAL ASPECTS:

Nyquist criterion requires only 2 samples per cycle. You can desample FDTD data - use only 2 samples per cycle - if you know you have CW data.

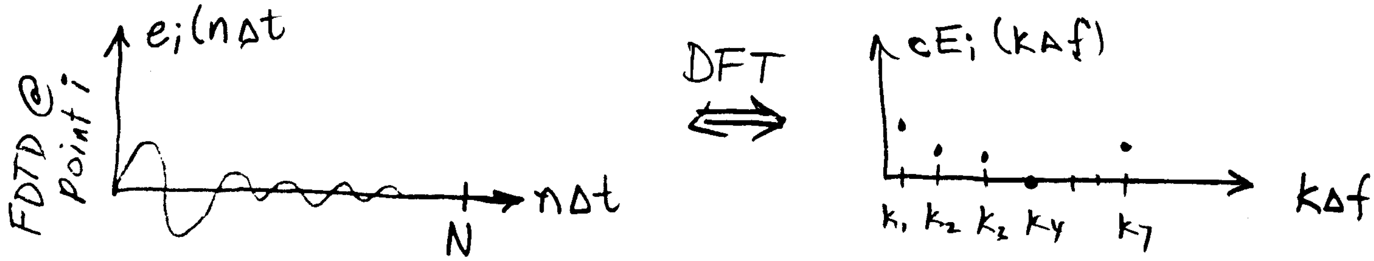
Pulsed Example



Choose Δf, Δt $\Rightarrow$ $N = \dfrac{1}{\Delta f \Delta t}$

For each $k\Delta f$ of interest, calculate

$$cE_o(k\Delta f) = \Delta t \sum_{n=0}^{N-1} e_o(n\Delta t) \exp\left(-j\frac{2\pi k n}{N}\right)$$



$$cE_i(k\Delta f) = \Delta t \sum_{n=0}^{N-1} e_i(n\Delta t) \exp\left(-j\frac{2\pi k n}{N}\right)$$

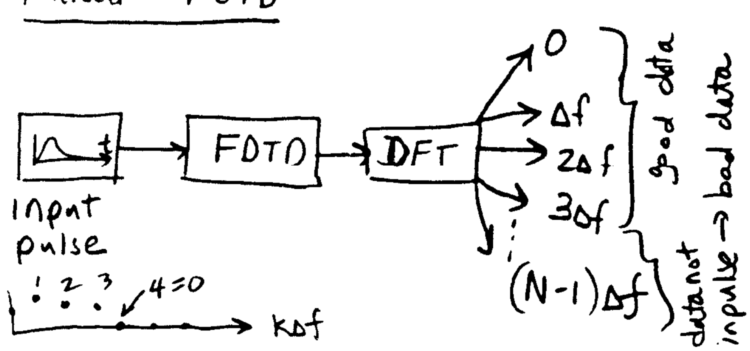
For each k of interest

The output pulse can be assumed to be made up of several frequencies 0, Δf, $2\Delta f$, $3\Delta f$, ... $(N-1)\Delta f$

The steady state value which would be observed if FDTD was run with CW input frequency $k\Delta f$ is:

$$E_i = \left|\frac{cE_i(k\Delta f)}{cE_o(k\Delta f)}\right| \qquad \phi_i = \operatorname{atan}\left[\frac{\operatorname{imag}(cE_i/cE_o)}{\operatorname{real}(cE_i/cE_o)}\right]$$

Pulsed FDTD



CW FDTD