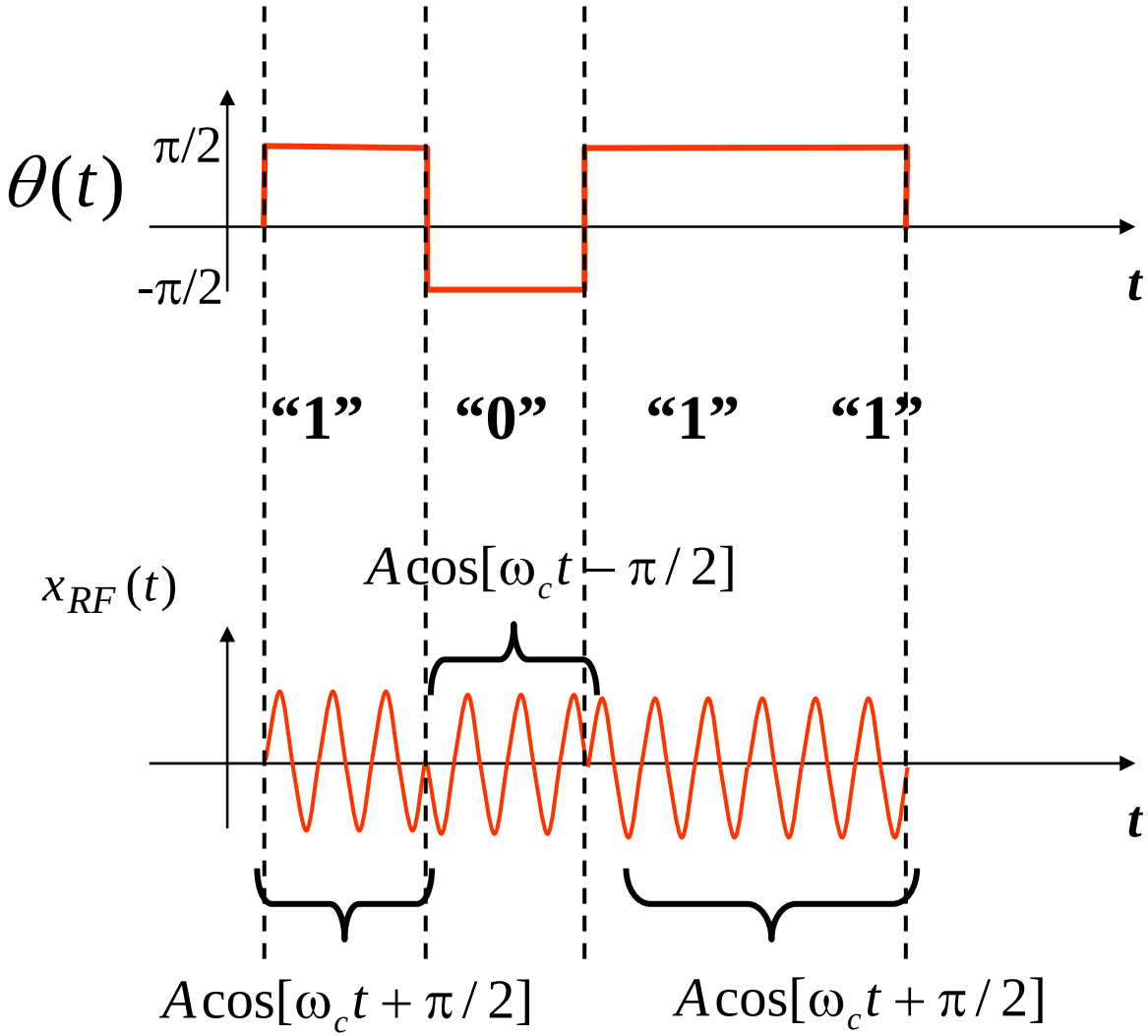
Examples of IQ Signals

Binary Phase Shift Keying (BPSK)

$$x_{RF}(t) = A\cos(\omega_c t + \theta(t))$$



Binary Phase Shift Keying (Cont.)

