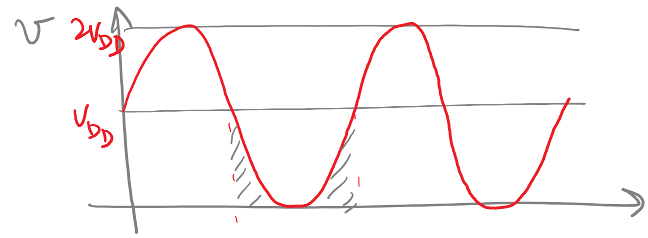
ECE 513 - Lecture 29.

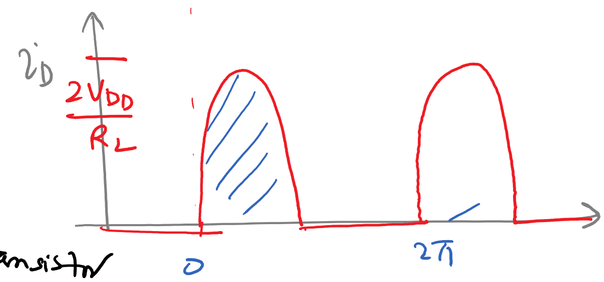
Tuesday, December 4, 2018 1:56 PM

Class - B

→ conduction angle $\theta = \pi$



* transistor conducts only half the period of fundamental frequency.
  - ↳ Bias V_{GS} such that the transistor is at the edge of cutoff s.t. $\theta = \pi$



⇒ The peak current in the load is still the same as class A ⇒ $\frac{2V_{DD}}{R}$

↳ power consumption is reduced compared to Class-A PA.

* g_m & the power gain is reduced to half w.r.t class-A
  ↳ − 6 dB

* The PA becomes non-linear

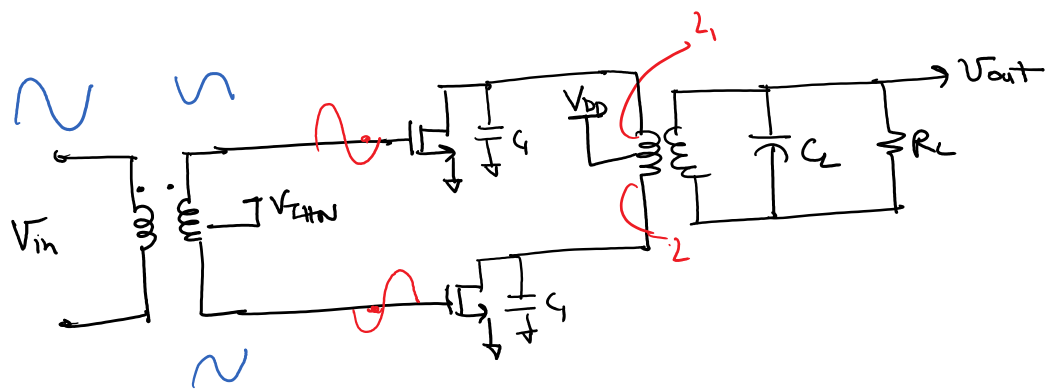
* A higher voltage swing is required for the same output power as class-A.

Average or DC current $\theta = \omega t$

$$I_{DC} = -\frac{I_{max}}{2\pi}\int_{\pi}^{2\pi} \sin\theta \, d\theta = \frac{I_{max}}{\pi} = \frac{2V_{DD}}{\pi R_L}$$

$$\eta_{drain} = \frac{P_L}{P_{DC}} = \frac{V_1 \cdot I_1}{2 I_{DC} V_{DD}} = \frac{V_{DD} \cdot \frac{I_{max}}{2}}{\frac{2V_{DD}}{\pi} I_{max}} = \frac{\pi}{4} = 78.5\%$$

Push pull class-B PA :



Balun

$\theta = \pi$

Class-C → $\theta < \pi$

* A significant contributor to the nonlinearity of Class B stage is the C_{gs}, which varies significantly when the transistor is driven into the cutoff region.
  - ↳ This leads to deviation from the 50% duty cycle
    - ↳ degrades the overall efficiency
      - ↳ One technique to reduce this nonlinearity is to place a short circuit at 2nd harmonic.

Class- AB :

* workhorse of the linear PA industry
  - ↳ Compromise between the efficiency of class-B and linearity of Class-A operation.

$\theta > \pi$

↳ θ depends upon the biasing condition

↳ experimentally determined as a sweet spot at which the g_m of a FET is $\frac{1}{2}$ of the peak-g_m of the transistor.

