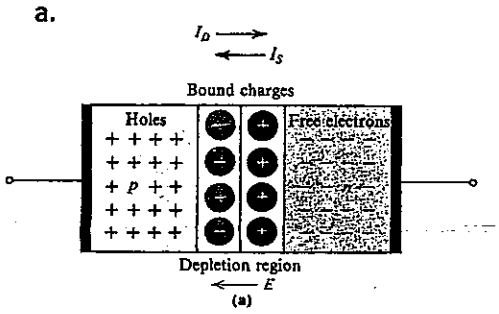
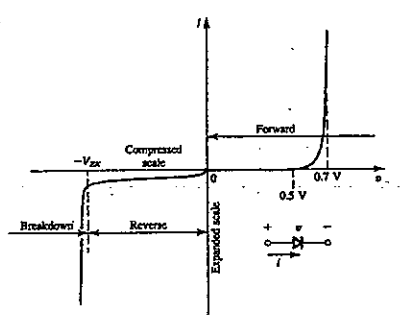
1. (20%) A transducer characterized by a voltage of 5 V rms and a resistance of 5 MΩ is available to drive a 50-Ω load. If connected directly, what voltage (2%) and power levels (2%) results at the load? If a unity-gain (i.e., $A_{vo} = 1$) buffer amplifier with 5 MΩ input resistance and 50 Ω output resistance is interposed between source and load, what do the output voltage (2%) and power gain (2%). For the new arrangement, find the voltage gain (3%) from source to load, and the power gain (3%). Please draw the circuit model of both configurations (direct drive (3%) and with unity-gain amplifier (3%)) to derive the answers.

2. (25%) Please use the following figures to qualitative description the characteristics of *pn* junction under (a) no applied voltage (open-circuited terminals) for the origins of I_D, I_S, V_O, and Depletion region (8%)
(b) the i-v characteristics of a silicon *pn* junction diode consists of three distinct regions: Forward (4%), Reverse (4%), and Breakdown (4%).
(c) One often uses a center-tapped secondary winding transformer and Full-wave diode rectifier circuit in a DC power supply as shown in Q3(c). Assuming a constant voltage-drop model for the diode, please sketch the input and output waveforms of v-t curve (5%)

a.



b.



c.

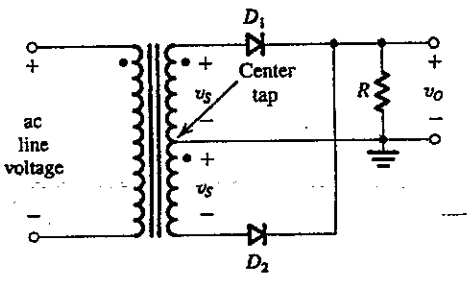


Figure Q2 (a)The pn junction with no applied voltage. (b) The diode i-v relationship. (c) Full-wave rectifier utilizing a transformer with a center-tapped winding circuit.

3. (20%) (a) Please give the five characteristics of the **ideal op amp.** (5%) (b) In reality, one can achieve such a superior performance by using the instrumentation amplifier as shown in the following figure. Please derive the overall differential voltage gain, $A_d \equiv \frac{v_o}{v_{Id}} = \frac{R_4}{R_3}\left(1+\frac{R_2}{R_1}\right)$, where $v_{Id} = v_{I1} - v_{I2}$ (10%). And discuss the advantages and disadvantages of this circuit. (5%)

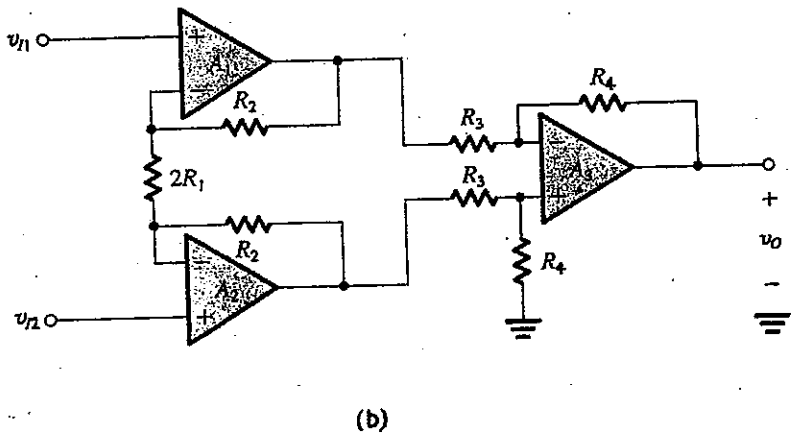


Figure Q3. A popular circuit for an instrumentation amplifier.

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4. (20%) The metal-oxide-semiconductor field-effect transistor (MOSFET) has become by far the most widely used electronic device, especially in the design of very large scale integrated circuits (VLSI) thanks to its small feature size, relatively simple fabrication process, and low power comparing to BJT. (a) For its importance, Please use the NMOS configurations and the i_D vs v_{DS} curve in the following figures to briefly explain the physical operation principle of a NMOS transistor under conditions of i. $v_{DS} \leq V_{OV}$ and ii. $v_{DS} \geq V_{OV}$.