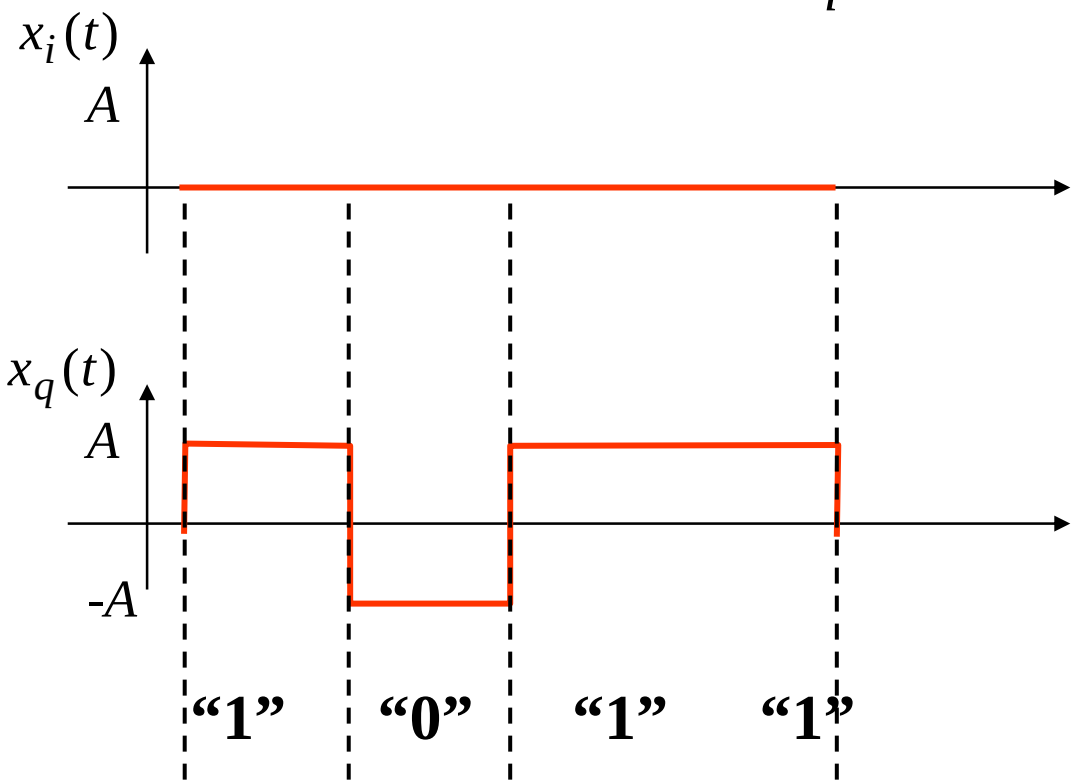
What is the LPE signal for BPSK?

Applying the General Result to BPSK gives:

$$x_l(t) = x_i(t) + jx_q(t)$$

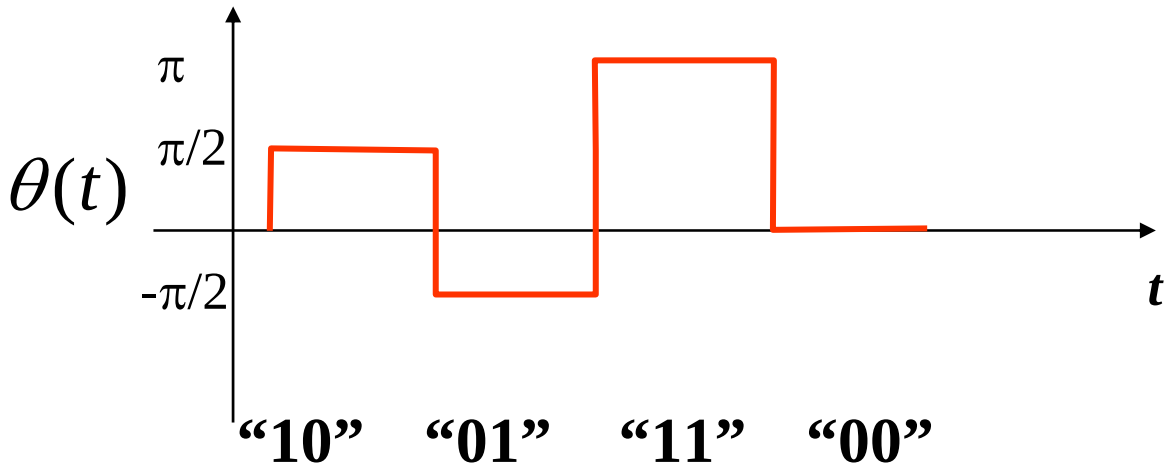
$$x_i(t) = A\cos[\theta(t)]$$

$$x_q(t) = A\sin[\theta(t)]$$

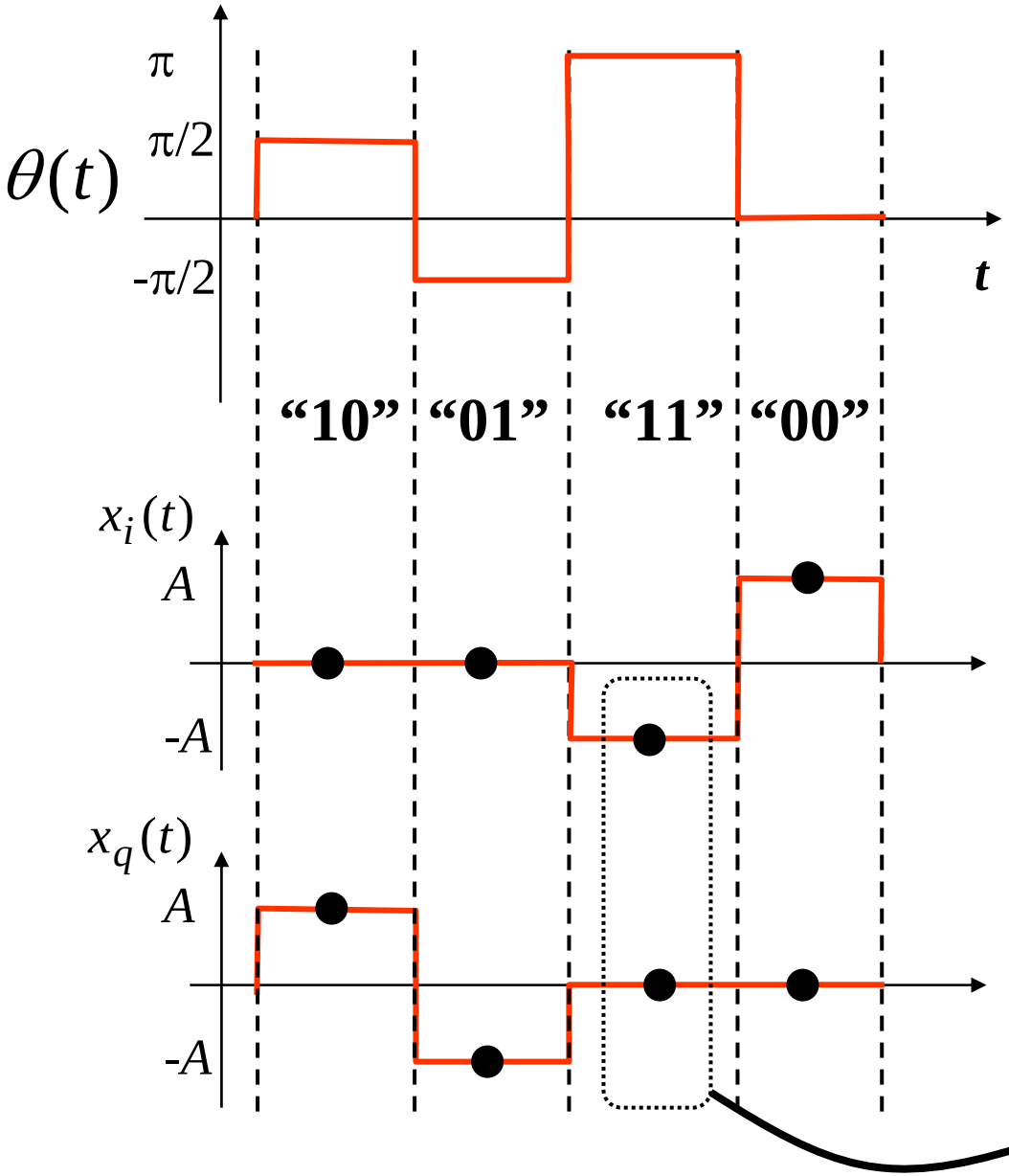


Quad Phase Shift Keying (QPSK)

