

Analog Electronic Circuits (UEC301)

By



Dr.Mayank Kumar Rai
Associate Professor,
ECED, TIET, Patiala

Thapar Institute of Engineering & Technology
(Deemed to be University)
Bhadson Road, Patiala, Punjab, Pin-147004
Contact No. : +91-175-2393201
Email : info@thapar.edu

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THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Subject: Analog Electronic Circuits (UEC301)

Faculty name: Dr. Mayank Kumar Rai (Associate Professor & Course Coordinator)

Topic of today's Lecture : High frequency hybrid Model and Operation of BJT

Key points

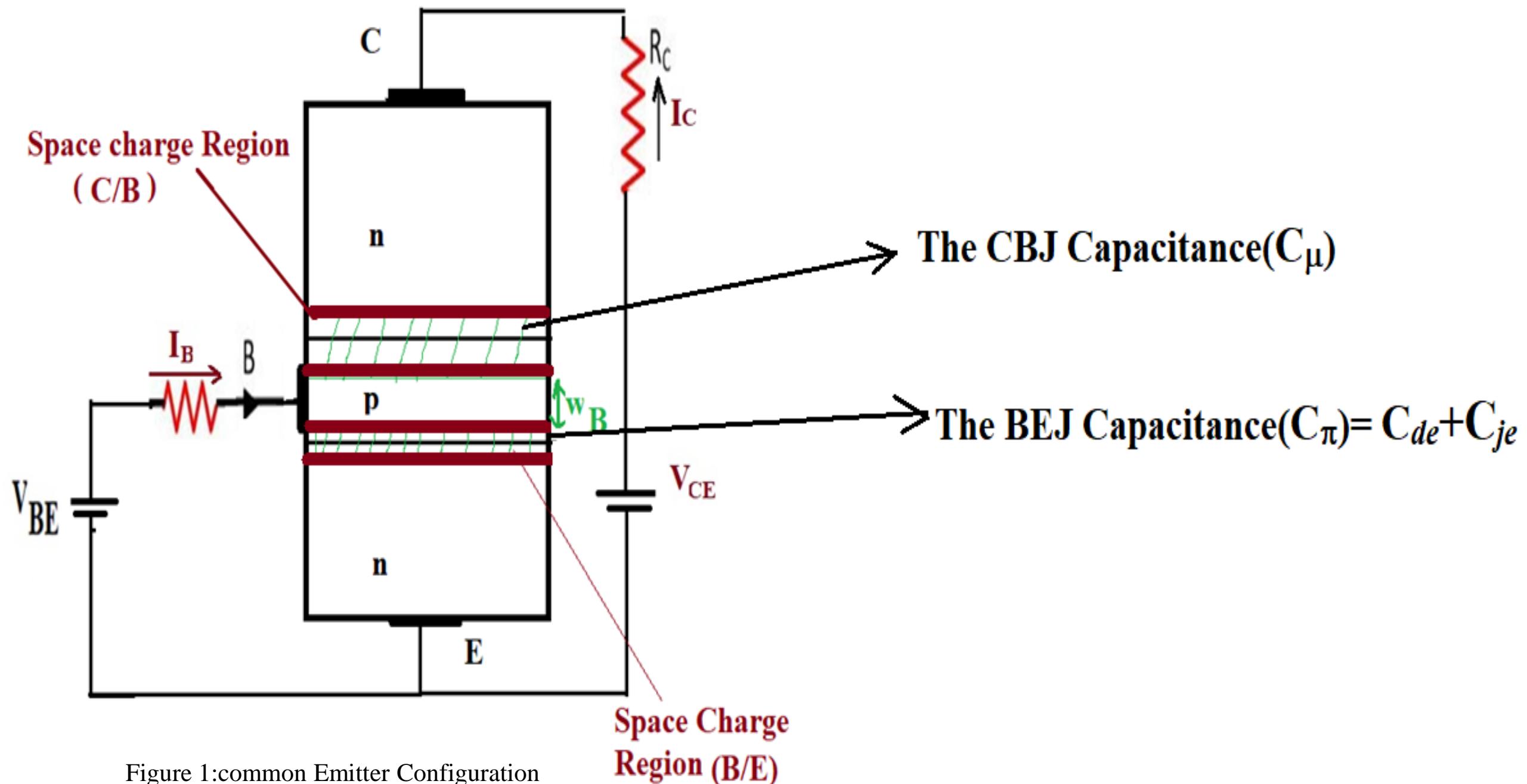
- ✓ **The BJT capacitances**
- ✓ **The high frequency hybrid Model**
- ✓ **The high frequency operation of BJT**

