

EE 3113

INTRODUCTION INTO RF

CIRCUIT DESIGN

Lecture Notes for A-term 1999

LECTURE 19

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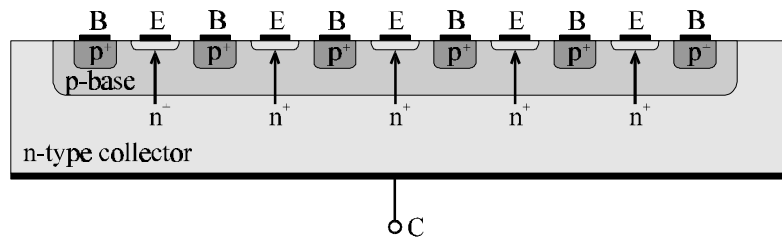
RF Transistors

- BJT: low noise, linear power amplification, power applications (bipolar operation)
- GaAs FET: very low noise, low power (monopolar operation)
- HEMT (High electron mobility transistor): very high frequency ($f > 20$ GHz) (electron gas)

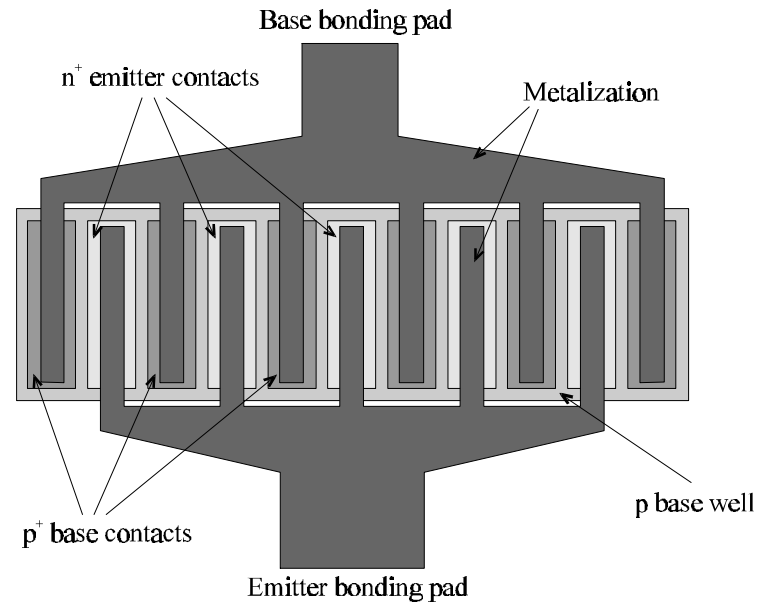
- Major issue when dealing with RF transistors:
NOISE
 - shot noise in emitter-base
 - shot noise in collector system
 - thermal noise in base resistance
- How to reduce noise
 - minimize current flow across pn-junction
 - minimize resistance
- Solution
 - Finger structure of base, emitter configuration

Finger structure of BJT

(see pp. 325 - 342)