$$x_{RF}(t) = A\cos(\omega_c t + \theta(t))$$



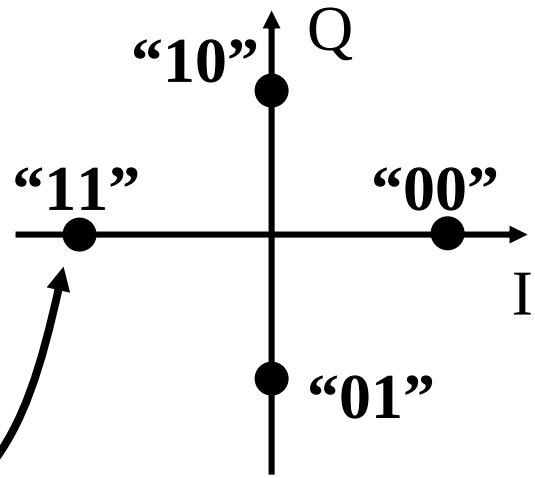
Quad Phase Shift Keying (cont.)



$$x_i(t) = A\cos[\theta(t)]$$

$$x_q(t) = A\sin[\theta(t)]$$

"Signal Constellation"



Radar Pulse Train - Linear FM

Most radars use signals that are trains of pulses.
Those pulses have a carrier frequency that also has frequency modulation imparted on it – and often the frequency is varied linearly with time (during the pulse).

$$x(t) = A(t)\cos[\omega_c t + \theta(t)]$$

$$\omega_i(t) = \frac{d}{dt}[\omega_c t + \theta(t)]$$

$$= \omega_c + \frac{d}{dt}\theta(t)$$

Sinusoid with:

- **Carrier Frequency ω_c**
- **Time-Varying Phase $\theta(t)$**

Gives Inst. Frequency of:

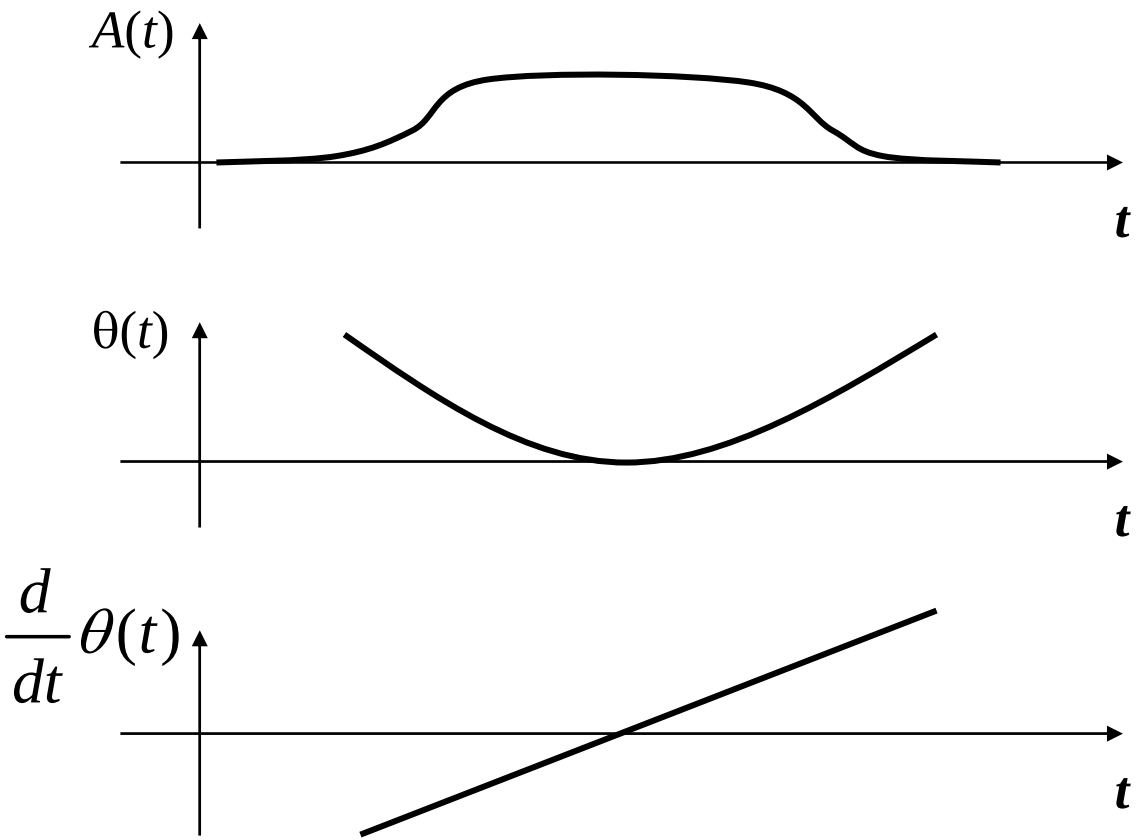
- **Center ω_c**
- **Frequency Deviation $\frac{d}{dt}\theta(t)$**