Contents of this lecture are based on the following books:

- *Jacob Milman & and C.C.Halkias, “Integrated Electronics Analog and Digital Circuit and Systems”Second Edition.*
- *Adel S. Sedra & K. C. Smith, “MicroElectronic Circuits Theory and Application” Fifth Edition.*
- *Robert L. Boylestad & L. Nashelsky, “Electronic Devices and Circuit Theory” Eleventh Edition.*



The BJT capacitances



The BJT internal Capacitances

$$(1) \text{ BEJ Capacitances} (C_{\pi}) = C_{de} + C_{je} \dots \dots \dots (1)$$

Small signal diffusion capacitance, $C_{de} = \frac{dQ_n}{dv_{BE}}$ (2),

where $Q_n = \frac{W^2 i_c}{2D_n} = \tau_f i_c$, $\tau_f = \frac{W^2}{2D_n}$

$$C_{de} = \frac{dQ_n}{dv_{BE}} = \tau_f \frac{di_c}{dv_{BE}} \quad \dots \dots \dots \quad (3),$$

where $g_m = \frac{di_c}{dv_{BE}} = \frac{i_c}{V_T}$

$$\text{Depletion layer capacitance, } C_{je} = \frac{C_{jeo}}{(1 - \frac{V_{BE}}{V_{0E}})^m} \quad \dots \dots \dots \quad (5)$$

(2) CBJ Capacitances(C_{ϕ}):

$$C_\mu = \frac{C_{\mu o}}{\left(1 - \frac{V_{CB}}{V_{0C}}\right)m} \quad \dots \dots \dots \quad (6)$$

