Might you consider to me, in writing by dead regular.

I'm still here for your class.

Replace as I find it better.

Resistors - applications: gyro, accelerometers, (seshin), E, time (8), 63, 63, 63 filters (Nguyen)

Limits:
- Paschen Curve
- Electrostatic instability
- Pull-in
- Comb instability

Why does the air break down? Between insulator electrons pick up enough KE to dislodge.

Prob ionization > Prob attachment.

Paschen

200-300V

Paschen Curve

Paschen Curve

"breakdown"

Neon bulbs

Fluorescent lights

Plasma etch, dep

Paschen Curve

$V_{BD} = \frac{3\text{MV}}{m} = \frac{3\text{V}}{\mu\text{m}}$

Paschen Curve

$V_{BD} = \frac{16\text{V}}{m}$

Paschen Curve

$V_{BD} = \frac{1\text{V}}{\mu\text{m}}$

Paschen Curve

Paschen Curve

why about 2nm? $V_{BD} \gg 300\text{V}$, right?

Yes, 52

7nm

other field lines

impact ionization

Oxide breakdown

$E_{BD, \text{SiO}_2} = (0.1-1) \frac{10}{\mu\text{m}}$
Pull-in Example: relays

-v2
\[ V_{PD} \]
\[ V_D \]
\[ V_{DO} \]
\[ R \]
\[ g \]
\[ g_0 \]
\[ g_f \]
\[ V_{PD} = \frac{P_{relay}}{R + R_{relay}} \]

Inverter
\[ V_i \]
\[ V_o \]
Truth table

Also stores stable information (1st)

If \( V = V_{\text{mid}} \), output depends on previous input!

Model

\[ F = K(g_0 - g) \]

\[ F_e = -\frac{1}{2} \epsilon_0 \frac{V^2 A}{g^2} \]

\[ F_K = \frac{F_e}{K} \]

\[ V = 0 \]

\[ F_{net} = F_K = K(g_0 - g) \]

For \( V_i \) and \( V_o \), 2 equilibria, 1 stable, 1 unstable.

For \( V_o \), no equilibrium.

Will pull in if pulled closer though.
$g^*$ stable iff \( \frac{df}{dg} \bigg|_{g^*} < 0 \)

Find \( V_{P2} \), where \( \frac{df}{dg} \bigg|_{g^*} = 0 \)

and \( g_{P1} = g^* \) at that \( V_{P1} \)

Equilibrium implies \( F_{rel} = 0 \) at \( g^*_0 = g_{P1} \)

\[
K(g_0 - g^*_0) = \frac{1}{2} \epsilon_0 V_{P1}^2 \frac{A}{g_{P1}^2}
\]

Second order

\[
K(g_0 - g_{ex}) V_{P1} = \sqrt{K \left( \frac{2}{3} g_0 \right)^3} = \sqrt{\frac{2}{27} \frac{K g_0^2}{\epsilon_0}}
\]

4th order non-linear ODE

no simple solution

\[
EI \frac{d^4q(x)}{dx^4} = \frac{1}{2} \epsilon_0 V^2 w \frac{1}{g(x)^2}
\]

\[
V_{P1}^2 = \frac{0.28 \epsilon_0 g_0^3}{E L^4 (1 + 0.42 \frac{g}{L})^2}
\]

\( \frac{1}{2} \epsilon_0 V_{P1}^2 \frac{A}{g_{P1}^2} \) Osterberg

\( \frac{1}{2} \epsilon_0 V_{P1}^2 \frac{A}{g_{P1}^2} \) Dirichlet pull-in

Pull-out (release)

At pull-in \( K(g_0 - \frac{2}{3} g_0) = \frac{1}{2} \epsilon_0 V_{P1}^2 \frac{A}{g_{P1}^2} \)

At pull-out \( K(g_0 - g_f) = \frac{1}{2} \epsilon_0 V_{P0}^2 \frac{A}{g_f^2} \)

solve for \( V_{P0} \)