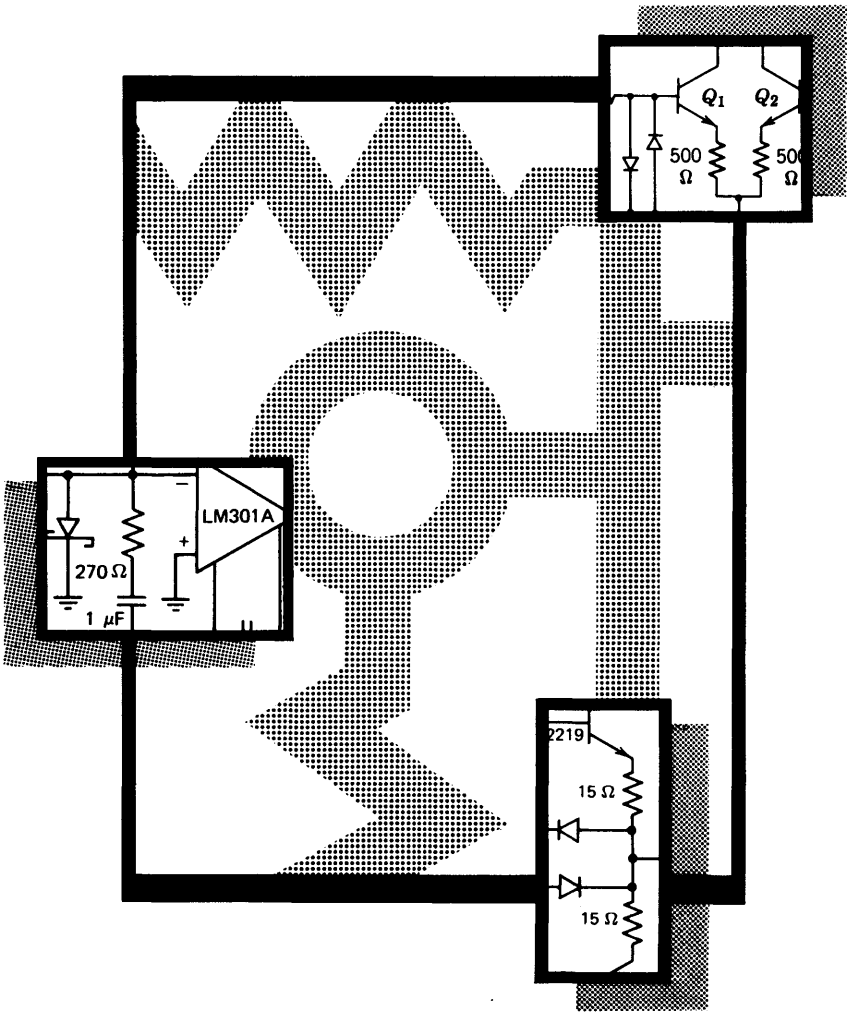
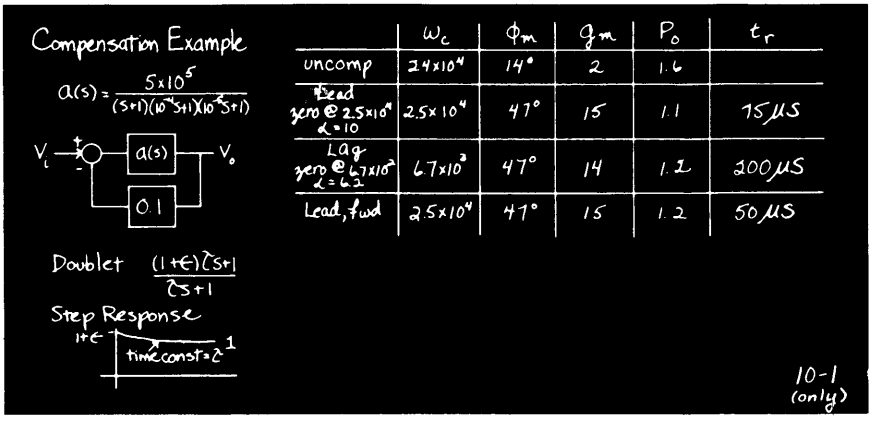
Compensation Example 10