The high frequency hybrid Model

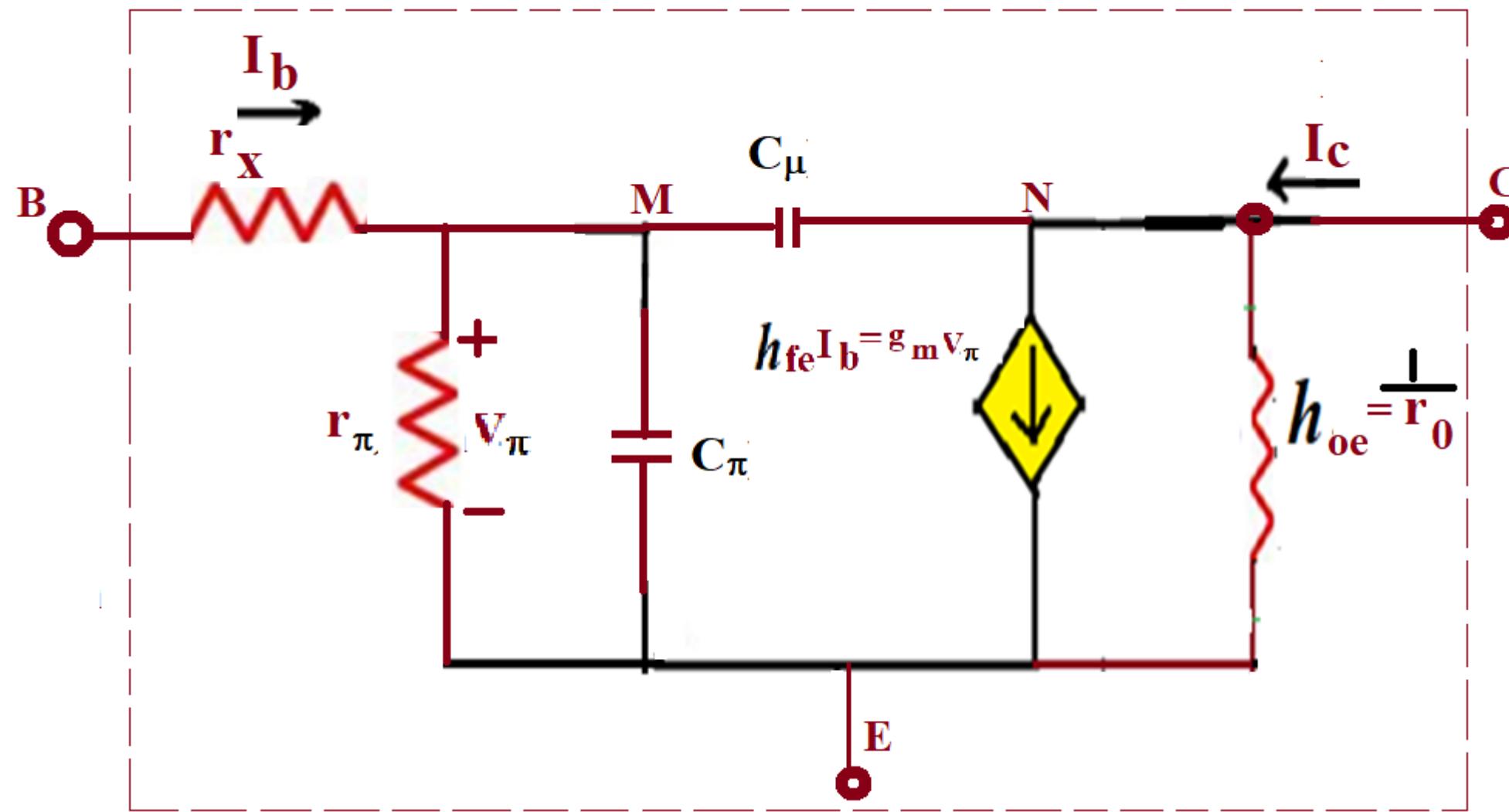
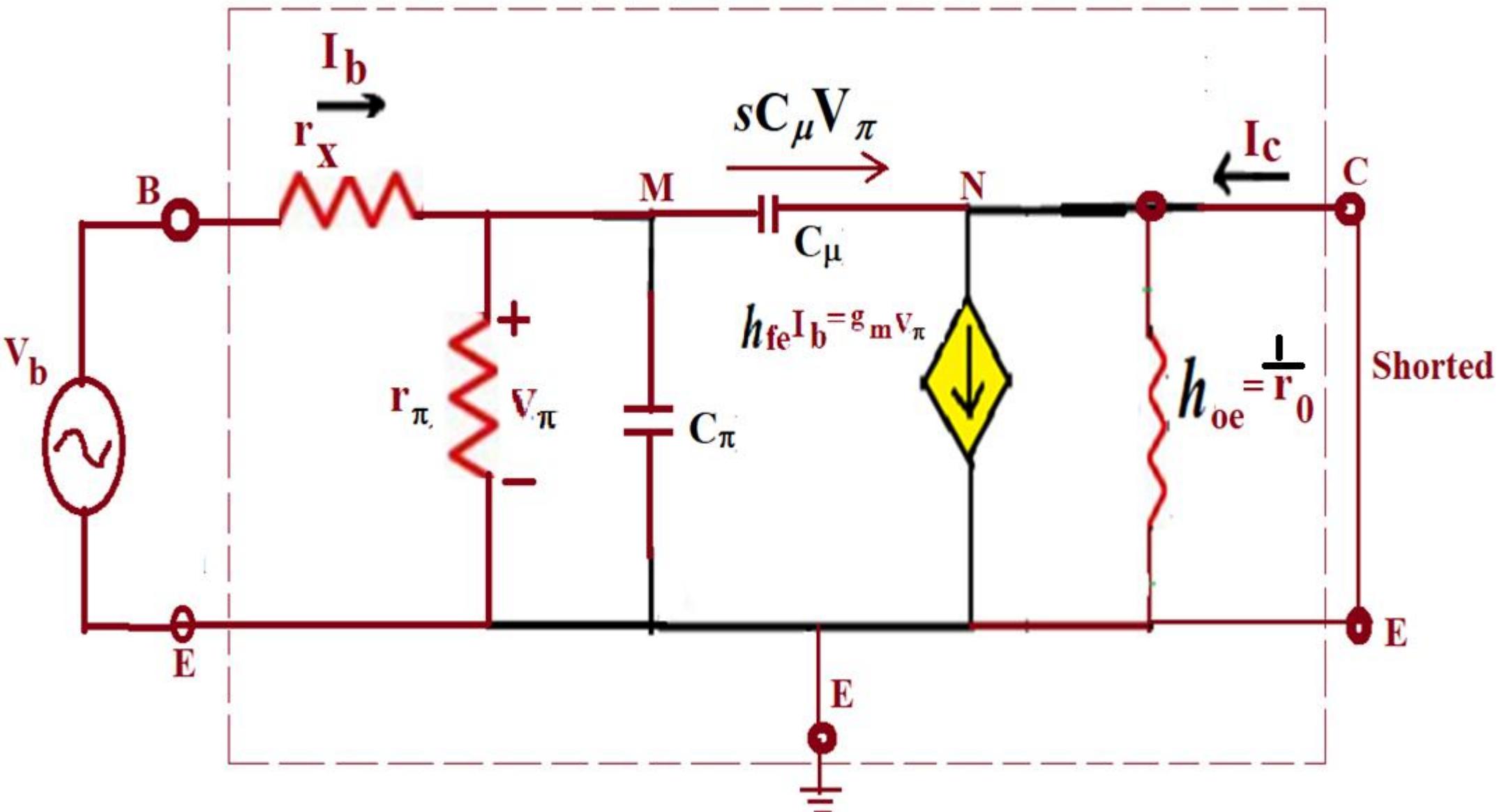
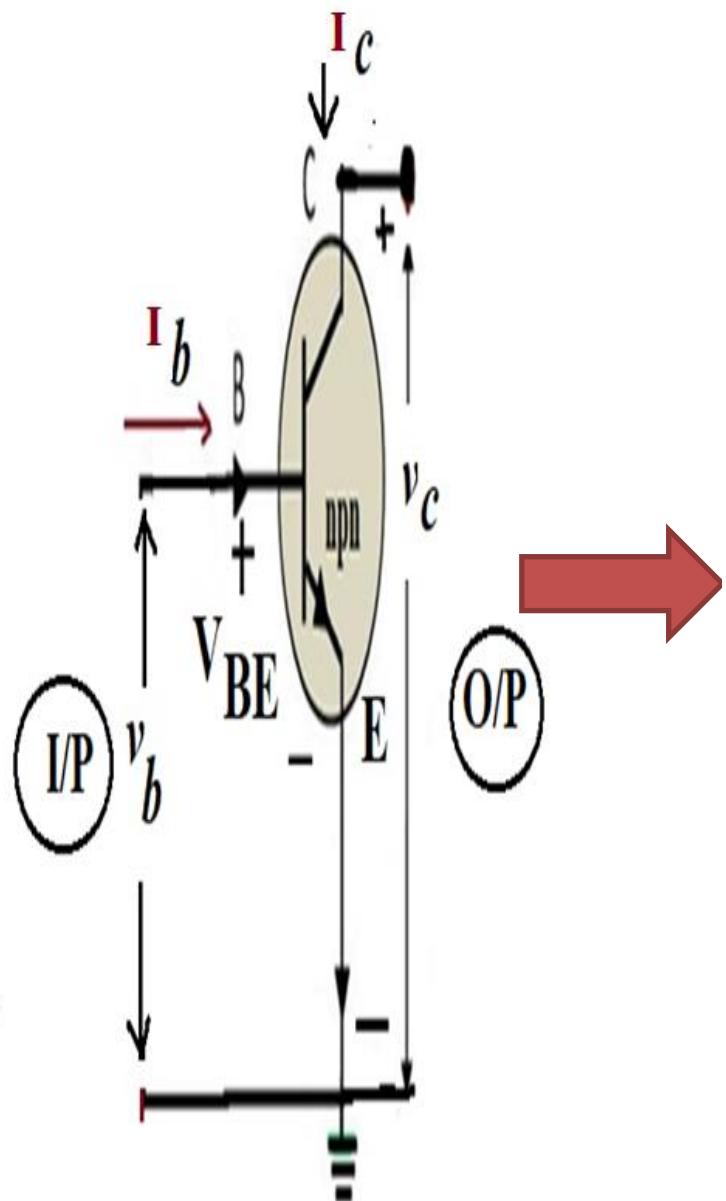


