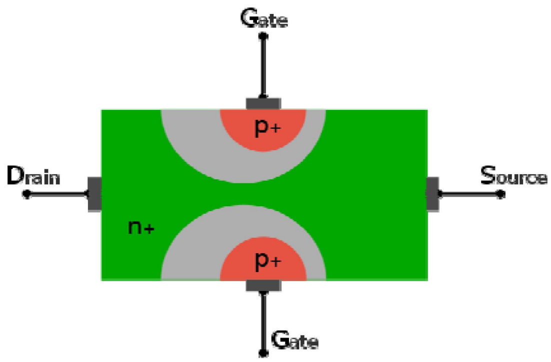
SIERRA COLLEGE

MECH 10
Fundamentals of Electronics

Mechatronics Real Skills Real Jobs

Class 24
Field Effect Transistors



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MECH 10
Fundamentals of Electronics

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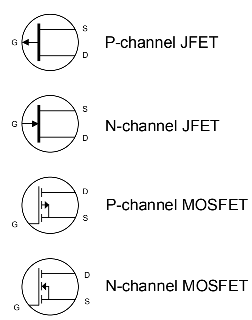
- Field Effect Transistor
  - Operation
    - Conductivity control
  - Connections
    - Gate, source, drain
  - Types
    - Junction FET
    - Metal-oxide semiconductor FET



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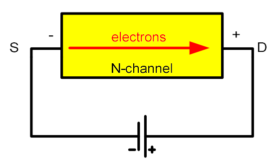
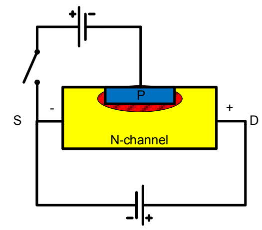
Fundamentals of Electronics

- Field Effect Transistor
  - Operation
    - Uses an electric field to control conductivity



N-channel conductor



N-channel conductor
P-type gate control

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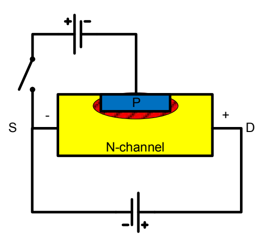
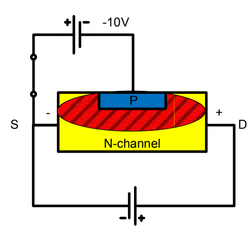
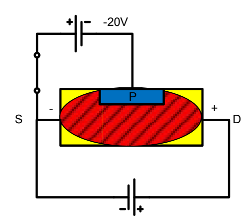
- Field Effect Transistor
  - Operation
    - Reverse gate bias
      - Increased depletion region
      - Restricted N-channel conduction



Gate bias zero



Gate bias -10V



Gate bias -20V

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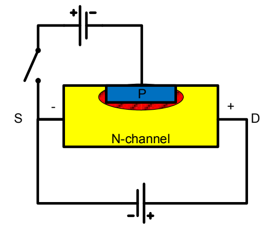
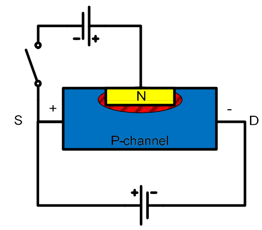
- Field Effect Transistor
  - Connections
    - Source
      - Sources charge carriers
    - Drain
      - Sinks charge carriers
    - Gate
      - Controls depletion zone size & current channel conduction





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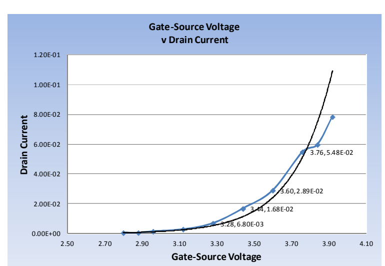
- Field Effect Transistor
  - Trans-conductance
    - The change in drain current divided by the change in gate voltage
    - Control response

$$g_m = \frac{\Delta I_D}{\Delta V_{GS}}$$

Where;
g_M = conductance (S)
ΔI_D = change in drain current
ΔV_S = change in gate source voltage



Name	Unit symbol	Quantity	Symbol
conductance	S	siemens	g_m

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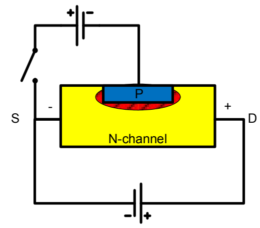
- FET Types
  - Junction FET
    - Single PN junction
    - Advantages
      - High trans-conductance
      - High input impedance (1000’s Ω)
      - Thermal stability
      - Zero offset voltage
    - Disadvantages
      - Special handling



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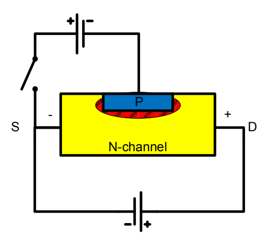
- FET Types
  - Junction FET
    - Maximum Ratings
      - V_{GS} – gate source voltage (30 to 50V typical)
      - V_{GD} – gate drain voltage (30 to 50V typical)
      - V_{DS} – drain source voltage (30 to 50V typical)



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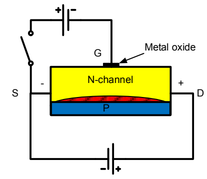
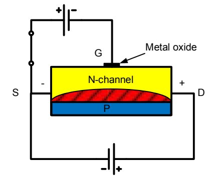
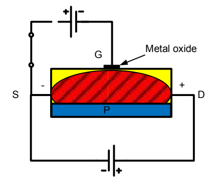
- FET Types
  - MOSFET
    - Metal-oxide semiconductor
      - Insulated gate FET
    - Depletion Mode – reverse gate/source bias
    - Enhancement Mode – forward gate/source bias



