

FET DC Models and Biasing Circuits

Dr. José Ernesto Rayas Sánchez

Some figures of this presentation were taken from the instructional resources of the following textbooks:

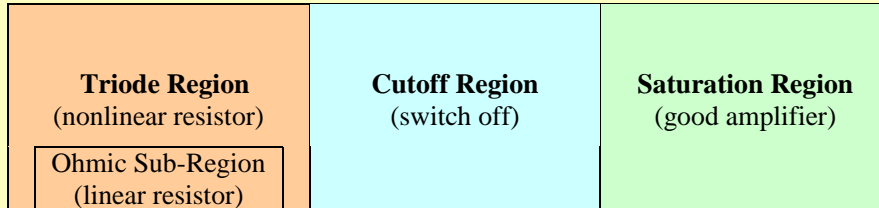
A. S. Sedra and K. C. Smith, *Microelectronic Circuits*. New York, NY: Oxford University Press, 2003.

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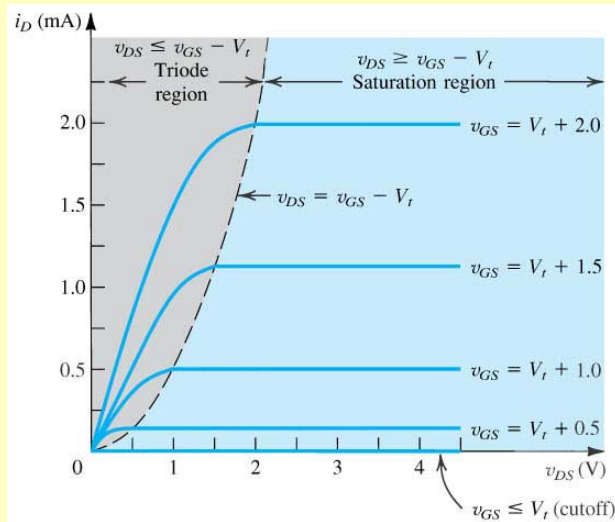
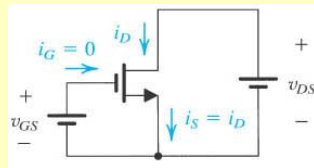
Outline

- Regions of operation for FETs in general
- Operation regions for MOSFETs
- DC Models for MOSFETs
- Operation regions for JFETs
- DC Models for JFETs
- Examples of biasing circuits for MOSFETs
- Examples of biasing circuits for JFETs

Regions of Operation of FETs



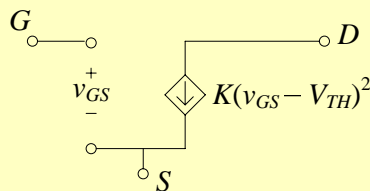
Regions of Operation of MOSFETs



DC Models for MOSFETs – Saturation

Neglecting the channel length modulation effect:

- NMOSFET

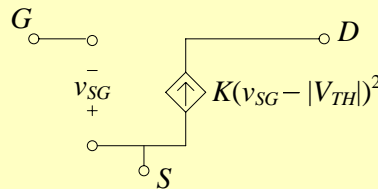


$$v_{GS} \geq V_{TH}$$

$$v_{DS} \geq v_{GS} - V_{TH}$$

$$K = \frac{1}{2} \mu_n C_{OX} \frac{W}{L}$$

- PMOSFET



$$v_{SG} \geq |V_{TH}|$$

$$v_{SD} \geq v_{SG} - |V_{TH}|$$

$$K = \frac{1}{2} \mu_p C_{OX} \frac{W}{L}$$

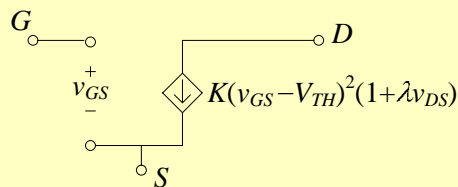
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DC Models for MOSFETs – Saturation

Including the channel length modulation effect:

