ANALOG CIRCUITS

Complete Multipage Master Handbook & Problem Solver | GATE ECE 2027

Target Exam:	GATE 2027 Electronics & Communication (EC)
Organizing Institute:	IIT Madras
Syllabus Standard:	100% Complete Syllabus + 2027 Revisions
Edition:	Comprehensive Multipage Textbook & Problem Solver

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CHAPTER 1: DIODE CIRCUITS & REGULATORS

1.1 Shockley Equation, Rectifiers & Clampers

Diodes act as non-linear unidirectional switches.

- **Diode Dynamic Resistance:** $r_d = V_T / I_D$.
- **Clamper Circuit:** Preserves peak-to-peak voltage V_{p-p} while shifting DC level.

CHAPTER 2: BJT & MOSFET SMALL-SIGNAL AMPLIFIERS

2.1 Hybrid-pi Model & Small-Signal Gain

Transistors are biased in active/saturation region for linear amplification.

- **BJT Transconductance:** $g_m = I_C / V_T$.
- **MOSFET Saturation Current:** $I_D = (1/2) * \mu_n * C_{ox} * (W/L) * (V_{GS} - V_{th})^2$.

CHAPTER 3: OP-AMP CIRCUITS & ACTIVE FILTERS

3.1 Ideal Op-Amp Rules & Applications

Ideal Op-Amps operate under infinite gain and zero input current rules.

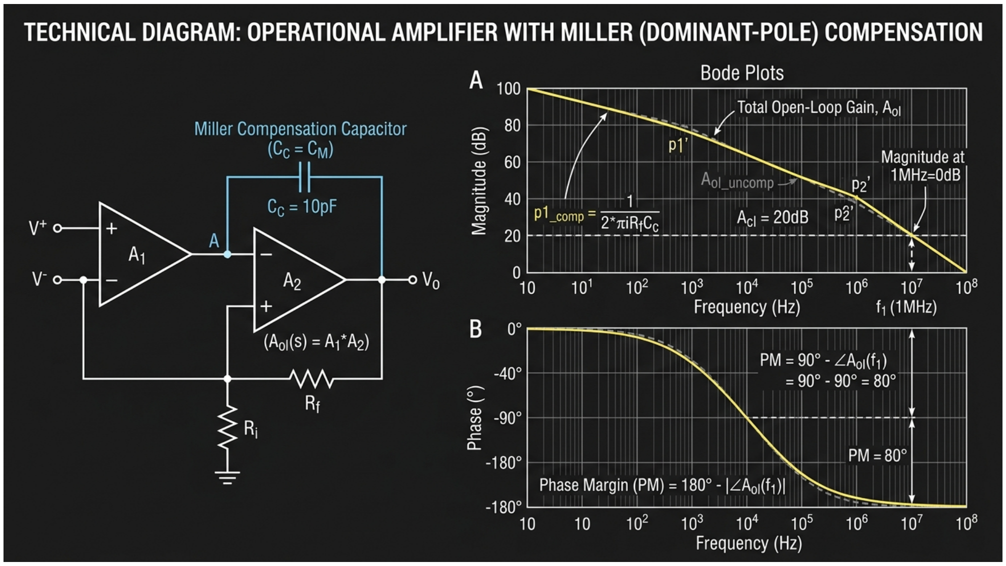
- **Virtual Short:** $V+ = V-$ under negative feedback.
- **Inverting Gain:** $A_v = -R_f / R_1$.
- **Non-Inverting Gain:** $A_v = 1 + R_f / R_1$.

CHAPTER 4: OP-AMP FREQUENCY RESPONSE & MILLER COMPENSATION

4.1 Miller (Dominant-Pole) Compensation & Phase Margin (NEW FOR GATE 2027)

Miller compensation stabilizes feedback amplifiers by pole splitting.

- **Pole Splitting:** Dominant pole p1 moves to lower frequency p1' = 1/(2*pi*R_in*A2*C_C).
- **Gain-Bandwidth Product:** GBW = g_m1 / (2*pi*C_C).
- **Phase Margin:** PM = 180° + angle(T(j*omega_gc)). Target PM >= 60° for clean stability.



WORKED GATE NUMERICAL: Miller Capacitor Calculation

Problem: Find Miller capacitor C_C for GBW = 10 MHz given g_m1 = 0.628 mA/V.

Step-by-Step Derivation & Solution:
GBW = g_m1 / (2*pi*C_C) -> C_C = 0.628*10^-3 / (2*pi * 10^7) = **10 pF**.

CHAPTER 5: FEEDBACK AMPLIFIERS & OSCILLATORS

5.1 4 Feedback Topologies & Barkhausen Criterion

Feedback alters input and output impedances and stability.

- **Voltage-Series Feedback:** Increases R_in, decreases R_out.
- **Barkhausen Condition:** |A * beta| = 1 and phase shift angle(A * beta) = 0° or 360° for sustained oscillation.