Figure 2 : The high frequency hybrid π model.

Impedance of $C = 1/sC$, where $s = j\omega$

The high frequency operation of BJT



The current gain (h_{fe})

$$\text{Current across } C_\mu (I_{C\mu}) = \frac{V_M - V_N}{1/sC_\mu} \dots\dots\dots(7),$$

where $V_N = V_{ce} = 0$ & $V_M = V_\pi$

Apply *k.c.l.* to collector end

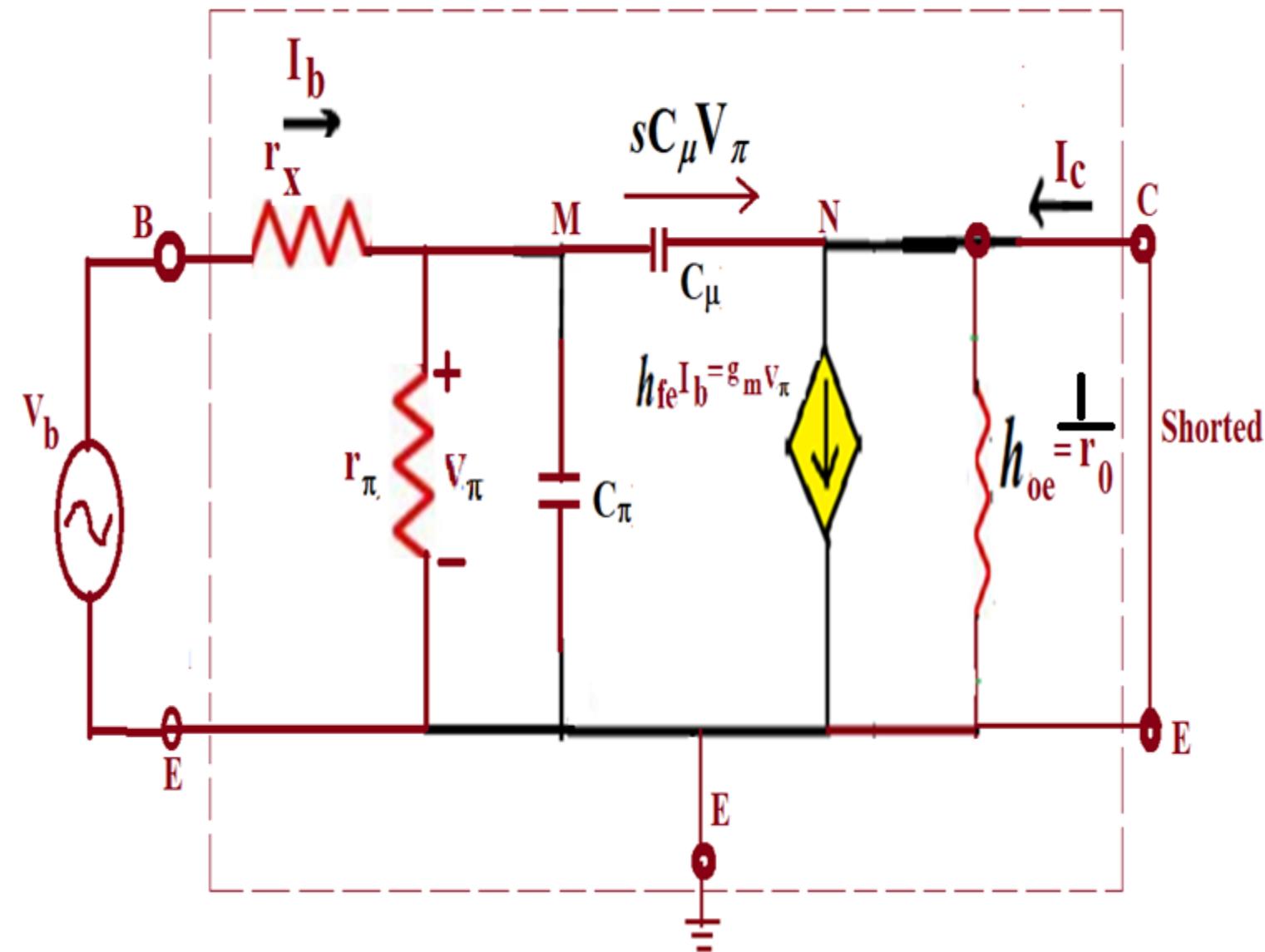


Figure 4: The high frequency hybrid π model based circuit.

$$h_{fe} = \frac{I_c}{I_b} = \frac{g_m - sC_\mu}{\frac{1}{r_\pi} + s(C_\mu + C_\pi)} \dots \dots \dots (13)$$

$$h_{fe} = \frac{g_m r_\pi}{1+s(C_\mu + C_\pi)r_\pi} = \frac{\beta_o}{1+s(C_\mu + C_\pi)r_\pi} \dots (14)$$

$$\text{Transfer function} = \frac{K}{1+s/\omega_0}$$

h_{fe} has single pole response with a 3-dB frequency at $\omega_0 = \omega_B$

From the Fig.5 , the frequency at which h_{fe} drops to unity is called “*unity gain bandwidth*(ω_T)”.