- NMOSFET

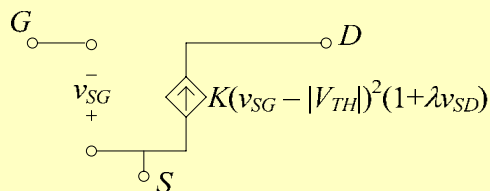


$$v_{GS} \geq V_{TH}$$

$$v_{DS} \geq v_{GS} - V_{TH}$$

$$K = \frac{1}{2} \mu_n C_{OX} \frac{W}{L}$$

- PMOSFET



$$v_{SG} \geq |V_{TH}|$$

$$v_{SD} \geq v_{SG} - |V_{TH}|$$

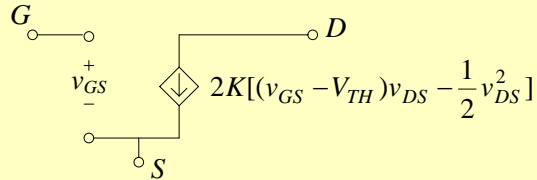
$$K = \frac{1}{2} \mu_p C_{OX} \frac{W}{L}$$

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DC Models for MOSFETs – Triode

- NMOSFET

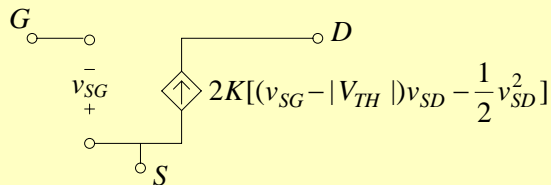


$$v_{GS} \geq V_{TH}$$

$$v_{DS} < v_{GS} - V_{TH}$$

$$K = \frac{1}{2} \mu_n C_{OX} \frac{W}{L}$$

- PMOSFET



$$v_{SG} \geq |V_{TH}|$$

$$v_{SD} < v_{SG} - |V_{TH}|$$

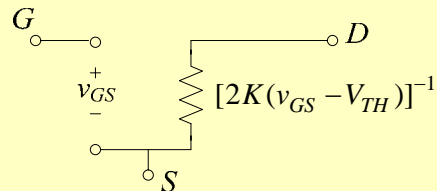
$$K = \frac{1}{2} \mu_p C_{OX} \frac{W}{L}$$

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DC Models for MOSFETs – Ohmic

- NMOSFET

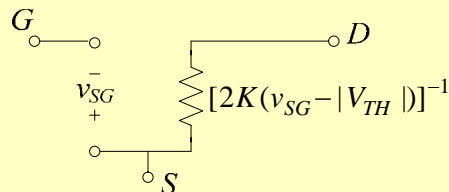


$$v_{GS} \geq V_{TH}$$

$$v_{DS} \ll v_{GS} - V_{TH}$$

$$K = \frac{1}{2} \mu_n C_{OX} \frac{W}{L}$$

- PMOSFET



$$v_{SG} \geq |V_{TH}|$$

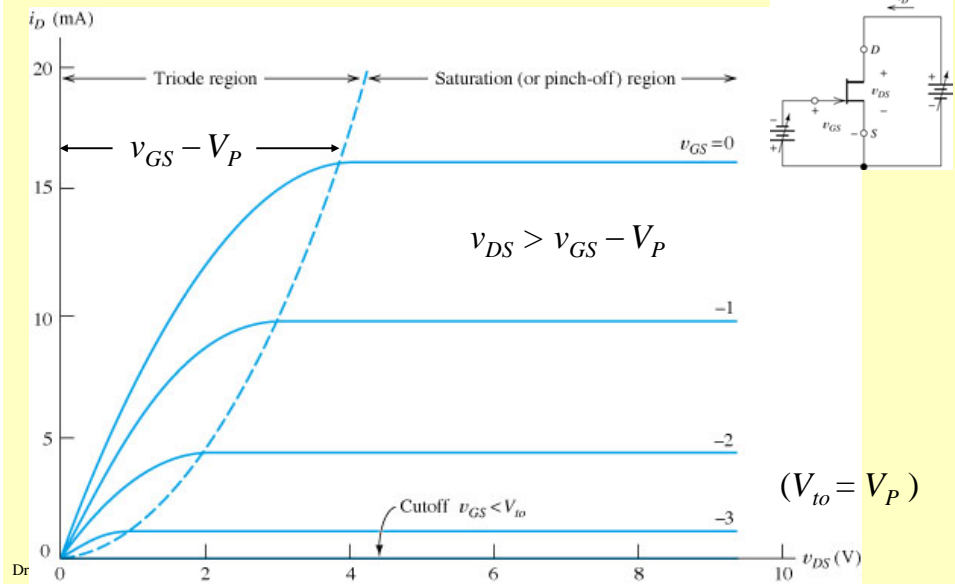
$$v_{SD} \ll v_{SG} - |V_{TH}|$$

$$K = \frac{1}{2} \mu_p C_{OX} \frac{W}{L}$$

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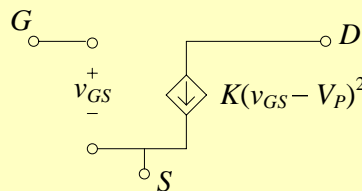
Regions of Operation of JFETs