DEPLETION MODE (0V)



DEPLETION MODE (-10V)



DEPLETION MODE (-20V)

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MECH 10
Fundamentals of Electronics

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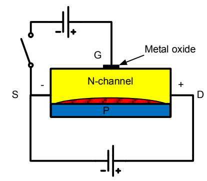
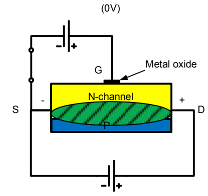
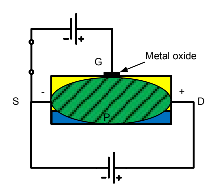
- FET Types
  - MOSFET
    - Advantages
      - High trans-conductance
      - High input impedance (meg Ω)
      - Zero power consumption
      - Ideally suited for large scale integration
    - Disadvantages
      - Special handling



ENHANCEMENT MODE (0V)



ENHANCEMENT MODE (+10V)



ENHANCEMENT MODE (+20V)

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Fundamentals of Electronics

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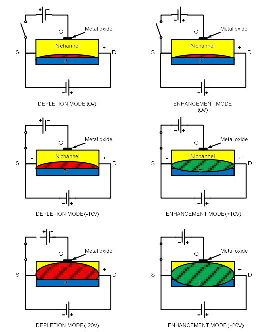
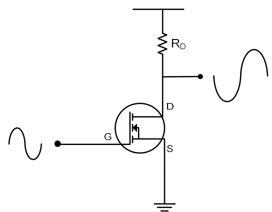
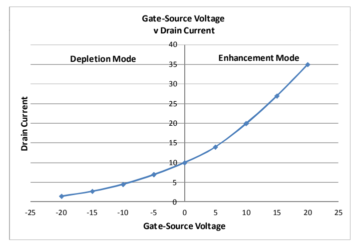
- FET Types
  - MOSFET
    - Advantages
      - Operates with forward & reverse bias
      - Bipolar trans-conductance curve
      - Class A amplifier, without the DC quiescent point







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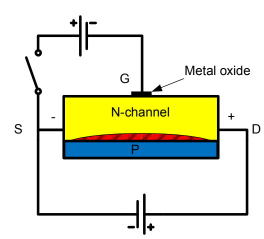
- FET Types
  - MOSFET
    - Maximum Ratings
      - V_{GS} – gate source voltage (30 to 50V typical)
      - V_{GD} – gate drain voltage (30 to 50V typical)
      - V_{DS} – drain source voltage (30 to 50V typical)



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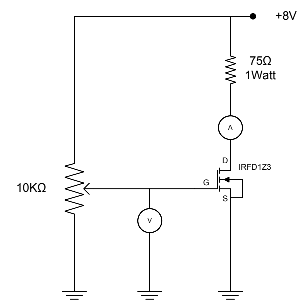
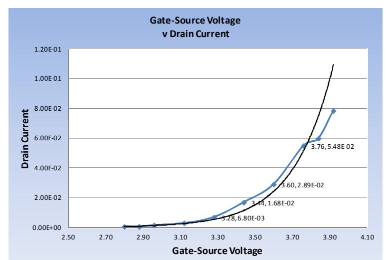
- MOSFET Amplifier Lab
  - Test points
    - $V_{GS(th)}$ – threshold voltage
    - V_{GS} – gate source voltage
    - I_D – drain current
  - Transfer Curve
  - Trans-conductance
  - Channel resistance
    - V_{DS} & I_D

$$g_m = \frac{\Delta I_D}{\Delta V_{GS}}$$



CIRCUIT 1



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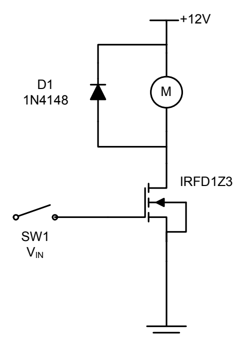
- MOSFET Motor Switch Lab
  - GS Trainer digital switch
    - Measure V_{out}
  - MOSFET in saturation mode



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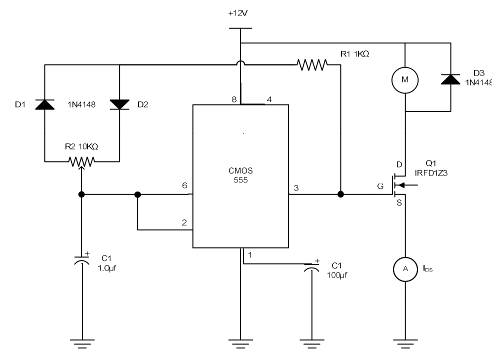
- PWM Motor Control
  - 555 timer & RC time constants
  - Voltage controlled output
    - Measure
      - PWM duty cycle
      - I_{DS}



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- Lab 24 – MOSFET Motor Drive

Learning Objectives

- Build and test; MOSFET amplifier performance
- Measure gate voltage and drain current
- Plot the gate voltage / drain current relationship on a scatter plot
- Interface digital output with a MOSFET motor control

		Points Possible
Documentation	Quality of documentation (neatness, clarity, spelling, grammar)	**10**
MOSFET Test Circuit	$V_{GS(th)}$ recorded, compared to data sheet; Data table and scatter plot showing drain current and gate voltage; g_{fs} calculated and compared to data sheet; R_{DSon} calculated and compared to data sheet;	**10**
MOSFET Switch	Circuit function verified	**5**
Conclusions	Questions answered completely & accurately	**10**
	Total	**45**
Motor Control w PWM MOSFET	IDS recorded at 25%, 50%, 75%, and 100% duty cycle; motor speeds noted	**10**