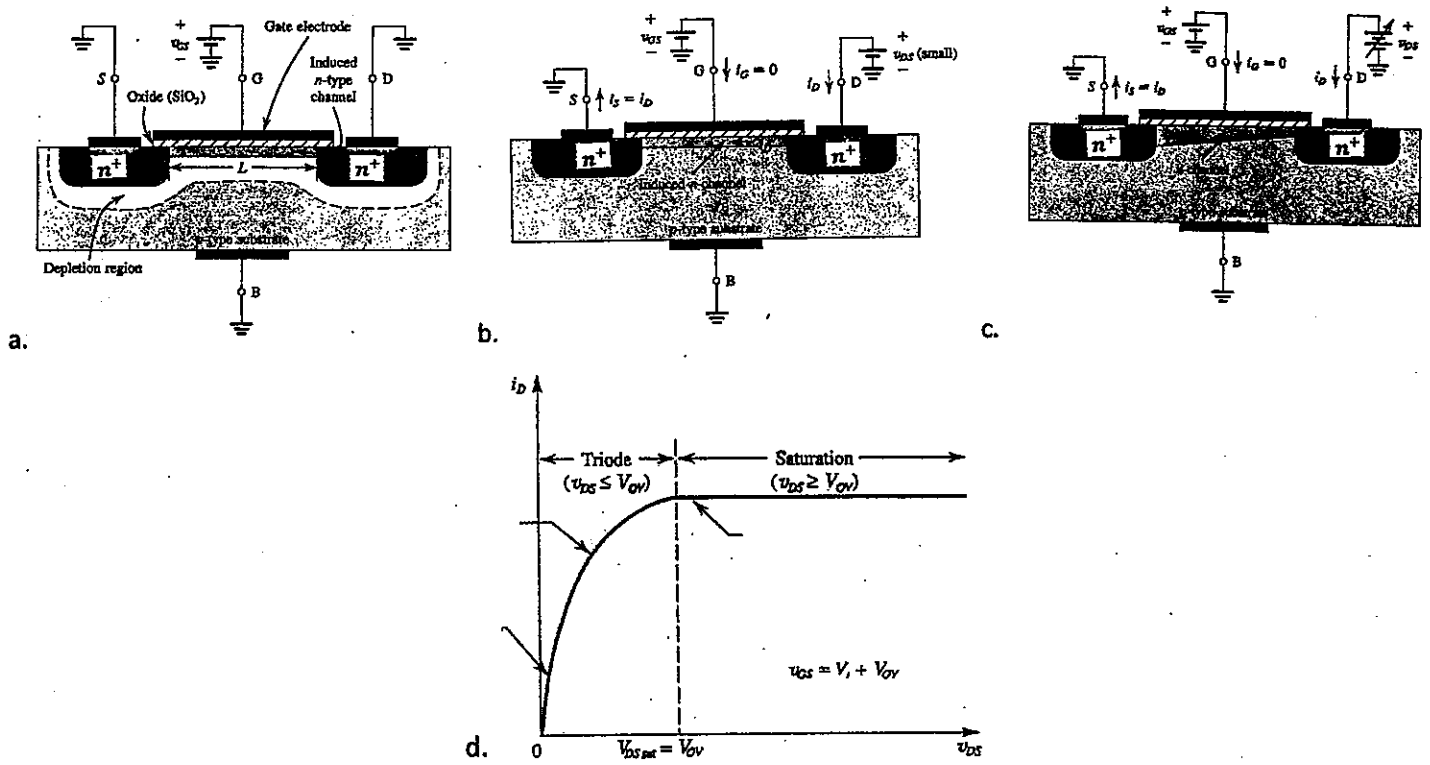

Figure Q4. The enhancement-type NMOS transistor under different bias configurations: (a) the enhancement-type NMOS transistor with a positive voltage applied to the gate, (b) $v_{DS} > V_t$, and a small v_{DS}, (c) v_{DS} is increased, and (d) corresponding i_D vs v_{DS} curve.

5. (15%) A common source (CS) amplifier utilizes a MOSFET biased at $I_D = 0.25$ mA with a $V_{OV} = 0.25$ V and $R_D = 20$ kΩ. The amplifier is fed with a signal source having $R_{sig} = 100$ kΩ and a 20 kΩ load is connected to the output. Find the R_{in}, A_{vo}, R_o, A_v, and G_v.

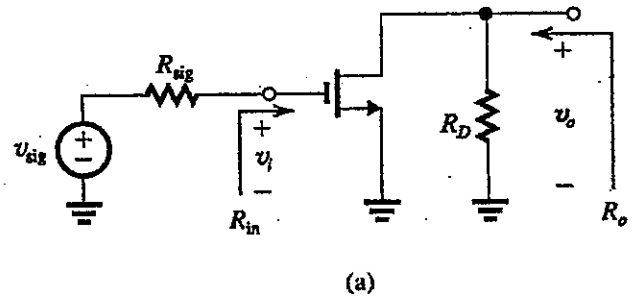

Figure Q5. Common-source amplifier fed with a signal v_{sig} from a generator with a resistance R_{sig} without showing the bias and loading circuit.

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