Notes on PA Design

Memory effect → Electrical → non-constant distortion behavior at different modulation frequencies (tone spacing) is called as electrical memory.

→ Thermal → Low freq envelope of signal heats up substrate and affects wafer / transistor properties for incoming signal.

→ Trapping effect → (related to semiconductor)

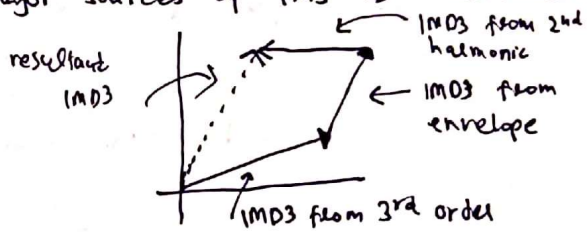
Electrical Memory

- IM3 are produced through → 3rd order distortion ($3a^2b$, $3ab^2$)
  → 2nd order interaction
  - ↙ Beat ($\omega_2-\omega_1$ with $2\omega_1/2\omega_2$)
  - ↘ 2nd harmonic ($2\omega_1/2\omega_2$ with ω_1/ω_2)

- An amplifier has many internal nodes which can generate higher order terms. ∴ it is not sufficient to model through one polynomial from input to output.

  For example, BJT r_π is one poly and r_o is one polynomial. Overall you can say response is cascade of two polys which which will have 3 major sources of IM3 as mentioned above.

  → Usually 2nd harm IMD3 has 180° phase because $2\omega_1-\omega_2$ / $2\omega_2-\omega_1$ of this negative signs. (negative of two tones) needed to generate IM3

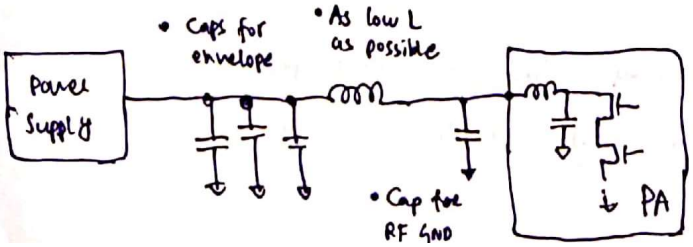


- Problem is not that there are additional IM3 sources. Problem is that 2nd harmonic or beat impedance behavior with frequency is poorly controlled. ∴ different tone spacings dont generate ~~different~~ same magnitude of IM3s.

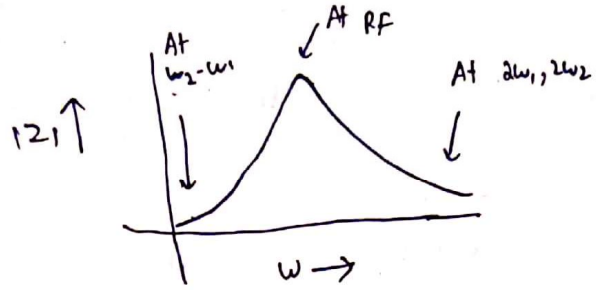
- Non-linearities can be considered as current sources, and voltage they produce depend on node impedances.

- Memory effect is solved to the first order by providing fixed impedance. However, that is still an issue for beat / envelope because that current has to come from relatively remote power supply as you cannot provide big enough cap for KHz-MHz envelopes to provide current. Therefore, there are inductances and resistances which create voltage drop depending on envelop variation. ∴ V_{DD} that PA gets is not constant and has ripples which produces IM3s. ∴

  → Goal is to provide fixed and very low impedance

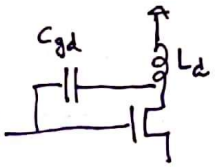


Bias network impedance Response



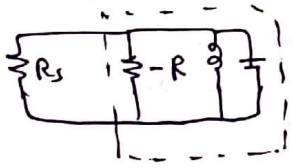
- This is how we should optimize bias network impedance.

⇒ low impedance at $\omega_2-\omega_1$ requires use of small series inductors which creat stability issues by presenting negative resistance at input.



→ C_{gd} transforms L_d to negative R. Y_{in} from $C_{gd} \approx C_{gd}(1+A) \approx j\omega C(1+g_m j\omega L)$
$\approx -\omega^2 g_m C_{gd} L_d$

→ Low freq, small −R in shunt → more dangerous



→ will oscillate if ~~$R_s < R$~~ R

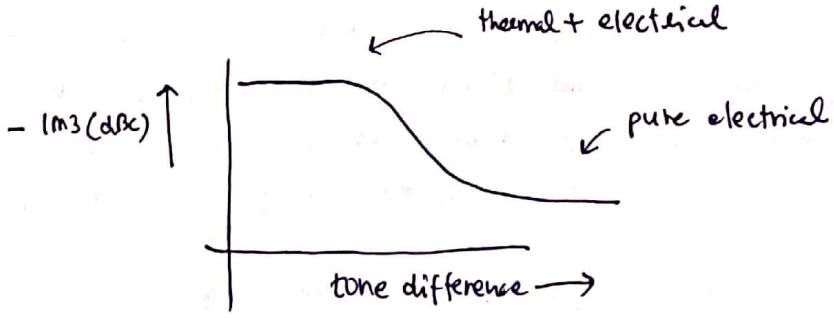
$\therefore \frac{-R_s R}{R_s - R}$ → −ive if $R_s > R$

⇒ Shaping 2nd harmonic may be desireable / undesirable depending upon waveform engineering.

Why memory effect is bad?

- c2 it may create assymetric IMD responses
- distortion depends on signal BW ∴ varies signal to signal

- Because memory-less predistortion becomes ineffective



- At high f, wafer does not get sufficient time ↑ heat up.
  ∴ Thermal memory effect is visible at low f only.