Want this to vary linearly

Radar Pulse Train - Linear FM (cont.)

To get a linear variation of the frequency we need a quadratic variation of the phase:

$$x(t) = A(t)\cos[\omega_c t + \theta(t)]$$

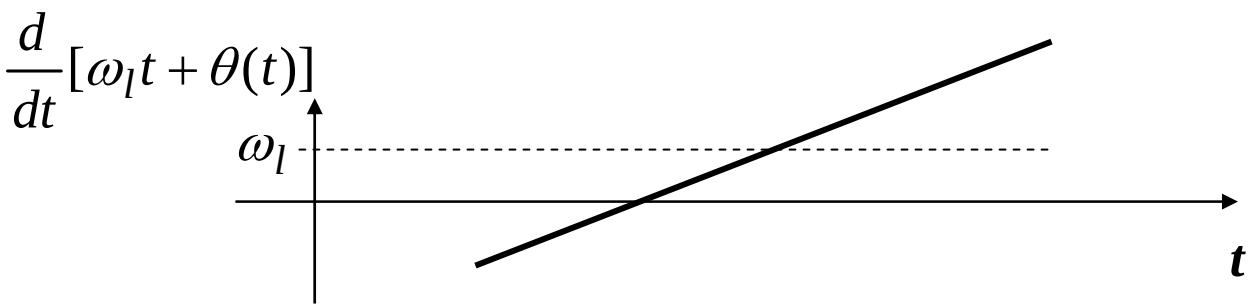


Radar Pulse Train - Linear FM (cont.)

The LPE Signal for the radar signal is:

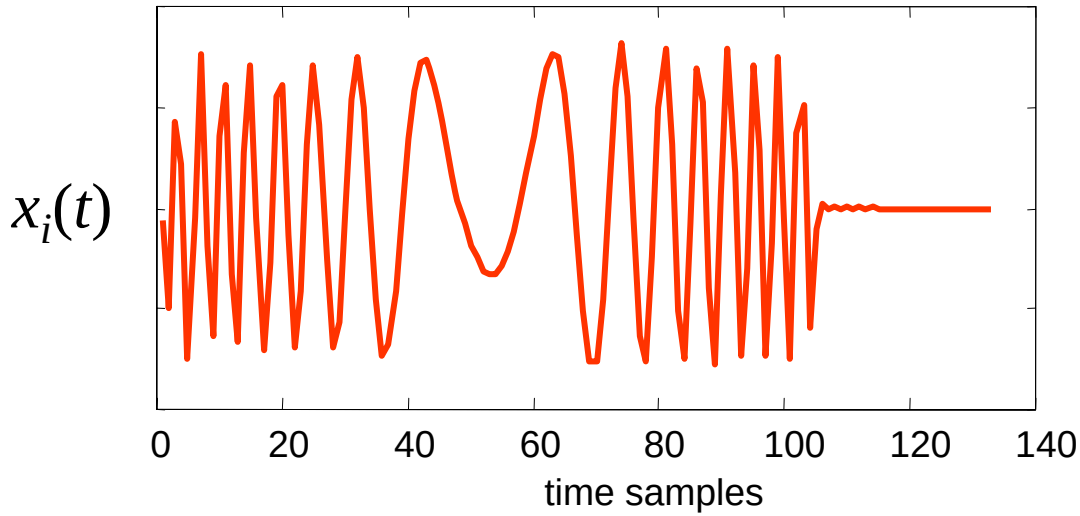
$$x_l(t) = A(t)e^{j[\omega_l t+\theta(t)]}$$
$$= \underbrace{A(t)\cos[\omega_l t + \theta(t)]}_{x_i(t)} + j\underbrace{A(t)\sin[\omega_l t + \theta(t)]}_{x_q(t)}$$

