

Electronics II Formula Sheet by Mark W.

- Over drive Voltage: $V_{OV} = (V_{GS} - V_t)$ • $k'_n = \mu_n C_{ox} (A/V^2)$
- Cut off ($i_D = 0$): $v_{GS} < V_{th}$; • Channel induced and Mosfet is in triode or saturation: $v_{GS} = v_{DS} + V_{OV}$

Stats	Triode region	Saturation Region
Conditions	$v_{GS} > V_t$ $v_{DS} < v_{GS}$	$v_{GS} \leq V_t$ $v_{DS} \geq v_{GS}$
i_D	$\frac{1}{2} k'_n \frac{W}{L} (v_{OV} - \frac{1}{2} v_{DS}) v_{DS}$	$\frac{1}{2} k'_n \frac{W}{L} v_{OV}^2$

- $g_m = \frac{\partial i_D}{\partial v_{GS}} = k'_n \frac{W}{L} v_{OV} = g_m = \sqrt{2K'_n i_D} \sqrt{\left(\frac{W}{L}\right)} = \frac{2i_D}{v_{OV}} (4.6, 2.6)$, • $V_A = \frac{1}{\lambda}$, • $r_o = \frac{V_A}{i_D}$, • $A_v = -g_m (R_D || r_o)$.

Characteristic Parameters

MOSFET	Voltage Gain, A_v	G_v	Input Resistance, R_i	Output Resistance, R_o
Common Source (Hybrid model)	$-g_m (R_D r_o R_L)$	$-\frac{R_C}{R_C + R_{sig}} g_m (R_D r_o R_L)$	∞	$R_D r_o$
Common Source with a source resistance (T-Model)	$\frac{-g_m (R_D R_L)}{1 + g_m R_s}$	$-\frac{R_C}{R_C + R_{sig}} \frac{g_m (R_D R_L)}{1 + g_m R_s}$	∞	R_D
Common Gate (T-Model)	$g_m (R_D R_L)$	$\frac{1}{1 + g_m R_{sig}} g_m (R_D R_L)$	$\frac{1}{g_m}$	R_D
Common Drain (T-Model)	$\frac{r_o R_L}{(r_o R_L) + \frac{1}{g_m}}$	$\frac{R_C}{R_C + R_{sig}} \frac{r_o R_L}{(r_o R_L) + \frac{1}{g_m}}$	∞	$\frac{1}{g_m}$

- $f_t = \frac{g_m}{2\pi(C_{gs} + C_{gd})}$ (Unity Gain Frequency) • $R_L' = R_D || r_o || R_L$ • $C_{eq} = C_{gs}(1 + g_m R_L)$ • $C_{in} = C_{gs} + C_{eq}$
- $f_{Hf} = \frac{1}{2\pi C_{in}(R_{sig} || R_C)}$ (Upper 3-dB freq.)

Differential and multi-stage amplifier

Let I be the total current in common mode voltage

- $v_{DS1} = v_{DS2} = V_{DD} - \frac{I}{2} R_D$, • $i_{D1} = i_{D2} = \frac{I}{2} = k'_n \frac{W}{L} v_{OV}^2$

The value of v_{GS} at which the entire bias current I is steered into Q1 is $v_{GS1max} = v_{GS1} + v_s = \sqrt{2} V_{OV}$

Output of differential pair taken single ended:

- Common-mode gain = $|A_{CM}| = \frac{R_D}{2R_{sig}}$, • Differential gain = $|A_d| = \frac{1}{2} g_m R_D$, • $CMMR = \left| \frac{A_d}{A_{CM}} \right| = g_m R_{sig}$

Output of differential pair taken differentially:

- Common-mode gain = $|A_{CM}| = 0$, • Differential gain = $|A_d| = g_m R_D$, • $CMMR = \left| \frac{A_d}{A_{CM}} \right| = \infty$

Mismatch effect (g_m and R_D):

- $A_{CM} = -\frac{\Delta R_D}{2R_{sig}}$ (Rd mismatch), • $CMMR = \left| \frac{A_d}{A_{CM}} \right| = 2g_m R_{sig} / \left(\frac{\Delta R_D}{R_D}\right)$, • $A_{CM} = \frac{R_D}{2R_{sig}} \frac{\Delta g_m}{g_m}$ (g_m mismatch), • $CMMR = \left| \frac{A_d}{A_{CM}} \right| = 2g_m R_{sig} / \left(\frac{\Delta g_m}{g_m}\right)$

Electronics Engineering Formula For Gate Maschs

Brendan G. Carr



Electronics Engineering Formula For Gate Maschs:

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Table of Contents Electronics Engineering Formula For Gate Maschs

1. Understanding the eBook Electronics Engineering Formula For Gate Maschs
 - The Rise of Digital Reading Electronics Engineering Formula For Gate Maschs
 - Advantages of eBooks Over Traditional Books
2. Identifying Electronics Engineering Formula For Gate Maschs
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Electronics Engineering Formula For Gate Maschs
 - User-Friendly Interface
4. Exploring eBook Recommendations from Electronics Engineering Formula For Gate Maschs
 - Personalized Recommendations
 - Electronics Engineering Formula For Gate Maschs User Reviews and Ratings
 - Electronics Engineering Formula For Gate Maschs and Bestseller Lists

5. Accessing Electronics Engineering Formula For Gate Maschs Free and Paid eBooks
 - Electronics Engineering Formula For Gate Maschs Public Domain eBooks
 - Electronics Engineering Formula For Gate Maschs eBook Subscription Services
 - Electronics Engineering Formula For Gate Maschs Budget-Friendly Options
6. Navigating Electronics Engineering Formula For Gate Maschs eBook Formats
 - ePub, PDF, MOBI, and More
 - Electronics Engineering Formula For Gate Maschs Compatibility with Devices
 - Electronics Engineering Formula For Gate Maschs Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Electronics Engineering Formula For Gate Maschs
 - Highlighting and Note-Taking Electronics Engineering Formula For Gate Maschs
 - Interactive Elements Electronics Engineering Formula For Gate Maschs
8. Staying Engaged with Electronics Engineering Formula For Gate Maschs
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Electronics Engineering Formula For Gate Maschs
9. Balancing eBooks and Physical Books Electronics Engineering Formula For Gate Maschs
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Electronics Engineering Formula For Gate Maschs
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Electronics Engineering Formula For Gate Maschs
 - Setting Reading Goals Electronics Engineering Formula For Gate Maschs
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Electronics Engineering Formula For Gate Maschs
 - Fact-Checking eBook Content of Electronics Engineering Formula For Gate Maschs
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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