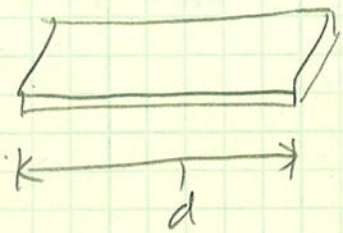
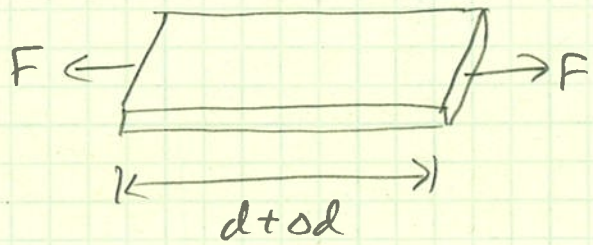
SAW Sensor Applications

1) SAW Strain Sensor

No strain



With strain (tensile)



strain $= \varepsilon = \frac{\Delta d}{d}$

$\tau_0 = \frac{d}{V}$ → time delay without strain

for f = RF frequency, phase delay = ϕ

where $\phi = 360^\circ \frac{\tau_0}{T} = 360^\circ \tau_0 f = 360^\circ \frac{df}{V}$ → no strain

with strain : $\varepsilon \neq 0$

$$\phi = 360^\circ \frac{(d+\Delta d) f}{V} > 0$$

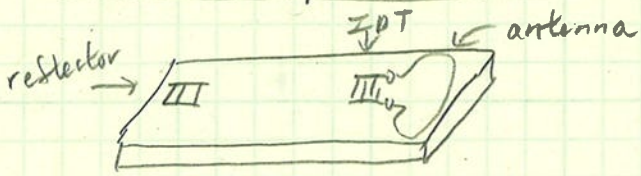
let $\Delta\phi = 360^\circ \frac{\Delta d f}{V} = 360^\circ \frac{\varepsilon d f}{V}$

This assumes that the acoustic wave velocity does not change due to the strain

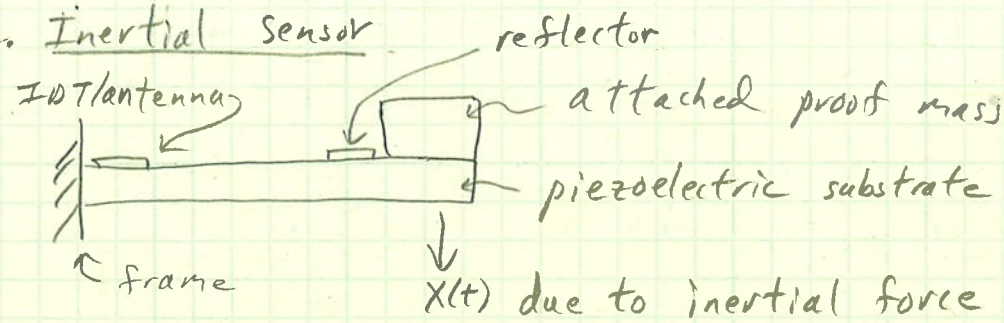
a. Compressive Strain

$\varepsilon < 0 \rightarrow \Delta\phi < 0$

b. Wireless implementation



2. <u>Inertial Sensor</u>



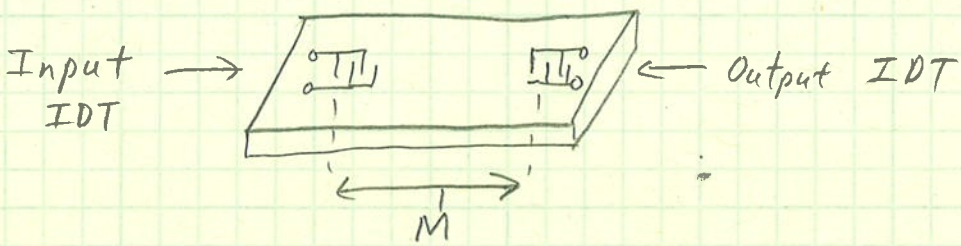
X(t) induces strain in substrate : $\varepsilon(t)$

$$\Delta\phi = \frac{360^\circ d f}{V}\,\varepsilon(t)$$

wireless sensor can detect translational acceleration or vibration (or anything causing motion in x-direction)

3. <u>Temperature Sensor</u>

Acoustic wave velocity, V, is dependent on temperature



time delay $= \tau_0 = \frac{M}{V} = \frac{M}{V(T)}$ where $T \equiv$ temperature

modeling τ_D as a $f(T)$

$$\tau_D(T) = \tau_{D_0}\left[1 + \alpha(T - T_0)\right]$$

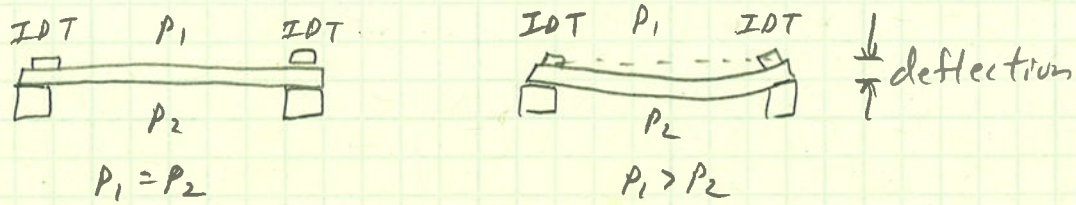
where T_0 is a reference temperature

and α is a substrate dependent temperature coefficient of time delay

Example: for YZ-cut lithium niobate, $\alpha = 94 \times 10^{-6}\ /^\circ C$

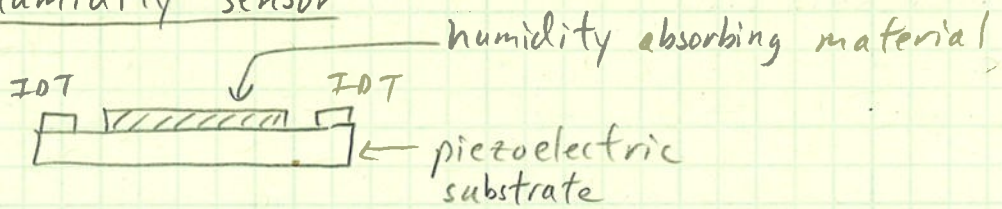
4. Pressure Sensor

→ Use a piezoelectric material as the pressure sensing diaphragm



Pressure difference deflects (strains: $\varepsilon > 0$) piezoelectric substrate : $\Delta\phi = 360^\circ \frac{\varepsilon d f}{V}$

5. Humidity Sensor



The SAW substrate has an area where a humidity (moisture) absorbing material is deposited as a thin layer.

→ As the material absorbs moisture, it swells, straining the SAW substrate : $\varepsilon > 0$

$$\therefore \phi = 360^\circ \frac{\varepsilon d f}{V}$$