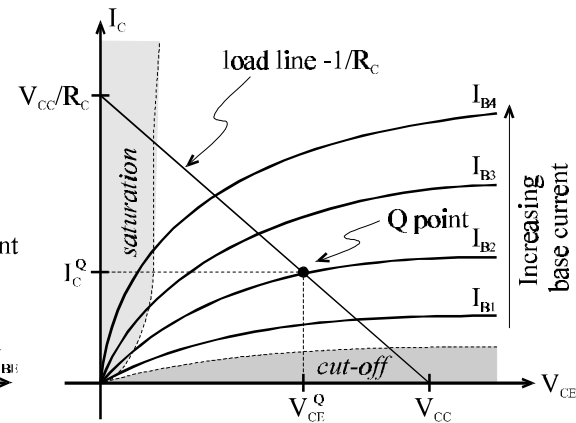
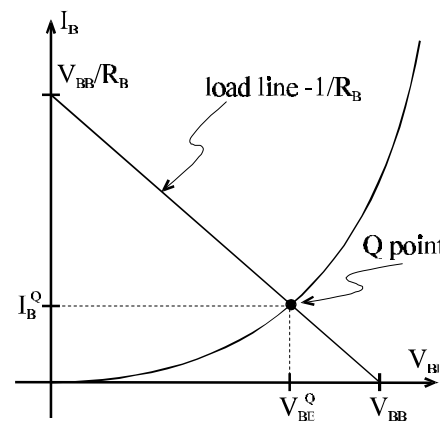
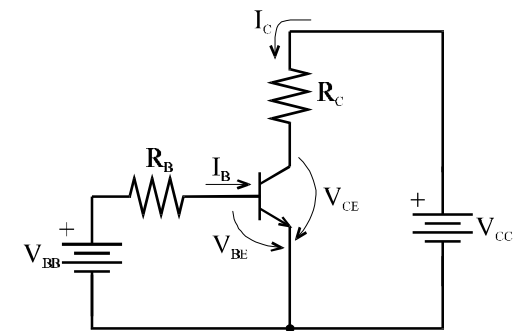
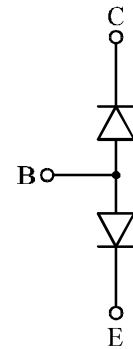
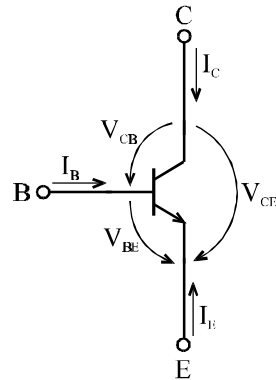
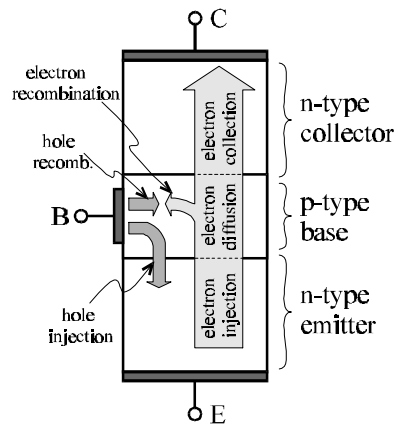


Cross-sectional view



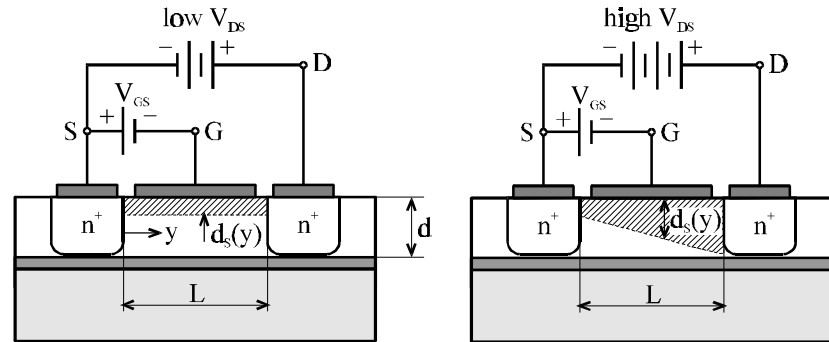
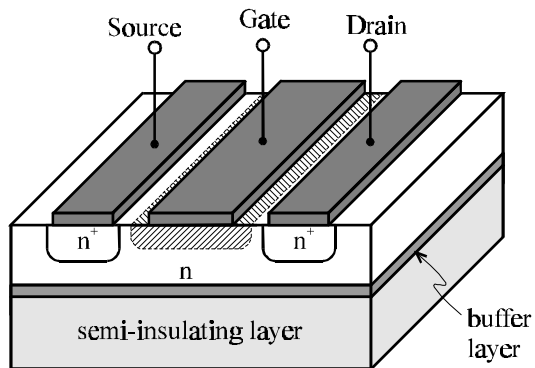
Top-down view

Functionality of BJT

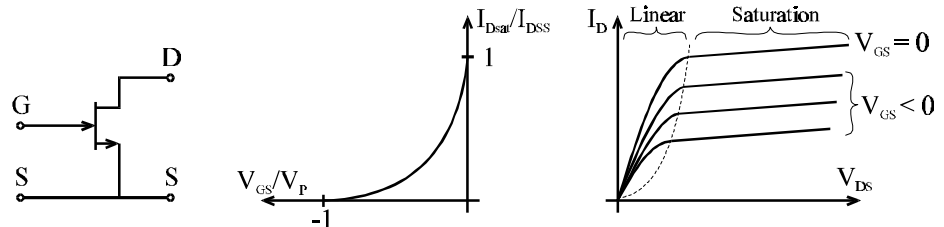


Structure of MESFET

(see pp. 344 - 355)