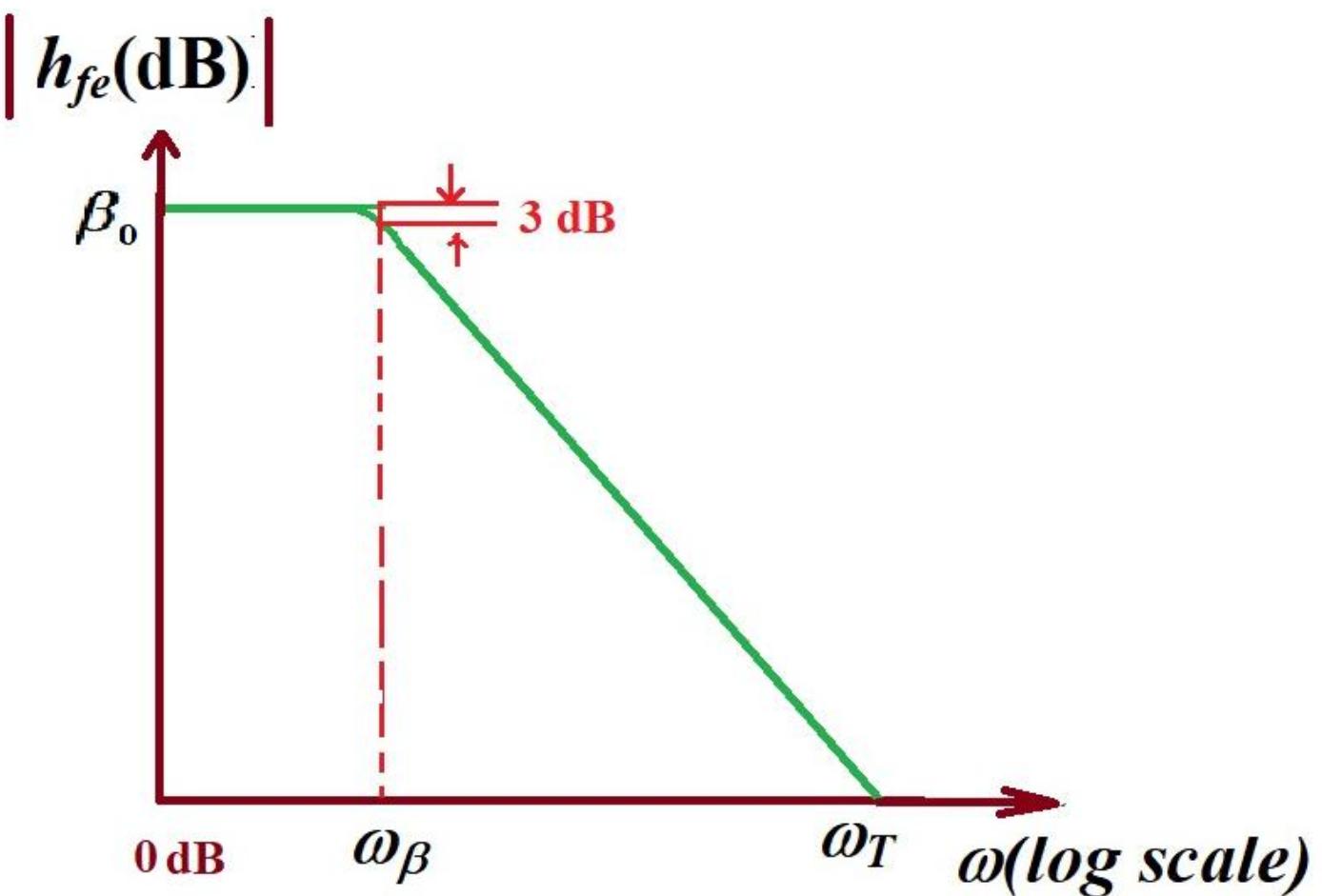
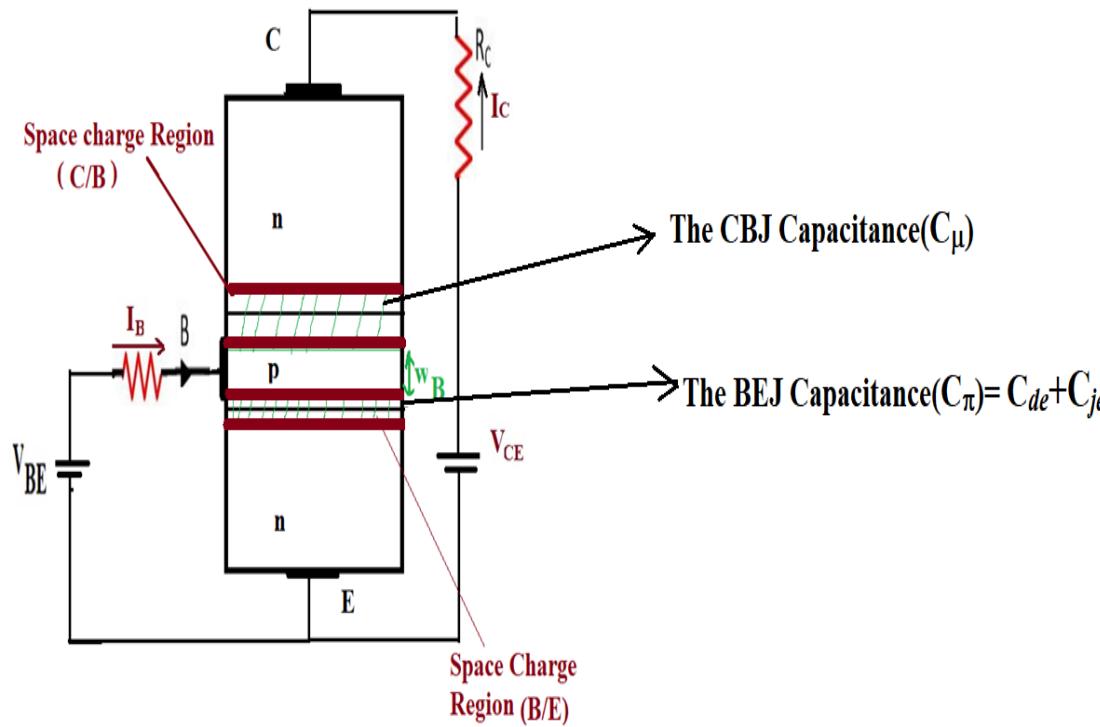