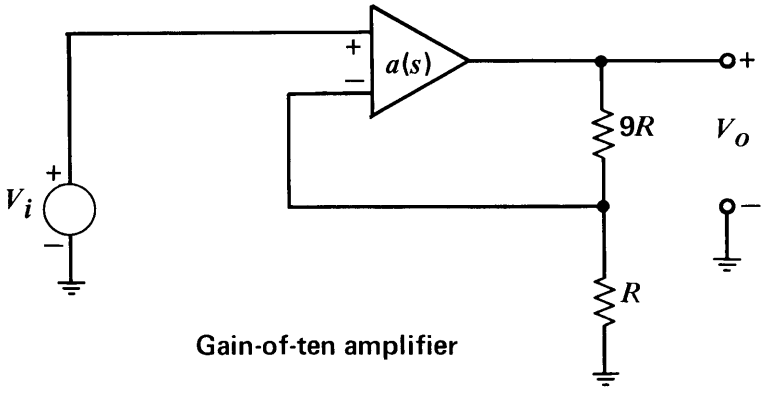


Blackboard 10.1



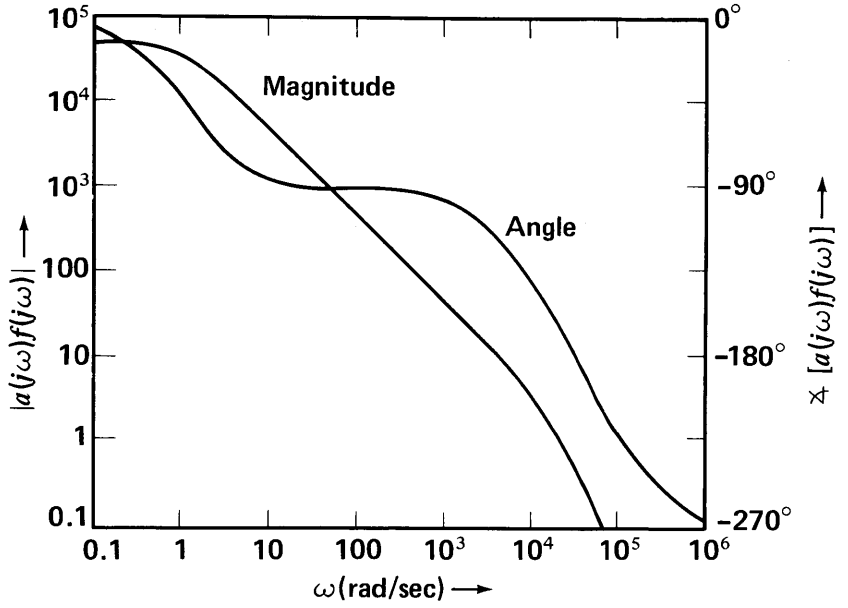
	ω_c	ϕ_m	g_m	P_o	t_r
uncomp	2.4×10^4	14°	2	1.6	
Lead zero @ 2.5×10^4 $\alpha=10$	2.5×10^4	47°	15	1.1	75 μs
Lag zero @ 6.7×10^2 $\alpha=62$	6.7×10^2	47°	14	1.2	200 μs
Lead, fwd	2.5×10^4	47°	15	1.2	50 μs

Viewgraph 10.1



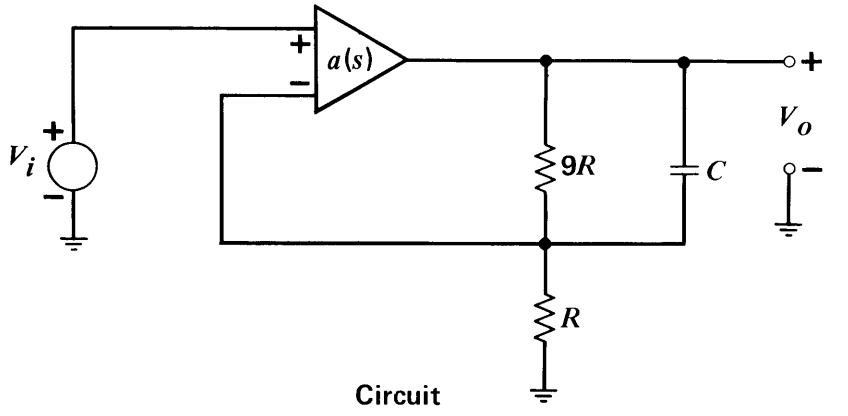
Gain-of-ten amplifier

Viewgraph 10.2



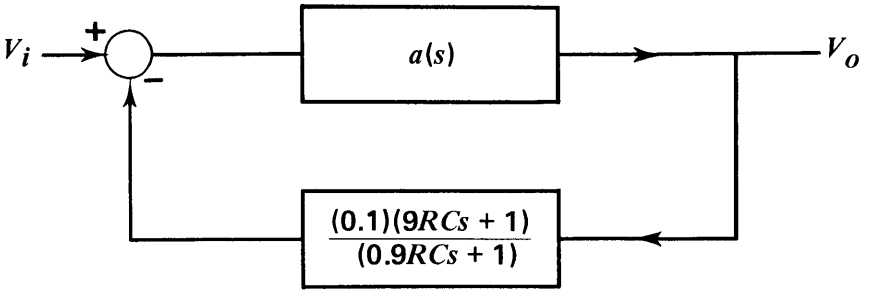
Bode plot for uncompensated gain-of-ten amplifier
$af = 5 \times 10^4 / [(s + 1)(10^{-4}s + 1)(10^{-5}s + 1)]$.

Viewgraph 10.3



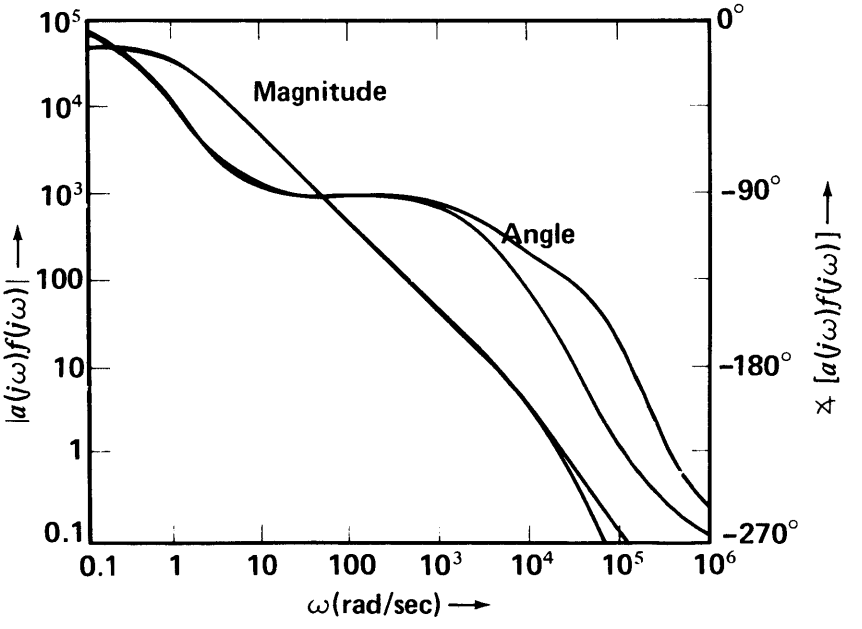
Circuit
Gain-of-ten amplifier with lead network in feedback path.

Viewgraph 10.4



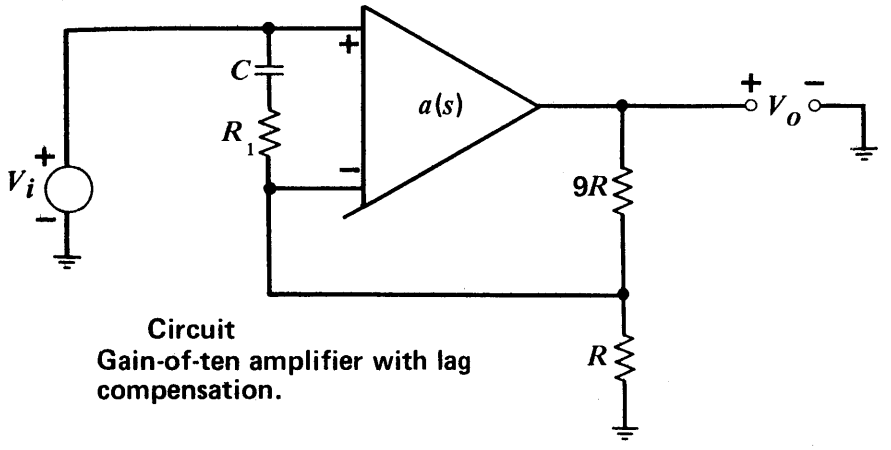
Block diagram
Gain-of-ten amplifier with lead network in feedback path.

Viewgraph 10.5



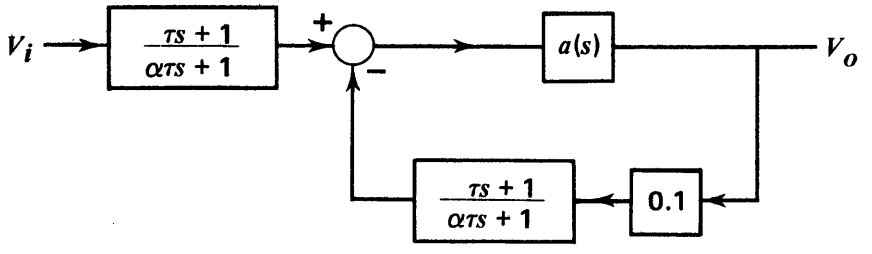
Bode plot for uncompensated gain-of-ten amplifier
$af = 5 \times 10^4 / [(s + 1)(10^{-4}s + 1)(10^{-5}s + 1)]$.

Viewgraph 10.6



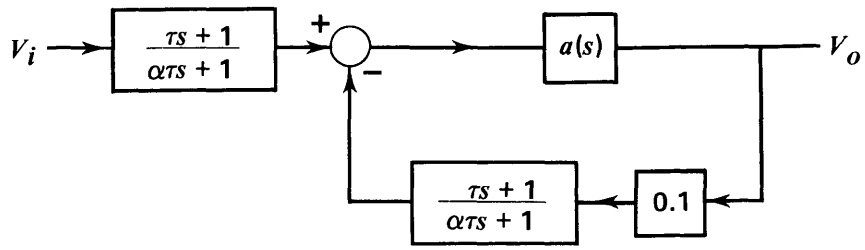
Circuit
Gain-of-ten amplifier with lag compensation.

Viewgraph 10.7



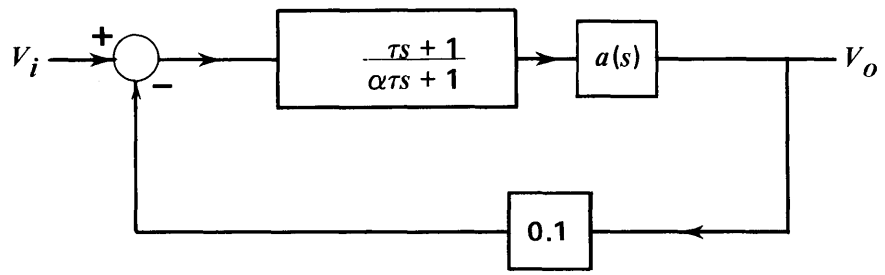
Block diagram
Gain-of-ten amplifier with lag compensation.

Viewgraph 10.8



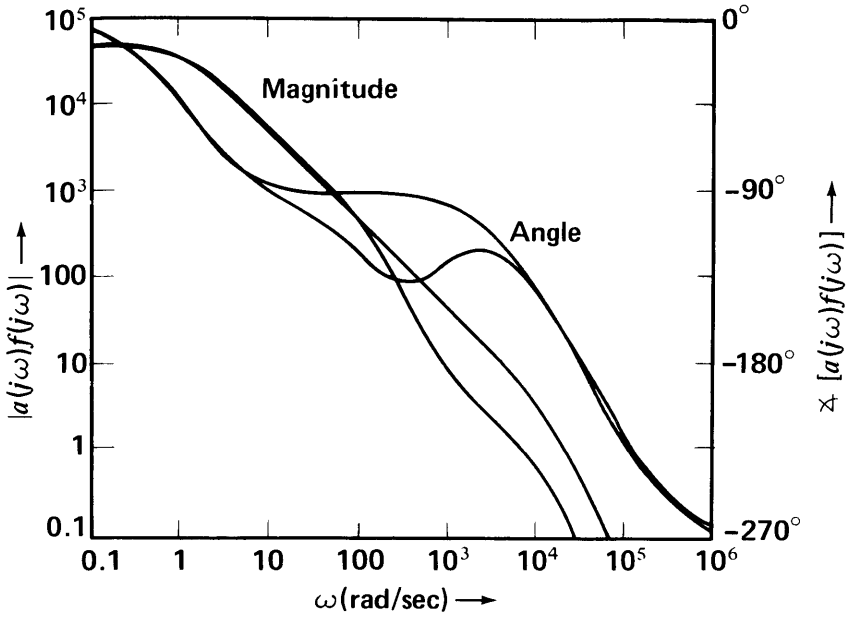
Block diagram
Gain-of-ten amplifier with lag compensation.

Viewgraph 10.9



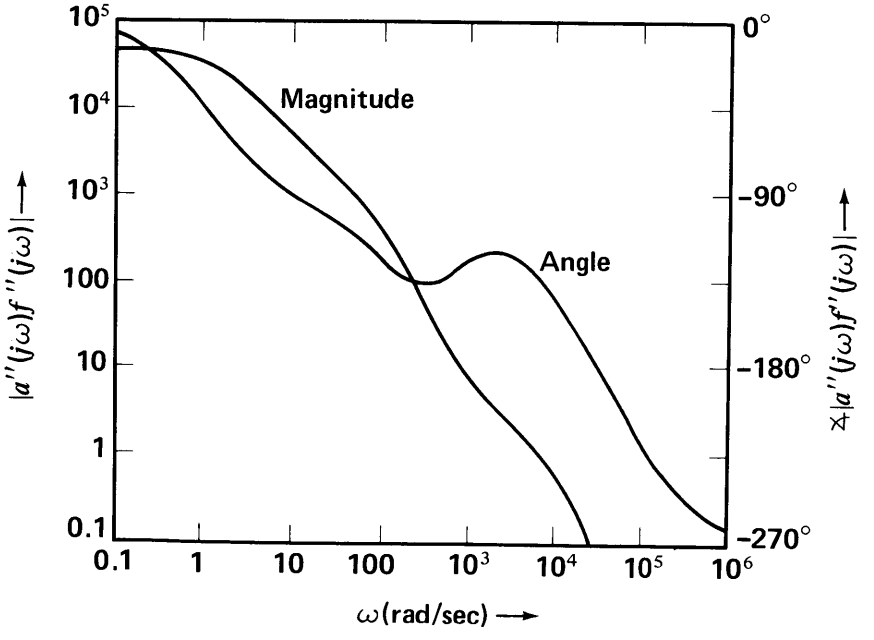
Block diagram following rearrangement.
Gain-of-ten amplifier with lag compensation.

Viewgraph 10.10



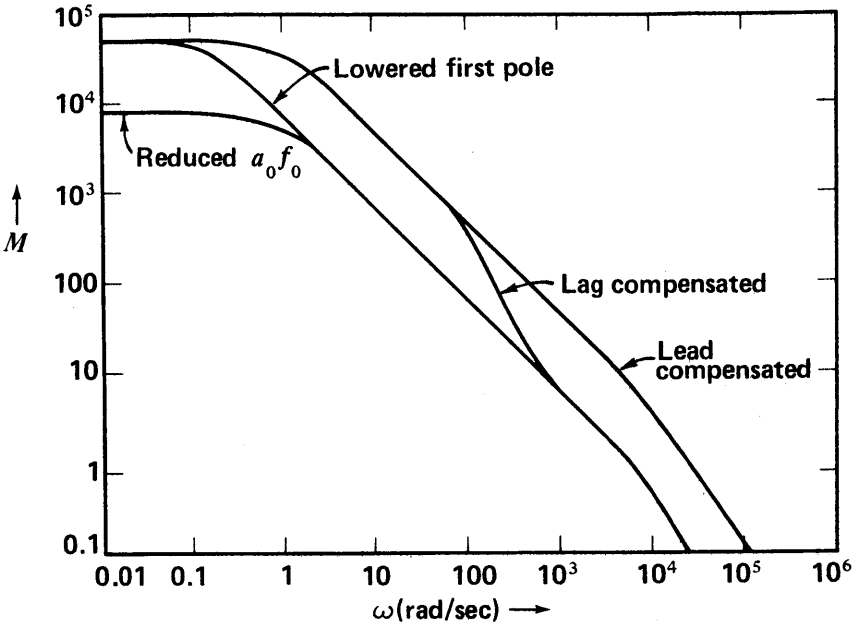
Bode plot for uncompensated gain-of-ten amplifier
$af = 5 \times 10^4 / [(s + 1)(10^{-4}s + 1)(10^{-5}s + 1)]$.

