

time, power dissipation, and power density are affected in terms of the scaling factor, S . To be more specific, what would happen if the design rules change from, say, $1\text{ }\mu\text{m}$ to $1/S\text{ }\mu\text{m}$ ($S>1$)?

SOLUTION :

	<i>Const E field</i>	<i>Const V_{DD}</i>
W, L, t_{ox}	$1/S$	$1/S$
V_{DD}	$1/S$	1
C_{ox}	S	S
$C = C_{ox}WL$	$1/S$	$1/S$
k_n, k_p	S	S
I_{DD}	$1/S$	S
$t_{delay} = CY/I_{DD}$	$1/S$	$1/S^2$
<i>Power</i> $I_{DD}V_{DD}$	$1/S^2$	S
<i>Power density</i> $\frac{\text{Power}}{\text{Area}}$	1	S^3

3.9 A pMOS transistor was fabricated on an n-type substrate with a bulk doping density of $N_D = 110^{16}\text{ cm}^{-3}$, gate doping density (n-type poly) of $N_D = 10^{20}\text{ cm}^{-3}$, $Q_{ox} = 1/q = 4 \times 10^{18}\text{ cm}^{-2}$, and gate oxide thickness of $t_{ox} = 1.6\text{ }\mu\text{m}$. Calculate the threshold voltage at room temperature for $V_{DS}=0$. Use $\phi_s = 11.7\text{ }\phi_0$.

SOLUTION :

$$\phi_s(\text{substrate}) = \frac{kT}{q} \ln \frac{N_D}{n_i} = 0.026 \ln \frac{110^{16}}{1.45 \times 10^{10}} = 0.348[\text{V}]$$

$$\phi_s(\text{gate}) = \frac{kT}{q} \ln \frac{N_{D,\text{poly}}}{n_i} = 0.026 \ln \frac{10^{20}}{1.45 \times 10^{10}} = 0.587[\text{V}]$$

$$\phi_{sc} = \phi_s(\text{substrate}) - \phi_s(\text{gate}) = 0.348 - 0.587 = -0.239[\text{V}]$$

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Table of Contents Digital Integrated Circuits Demassa Solution

1. Understanding the eBook Digital Integrated Circuits Demassa Solution
 - The Rise of Digital Reading Digital Integrated Circuits Demassa Solution
 - Advantages of eBooks Over Traditional Books
2. Identifying Digital Integrated Circuits Demassa Solution
 - 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 a Digital Integrated Circuits Demassa Solution
 - User-Friendly Interface
4. Exploring eBook Recommendations from Digital Integrated Circuits Demassa Solution
 - Personalized Recommendations
 - Digital Integrated Circuits Demassa Solution User Reviews and Ratings

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