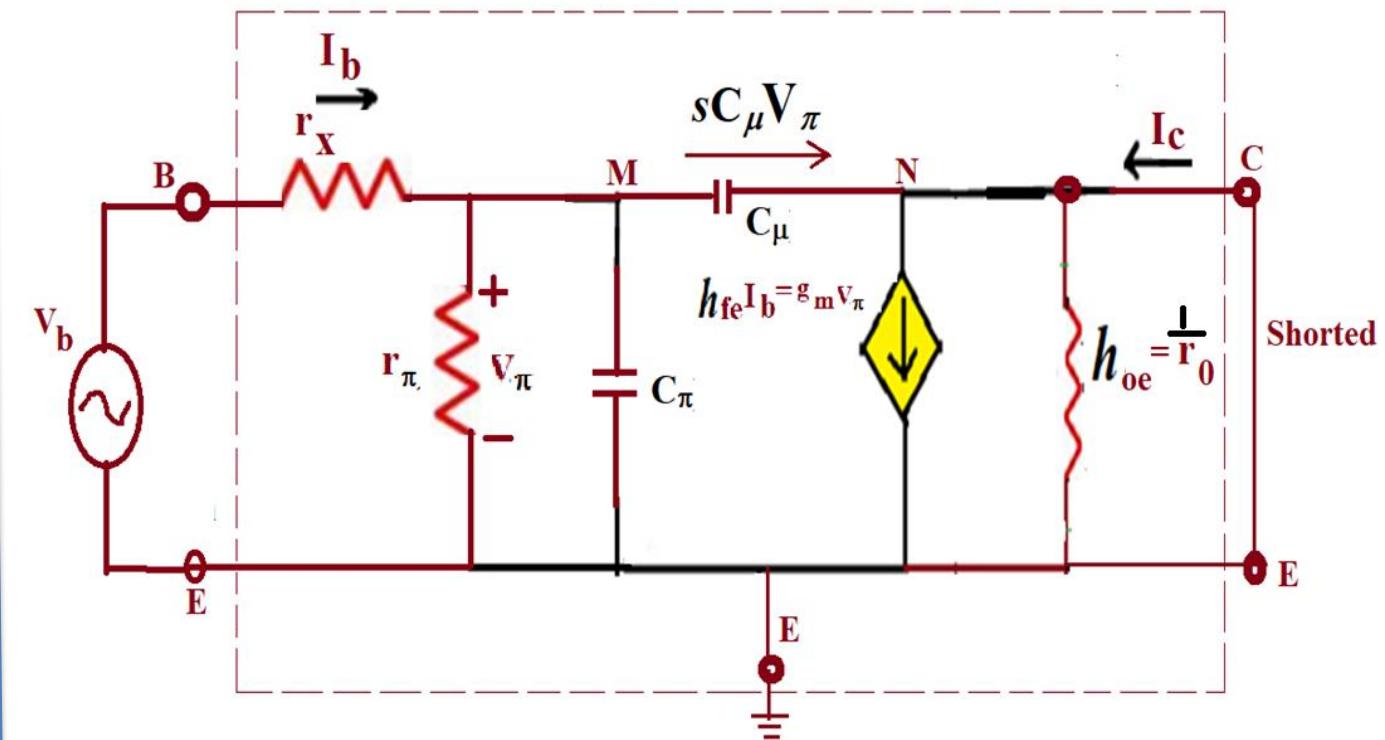
Figure 5: Frequency response.