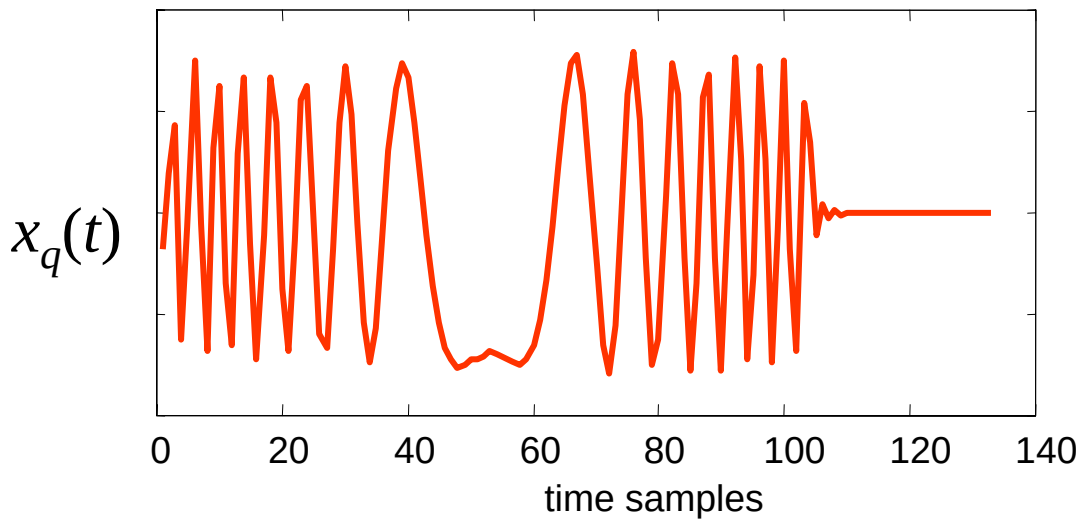
Small Value: Due to Uncertain Knowledge of ω_c



Radar Pulse Train - Linear FM (cont.)

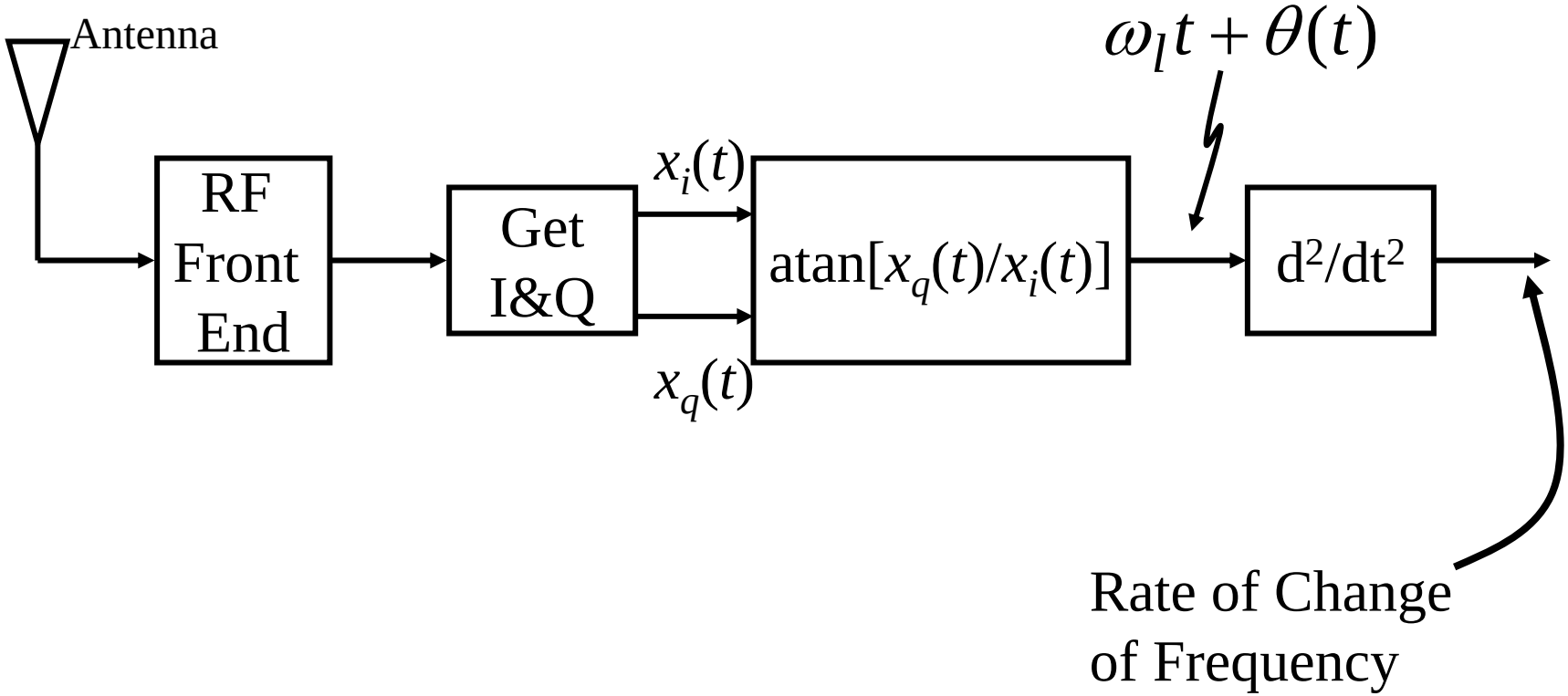
The IQ parts of Linear FM Radar Pulse:





Radar Pulse Train - Linear FM (cont.)

Say you intercepted a radar signal and want to measure its modulation rate (i.e rate of frequency change). You could do it like this:

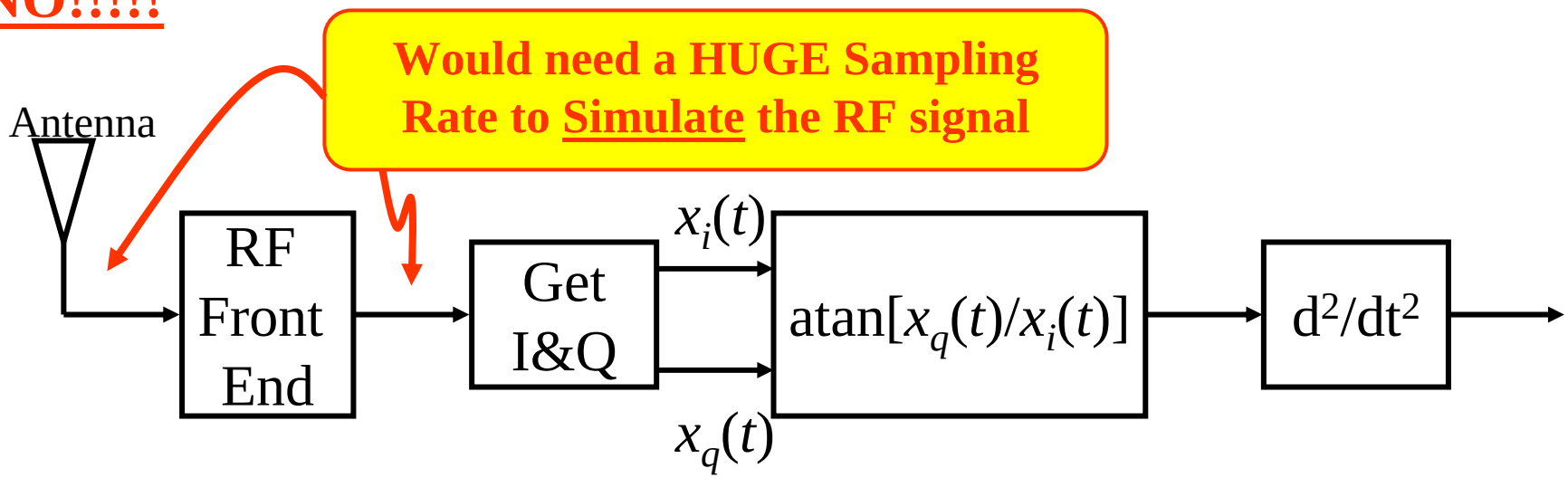


Radar Pulse Train - Linear FM (cont.)

Say you wanted to simulate this freq-rate-measurement processing to test how well it works…. How would you write code???

Would you need to simulate the RF signal and the RF Front-End?

NO!!!!!



Simulate using this: