Analog Electronics

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1st **semester**

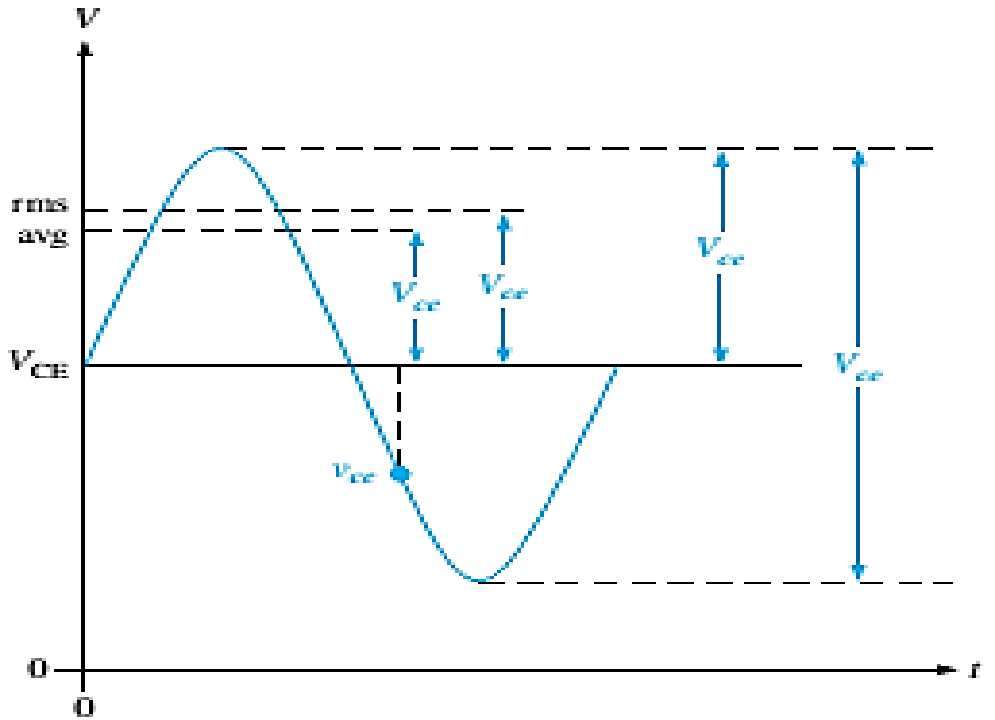
Chapter 5

Amplifiers
Lec. 10

Amplifier Operation

- **DC Quantities** use upper case Roman subscripts. **Example**: V_{CE} (The second letter in the subscript indicates the reference point).
- **AC Quantities** and time-varying signals use lowercase subscripts. Example: V_{ce}. Instantaneous quantities are represented by lowercase letters and subscripts such as I_c, I_e, I_b, and V_{ce}.
- **Internal transistor resistances** are indicated as lowercase quantities with a prime and an appropriate subscript. An example is the internal ac emitter resistance (r'_e) .
- **External resistances** are indicated as capital R with either a capital or lowercase subscript, depending on if it is a DC or AC resistance. Examples: R_C and R_c.

The Figure 1 shows an example of a specific waveform for the collector emitter voltage.



Linear Amplifier

- A **linear amplifier amplifies** a signal without distortion, so the output signal is an exact amplified replica of the input signal.
- A vo**ltage-divider-biased transistor** with a sinusoidal AC source capacitive coupled to the base through C_1 and a load capacitive coupled to the collector through C_2 is shown in Figure 2.