Functionality of MESFET

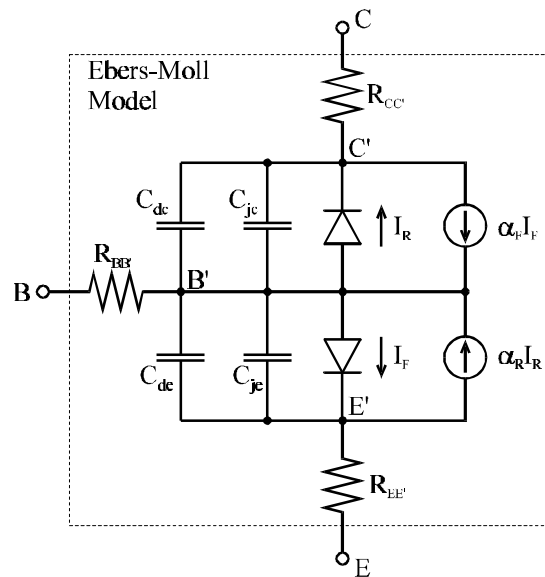


Modeling efforts for BJT

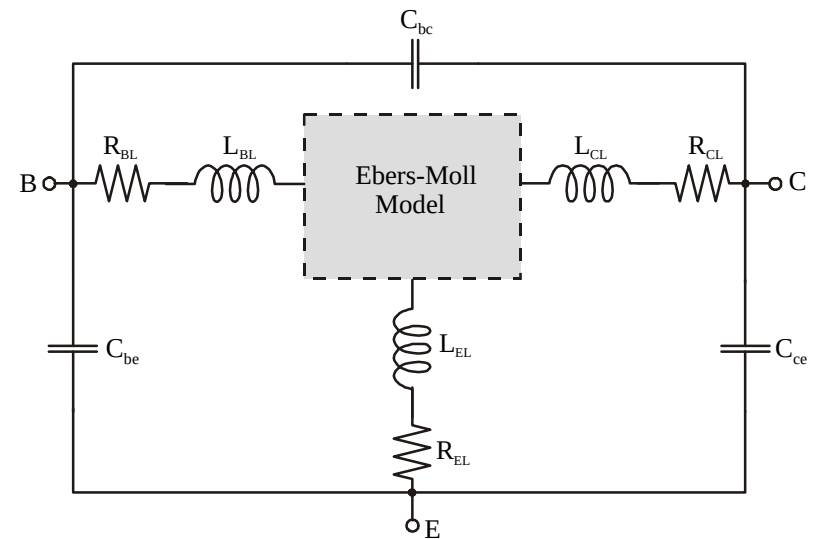
- Non-linear models
 - Ebers-Moll
 - Gummel-Poon
- Low frequency
 - h-parameter model
- High frequency
 - modified hybrid model with additional $C_{b'e}$ and $C_{b'e}$ capacitances
 - Miller effect is used to convert $C_{b'c}$ into input capacitance