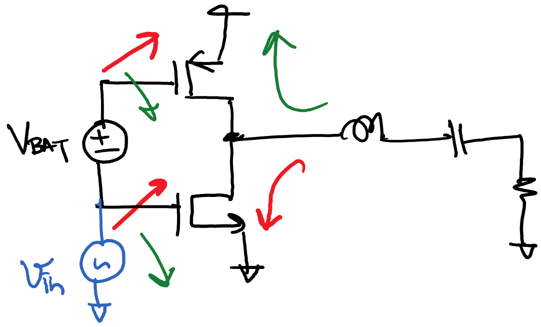
$\theta = \omega t$

$\theta_{off} = 2\pi - \theta$

$$
* \; i_D(t) = \begin{cases} I_{DC} + I_p \sin(\omega t), & \omega t < \frac{3\pi}{2} - \frac{\theta_{off}}{2} \\ 0, & \frac{3\pi}{2} - \frac{\theta_{off}}{2} \le \omega t \le \frac{3\pi}{2} + \frac{\theta_{off}}{2} \\ I_{DC} + I_p \sin(\omega t), & \omega t \ge \frac{3\pi}{2} + \frac{\theta_{off}}{2} \end{cases}
$$

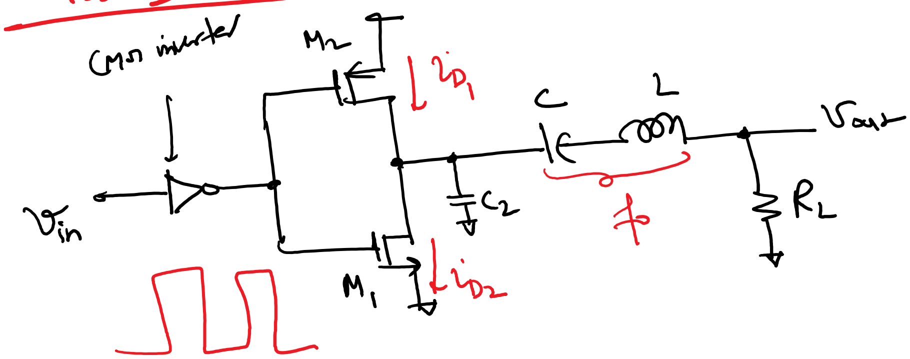
$$
\eta_{drain} = \frac{1}{2} \, \frac{1 - \frac{1}{2\pi}\left(\theta_{off} - \sin(\theta_{off})\right)}{\cos\left(\frac{\theta_{off}}{2}\right) + \frac{1}{\pi}\left\{\sin\left(\frac{\theta_{off}}{2} - \frac{\theta_{off}}{2}\cos\left(\frac{\theta_{off}}{2}\right)\right)\right\}} \cdot \left(\frac{V_{DD} - V_{in}}{V_{DD}}\right)
$$

Class AB is mostly used in push-pull configuration

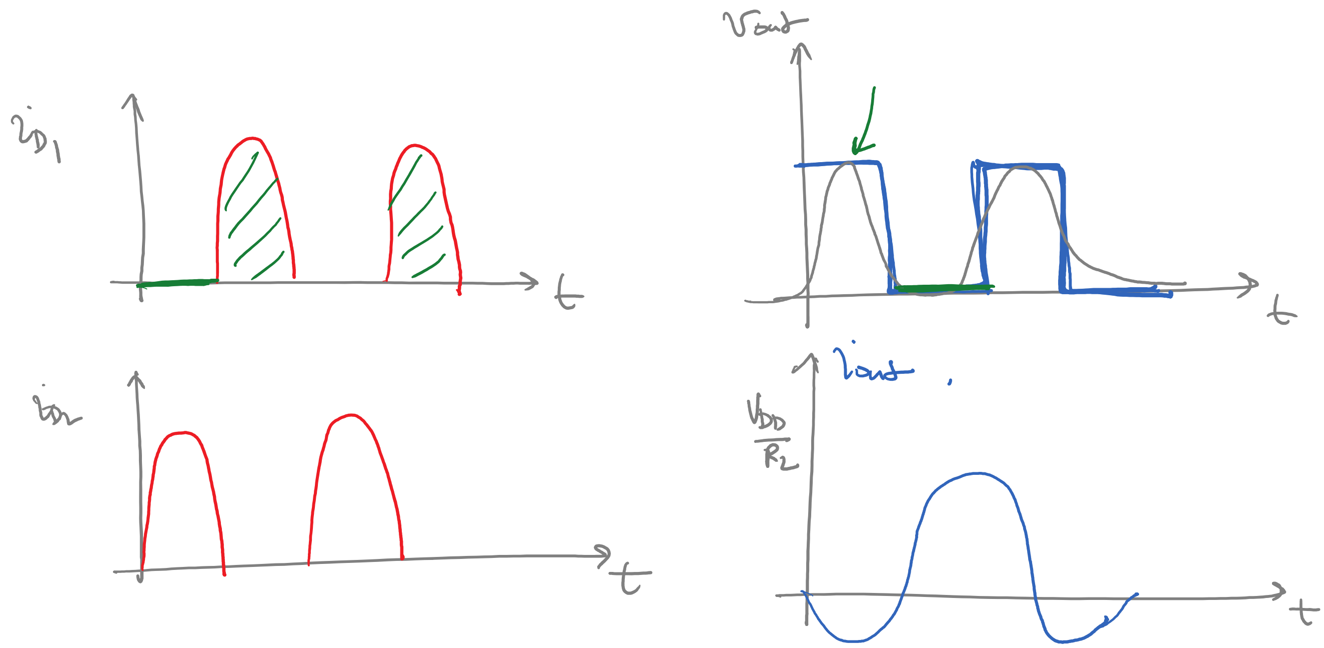

VBAT
Vin

Switching PAs:

Class-D PA



Current is pulled from V_{DD} through M_2

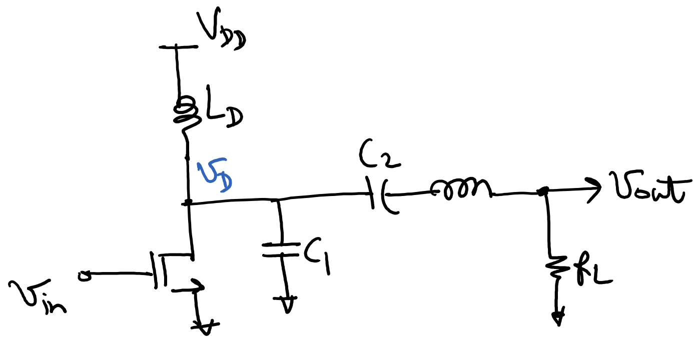


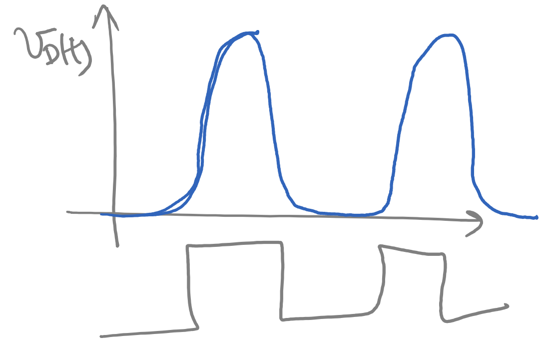
more suitable for frequencies $f_{RF} \ll f_T$ or f_{max}

2GHz $f_T > 100$ GHz

60GHz

Class-E:



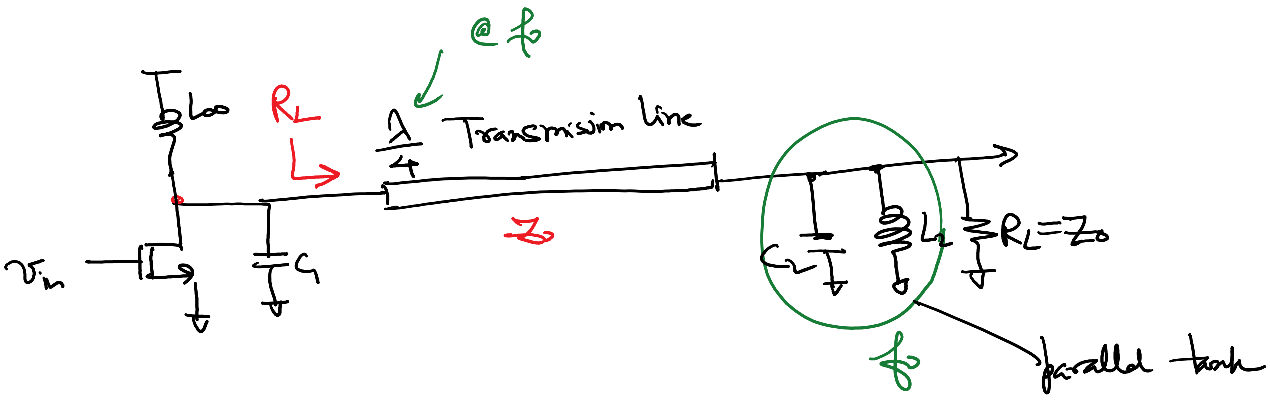


* Not only the drain switch voltage is $v_D = 0$ when the current is flowing but also $\frac{d}{dt} v_D(t) = 0$

↳ makes PA operation relatively insensitive to the rise time of the input signal

↳ the higher efficiency obtained is accompanied by a very strong nonlinearity

Class- F.



$Z_L(f_0) = R_L$

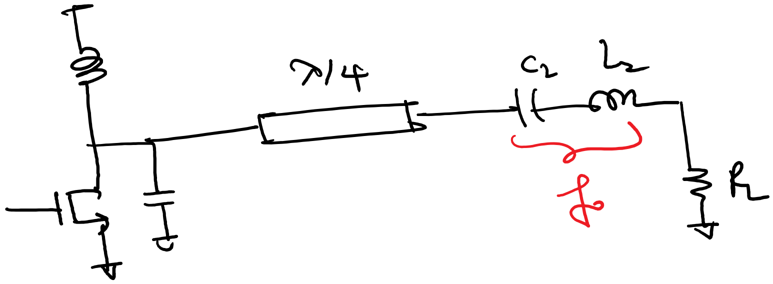
even harmonics $Z_L(2kf_0) = 0$

odd harmonics $Z_L((2k+1)f_0) = \infty$

* If the first three harmonics are terminated
↳ 81 %

If the first 5 harmonics are terminated
↳ 90% efficiency

Class F^{-1}:



* Switch is biased at JFET