Viewgraph 10.11



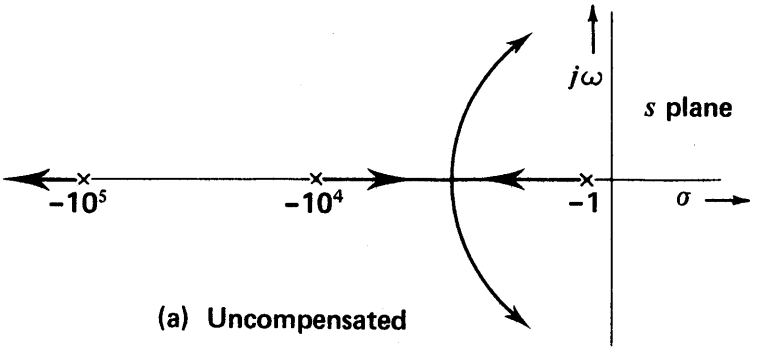
Bode plot for lag compensated gain-of-ten amplifier.
$a''f'' = 5 \times 10^4 (1.5 \times 10^{-3}s + 1)/$
$[(s + 1)(10^{-4}s + 1)(10^{-5}s + 1)(9.3 \times 10^{-3}s + 1)]$.

Viewgraph 10.12



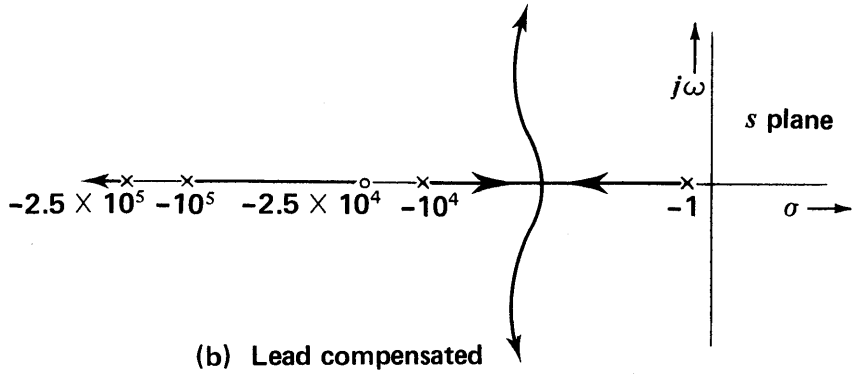
Effects of various types of compensation on loop-transmission magnitude.