Non-linear BJT model

Dynamic Ebers-Moll chip model

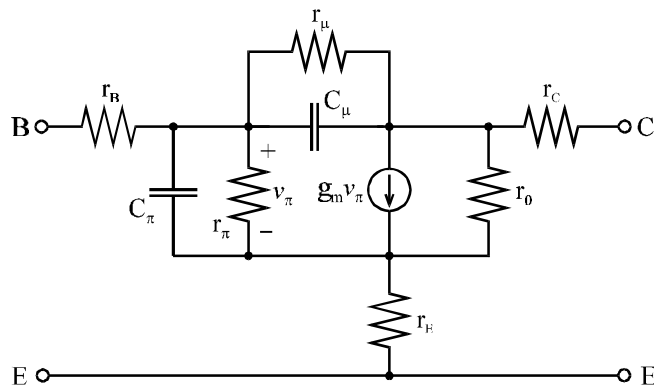


RF model with parasitic effects

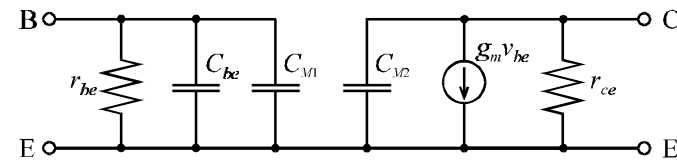
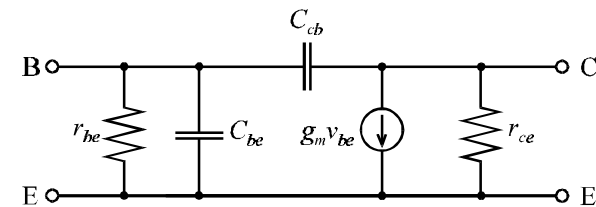


Small-signal BJT model

Hybrid-PI Ebers-Moll model (p. 384)



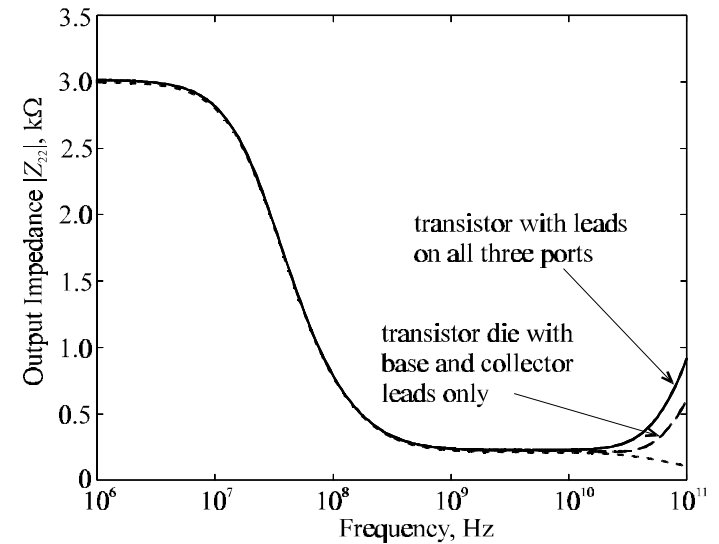
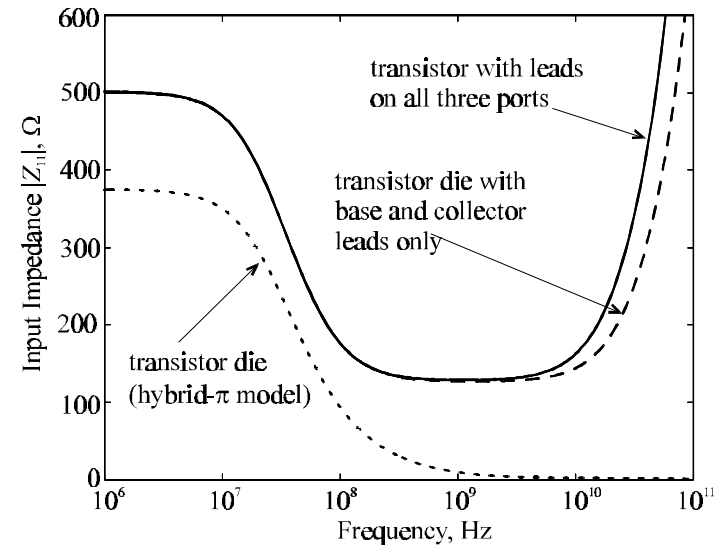
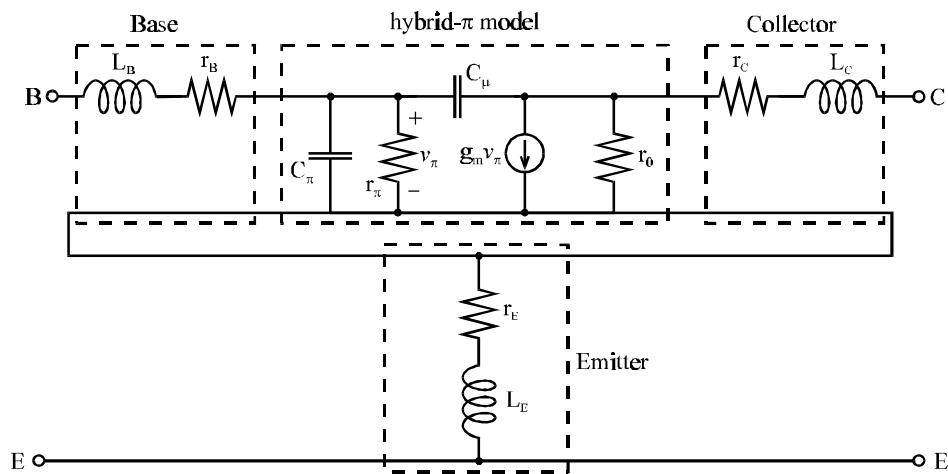
RF-model (p. 387)



