FREQUENCY DOMAIN AND FDTD

WHEN INTERESTED IN RESULTS AT A PARTICULAR FREQUENCY, WE CAN RUN A SIMULATION USING A SINUSOIDAL EXCITATION AT THE FREQUENCY OF INTEREST, OR WE CAN FEED THE SYSTEM WITH AN IMPULSE (APPROXIMATED USING A NARROW GAUSSIAN PULSE) AND THEN CONVERT THE RESULTS TO FREQUENCY DOMAIN AND ANALYZE THE POINT AND FREQUENCY OF INTEREST.

IF WE WANT TO CALCULATE THE FOURIER TRANSFORM OF THE E FIELD $\bar{E}(t)$ AT A FREQUENCY f, WE CAN USE:

$$\bar{E}(f) = \int_0^{t_T} \bar{E}(t) \cdot e^{-j 2\pi f t} \, dt$$

0 ← IMPLYING OUR SIGNALS ARE CAUSAL

REWRITING USING THE FINITE DIFFERENCE APPROXIMATION,

$$\bar{E}(f) = \sum_{i=0}^{n} \bar{E}(i \cdot \Delta t) \, e^{-j 2\pi f (i \, dt)}$$

WHERE n IS OUR CURRENT TIME STEP NUMBER, SEPARATING REAL AND IMAGINARY PARTS,

$$\bar{E}(f) = \sum_{i=0}^{n} \bar{E}(i \, \Delta t) \cdot \cos(2\pi f \, \Delta t \, i) - j \sum_{i=0}^{n} \bar{E}(i \, \Delta t) \sin(2\pi f \, \Delta t \, i)$$

<u>IN TERMS OF COMPUTER CODE</u>, FOR OUR 1D CASE,

```
REAL_PART(m,K) = REAL_PART(m,K) + Ex(K) * COS(2*PI*FREQ(m)*dt*n)
IMAG_PART(m,K) = IMAG_PART(m,K) + Ex(K) * SIN(2*PI*FREQ(m)*dt*n)
```

WHERE

K INDICATES POSITION

m INDICATES INDEX INSIDE FREQUENCY VECTOR FREQ()

<u>AMPLITUDE</u> AND <u>PHASE</u> FOR EACH POINT AND FREQUENCY ARE:

```
AMPLITUDE(m,K) = SQRT(REAL_PART(m,K)^2 + IMAG_PART(m,K)^2)
PHASE(m,K) = ATAN(IMAG_PART(m,K) / REAL_PART(m,K))
```

OR `PHASE(m,K) = ATAN2(IMAG_PART(m,K), REAL_PART(m,K))`