Summary

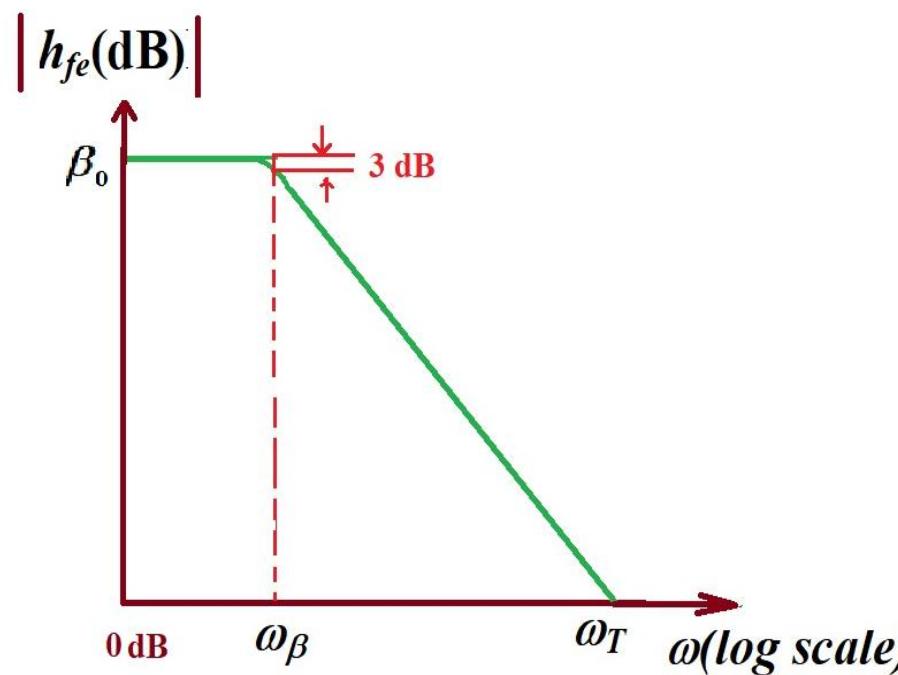
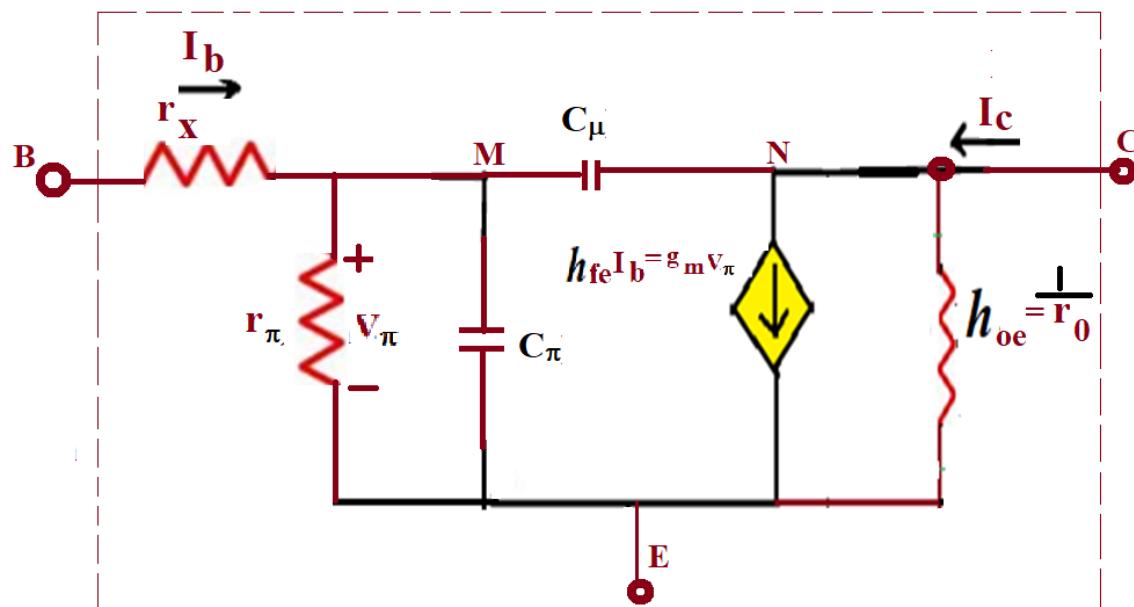
✓ The BJT capacitances



✓ The high frequency hybrid Model based circuit



✓ The high frequency hybrid Model



Thank You