Decoupled RF-model (Miller effect)

Performance analysis

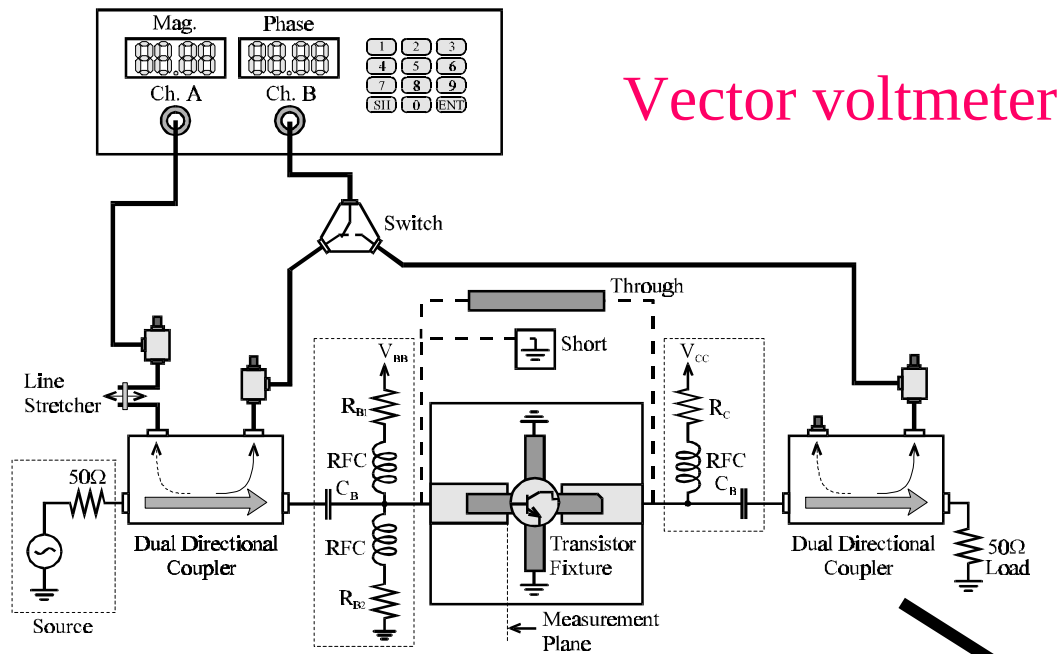
Hybrid Pi-model (see p. 392)



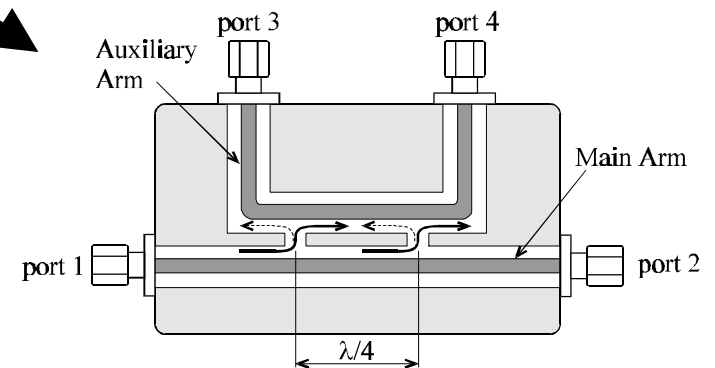
S-parameter modeling of BJT

- Hybrid model can be converted into S-parameters via input/output impedance and voltage relations
- S-parameters can also be directly measured for certain biasing and operating frequency condition (values are provided by manufacturer)

How to measure S-parameters?



Dual directional coupler



Alternative: Network analyzer with S-parameter test set

