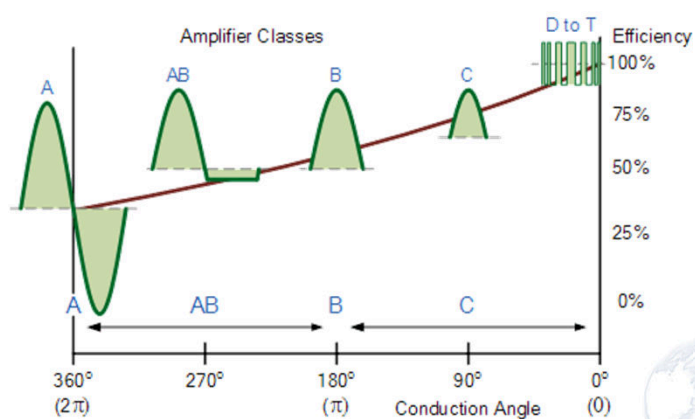


# Lecture 13: RF Power Amplifiers

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EE423: Communication Electronics

## Amplifier Classes



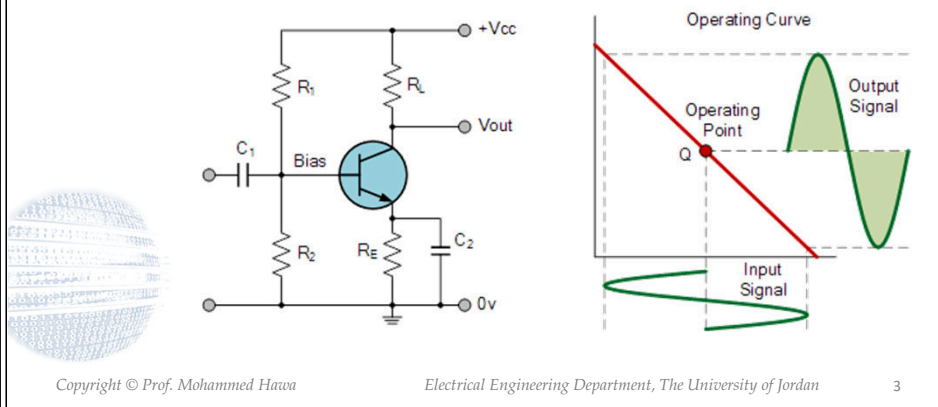
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## Class-A Amplifier

- Works only in linear region (avoids saturation region). Amplifier operates in full 360° conduction (i.e., always conducting).

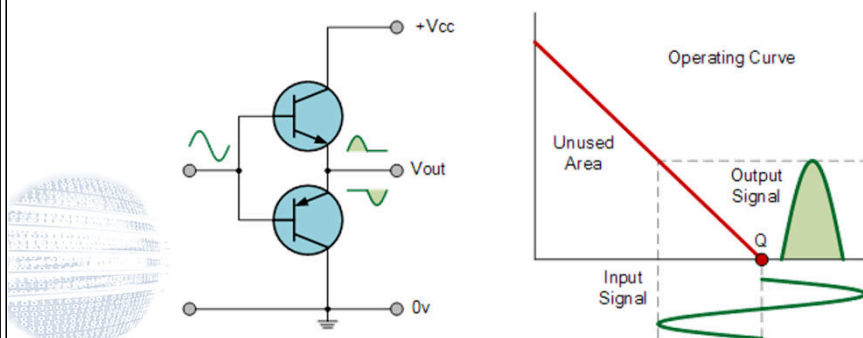


## Class-A Amplifier

- Provides very good linear performance (no distortion in output signal).
- Used in low-noise amplifiers (LNAs) and other small-signal amplifiers when linearity and low distortion are needed.
- Low efficiency: typically less than 50% power efficiency for the amplifier's transistor (rest is dissipated as heat). This is because transistor is always conducting, hence, always dissipating heat.

## Class-B Amplifier

- Only half (i.e.  $180^\circ$ ) of active devices' conduction angle is used.
- Achieved by moving biasing point.



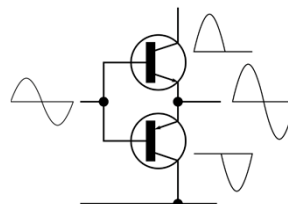
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## Push-Pull Amplifier

- For full-wave output, use “push-pull” amplifier configuration (two transistors), one conducts during the positive part, while the other conducts during the negative part.
- Boosts efficiency per transistor (70% to 75% efficiency) due to wider swing and smaller conduction angle. In other words, transistors are off half the time, but when they are on they are in full conduction.
- Linearity is not good (distortion).