DC Models for JFETs – Saturation

Neglecting the channel length modulation effect:

- N-JFET



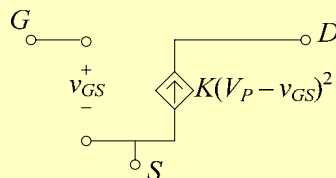
$$0 \geq v_{GS} \geq V_P$$

$$v_{DS} \geq v_{GS} - V_P$$

$$K = I_{DSS} / V_P^2$$

$$V_P < 0, I_{DSS} > 0$$

- P-JFET



$$0 \leq v_{GS} \leq V_P$$

$$v_{SD} \geq V_P - v_{GS}$$

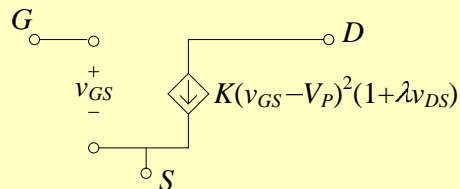
$$K = |I_{DSS}| / V_P^2$$

$$V_P > 0, I_{DSS} < 0$$

DC Models for JFETs – Saturation

Including the channel length modulation effect:

- N-JFET



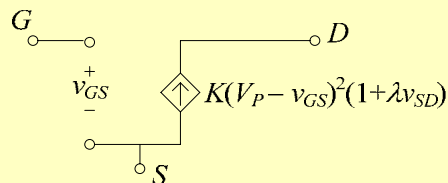
$$0 \geq v_{GS} \geq V_P$$

$$v_{DS} \geq v_{GS} - V_P$$

$$K = I_{DSS} / V_P^2$$

$$V_P < 0, I_{DSS} > 0$$

- P-JFET



$$0 \leq v_{GS} \leq V_P$$

$$v_{SD} \geq V_P - v_{GS}$$

$$K = |I_{DSS}| / V_P^2$$

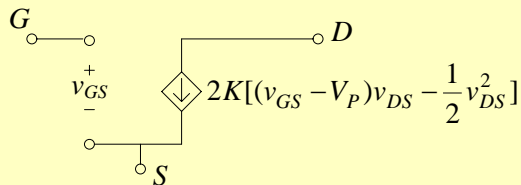
$$V_P > 0, I_{DSS} < 0$$

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DC Models for JFETs – Triode