Viewgraph 10.13



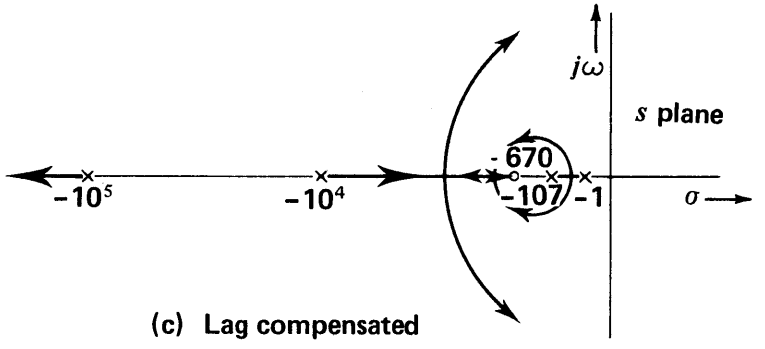
(a) Uncompensated

Viewgraph 10.14



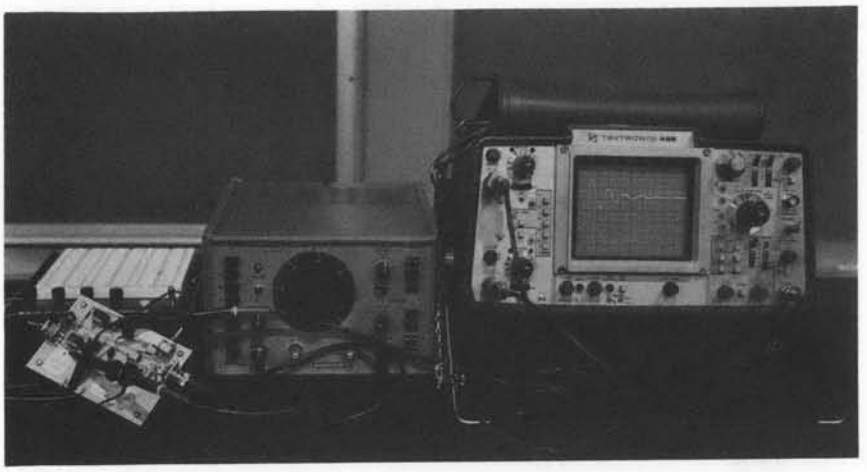
(b) Lead compensated

Viewgraph 10.15

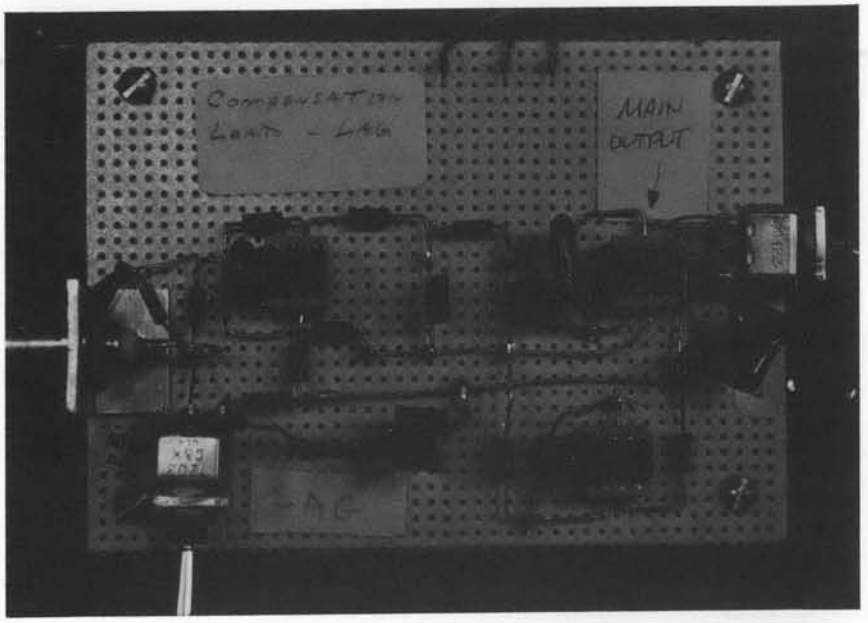


(c) Lag compensated

Demonstration Photograph 10.1 Gain-of-ten amplifier demonstration



Demonstration Photograph 10.2 Close-up of gain-of-ten amplifier



Comments

This lecture's analysis and the associated demonstrations show how the compensation methods developed earlier can be applied to a physical system. The demonstration system is, admittedly, somewhat contrived so that the required manipulations can be easily performed with accuracy. In many actual systems, exact system parameters are less certain. However, analysis parallel to that presented in the lecture generally provides an excellent first cut at the appropriate compensator, which may then be refined based on test results.

It is important that participants in this course have first-hand experience with the kind of analysis and measurements required for compensation. Toward this end, the problem (P5.15) suggested below, which includes substantial laboratory effort, is a very necessary part of the course.

Clarification

I suggest aiming for 47° of phase margin in the lag-compensated system without much justification for the design objective. The reason is effectively an educational one. We choose the lead compensation to provide the maximum possible phase margin given the constraints of the topology. This approach is reasonable, because the maximum achievable value of 47° is adequate, but certainly not overly conservative.

In the case of lag compensation, larger values of phase margin could be obtained by using larger values of α. The value of 47° was chosen so that direct stability and speed of response comparisons could be made with the lead-compensated amplifier.

Reading

Textbook: Sections 5.2.4 through 5.2.6.

Problems

Problem 10.1 (P5.8)

Problem 10.2 (P5.12)

Problem 10.3 (P5.13): In calculating the settling time for the lag-compensated gain-of-ten amplifier, make the simplifying assumption that the loop transmission is second order. That is, the poles of Equation 5.15 at 10^4 and 10^5 rad/sec may be ignored, and $a''(s)$ approximated by

$$a''(s) \simeq \frac{5 \times 10^5(1.5 \times 10^{-3}s + 1)}{(s + 1)(9.3 \times 10^{-3}s + 1)}$$

Problem 10.4 (P5.15)

RES.6-010 Electronic Feedback Systems

Spring 2013