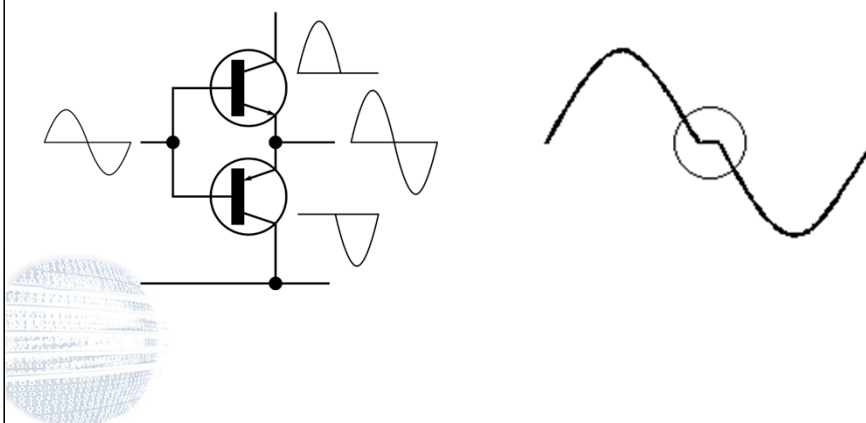


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## Push-Pull Crossover Distortion



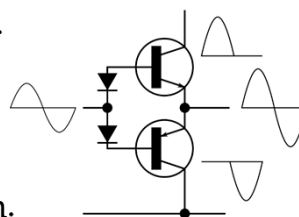
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## Class-AB Amplifier

- Conduction angle is somewhere between Class-A and Class-B (conduction angle  $180^\circ < \theta < 360^\circ$ ).
- Class AB is considered a good compromise to achieve good linearity with high efficiency.
- It also reduces crossover distortion.
- Efficiency is typically between 50% and 70% drain efficiency.

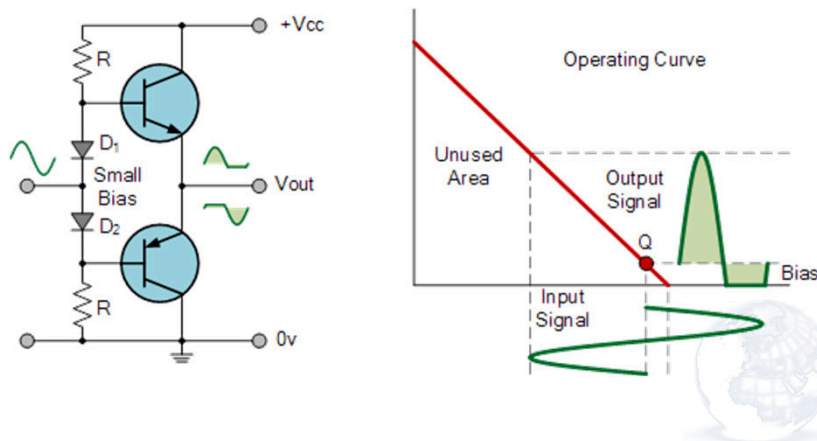


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## Class-AB Amplifier



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## Class-C Amplifiers

- In Class-C amplifiers, less than 50% of the input signal is used (conduction angle  $\theta < 180^\circ$ ).
- In other words, the input signal is used to switch the active device, resulting in pulses at the output.
- Distortion is high and practical use requires a tuned circuit as load (i.e., LC tank or BPF).
- Typical application is in RF transmitters operating at a single fixed carrier frequency, where the distortion is removed by the BPF (tuned load).
- Efficiency can reach 80% in radio-frequency applications.

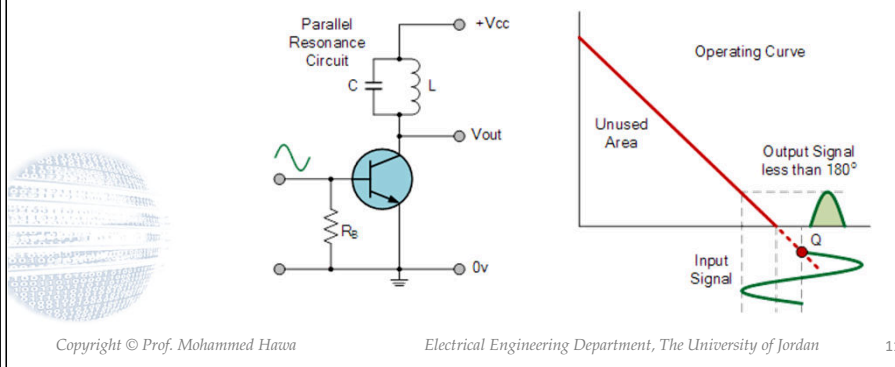
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## Untuned vs. Tuned Operation

- The input signal is used to switch the active device, causing pulses of current to flow through a tuned circuit forming part of the load.
- The distortion is controlled by the tuned load connected to the amplifier.



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## Other Classes

- Class-D, Class-E, Class-F, Class-G, Class-H, Class-T and Class-XD amplifiers use specific approaches or biasing methods to achieve high output power levels with high efficiency.
- For example, Class-D amplifier acts like a switch, boosting input signal by means of pulse width modulation (PWM) then reconstructing the switched PWM waveform back to the amplified version of the input waveform at the output of the amplifier.
- These nonlinear amplifiers are typically used for digital audio and motor-control applications.

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## Reminder: Multi-Stage Circuit