- N-JFET



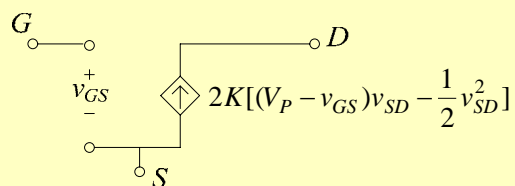
$$0 \geq v_{GS} \geq V_P$$

$$v_{DS} < v_{GS} - V_P$$

$$K = I_{DSS} / V_P^2$$

$$V_P < 0, I_{DSS} > 0$$

- P-JFET



$$0 \leq v_{GS} \leq V_P$$

$$v_{SD} < V_P - v_{GS}$$

$$K = |I_{DSS}| / V_P^2$$

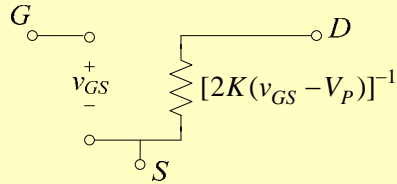
$$V_P > 0, I_{DSS} < 0$$

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DC Models for JFETs – Ohmic

- N-JFET



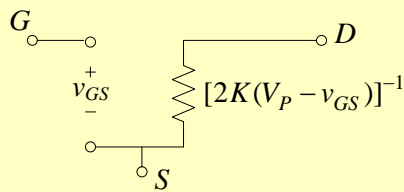
$$0 \geq v_{GS} \geq V_P$$

$$v_{DS} \ll v_{GS} - V_P$$

$$K = I_{DSS} / V_P^2$$

$$V_P < 0, I_{DSS} > 0$$

- P-JFET



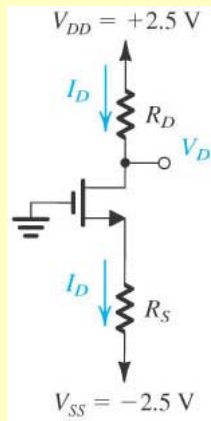
$$0 \leq v_{GS} \leq V_P$$

$$v_{SD} \ll V_P - v_{GS}$$

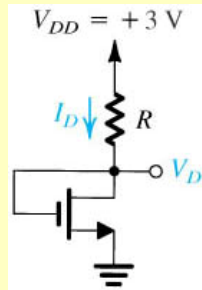
$$K = |I_{DSS}| / V_P^2$$

$$V_P > 0, I_{DSS} < 0$$

MOSFET Biasing Circuits – Example 1



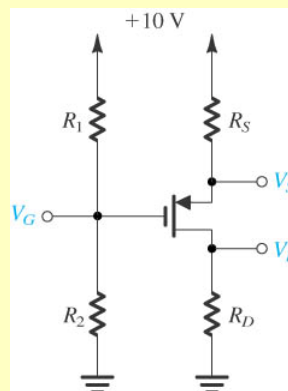
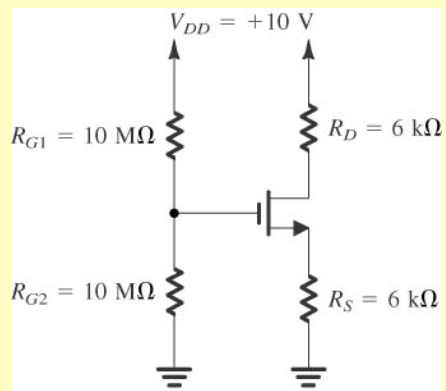
MOSFET Biasing Circuits – Example 2



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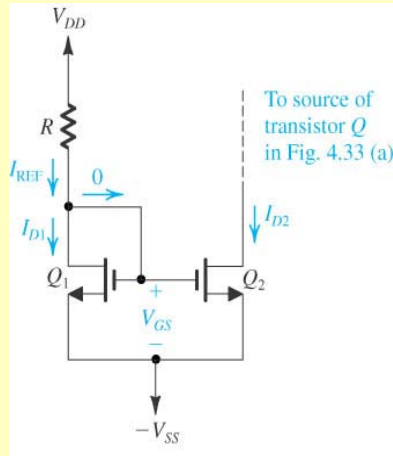
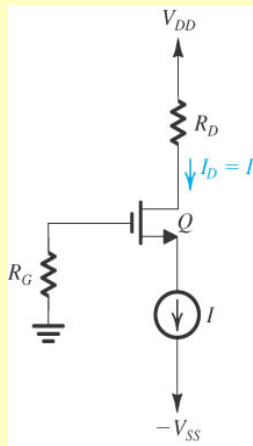
MOSFET Biasing Circuits – Example 3



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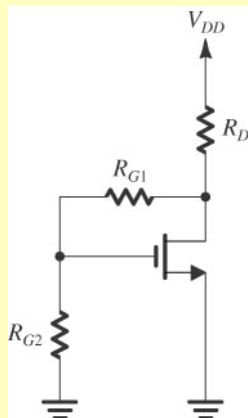
MOSFET Biasing Circuits – Example 4



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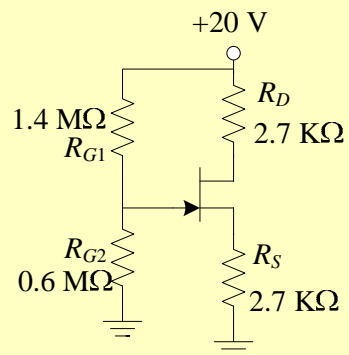
MOSFET Biasing Circuits – Example 5



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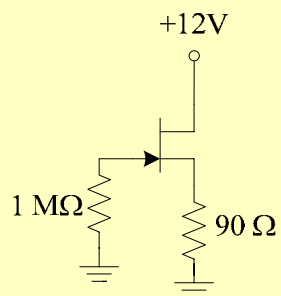
JFET Biasing Circuits – Example 1



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JFET Biasing Circuits – Example 2



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