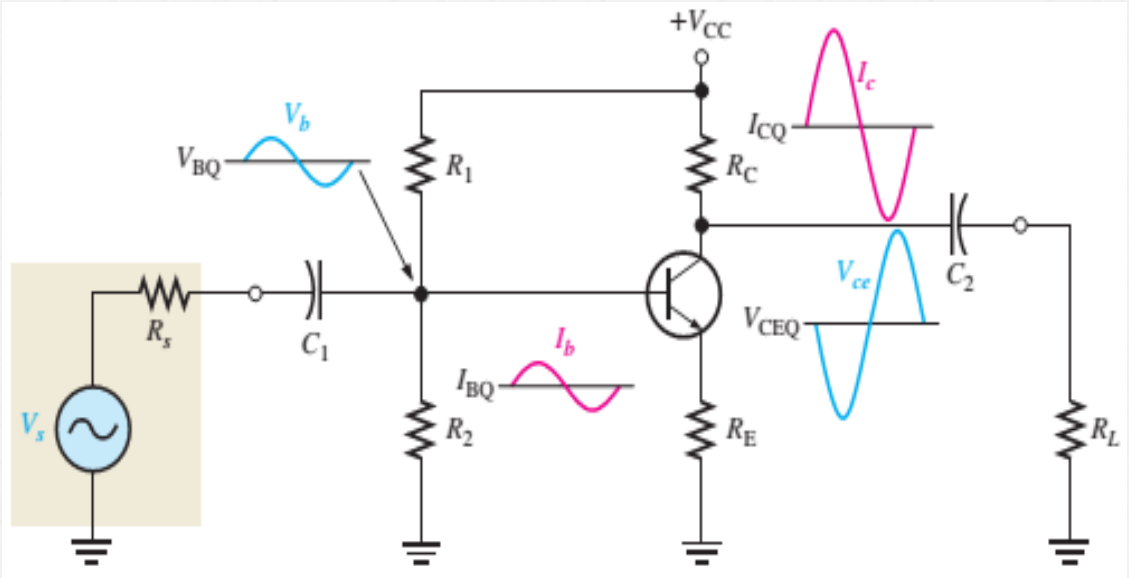


Figure 2

- For the **amplifier shown**, notice that the **voltage waveform is inverted between the input and output but has the same shape**.

Transistor AC Models

To assume the operation of a transistor in an amplifier circuit, representing the device by a model circuit is often useful.

A transistor model circuit **uses various internal transistor parameters** to **represent its operation**. Transistor models are described in this section based on resistance or **r parameters**.

Another system of parameters is **called h parameters**. The **five r parameters** commonly used for BJTs are given in the following.

Table 1. The lowercase letter r with a prime denotes resistances internal to the transistor.

r parameter	Description
α_{ac}	ac alpha (I_c/I_e)
β_{ac}	ac beta (I_c/I_b)
$\acute{r}_e$	ac emitter resistance
$\acute{r}_b$	ac base resistance
$\acute{r}_c$	ac collector resistance

To explain this model circuit in terms of a transistor's AC operation as follows:

A **resistance** ($\acute{r}_e$) appears between the **emitter and base** terminals. This is the resistance "seen" looking into the **emitter** of a **forward-biased transistor**. The **collector effectively** acts as a dependent current source of $\alpha_{ac}I_e$ or, equivalently, $\beta_{ac}I_b$, represented by the diamond-shaped symbol; these factors are shown in Figure 3.

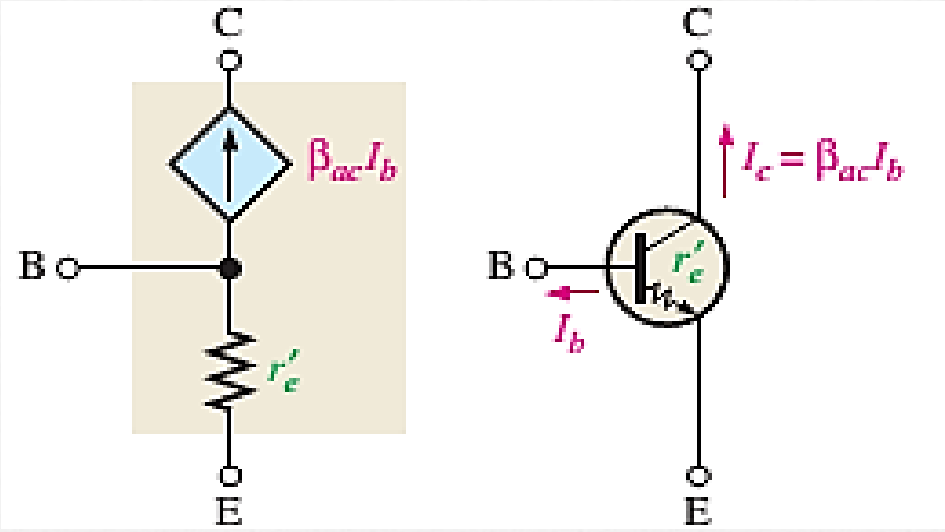


Figure 3: Relation of transistor symbol to r-parameter model.

It is also **temperature-dependent** and is based on an ambient temperature of 20°C.

H.W

H.W 1: Determine the ($\acute{r}_e$) of a transistor that is operating with a DC emitter current of 2 mA.

H.W 2: What is IE if ($\acute{r}_e$) = 8Ω?