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A SCENARIO OF PLANNING AND DEBUGGING

IN ELECTRONIC CIRCUIT DESIGN

by

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Abstract

The purpose of this short document is to exhibit how a HACKER-like top-down planning and debugging system can be applied to the problem of the design and debugging of simple analog electronic circuits. I believe, and I hope to establish, that this kind of processing goes on at all levels of the problem-solving process--from specific, concrete applications, like Electronic Design, through abstract piecing together and debugging of problem-solving strategies.

A Scenario of Planning and Debugging

in Electronic Circuit Design

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The essence of the theory is that the problem-solver starts out with a set of basic modules which are solutions to various basic problems. Each module is indexed by some coarse description of the problem it is intended to solve. There may be several modules which are solutions to the same coarsely described problem. The choice of which to use in any case constitutes a design decision and must be based upon a finer decription of the module, how it interacts with a finer description of the problem which it is to solve and other modules which it must interact with in solution of the problem of which it is a solution of a subproblem. When confronted by a problem, the problem-solver must first see if it has an immediate coarse solution to try out. If not, it must concoct one by breaking up the problem into subproblems and patching together the subsolutions. The proposed solution is then tried out and debugged. Debugging consists of isolating the cause of failure to one submodule or a particular sort of interaction between the submodules.

The affected region of the solution is then examined in finer detail and a subproblem is generated to patch the bug. The problem solver can be caused to acquire skill by saving the problem solutions it generates, coarsely indexing them by generalizations of the problems for which they were constructed.
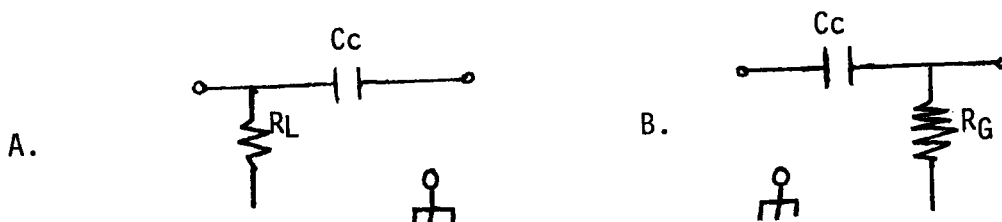
In this scenario the following modules are used:

I Class A amplifier: (tube type)
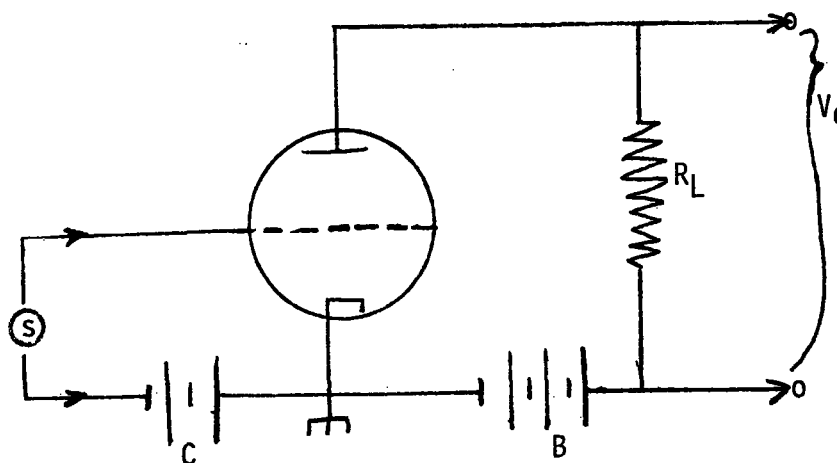
It is specified that the signal source, S, is pure A.C. and (to first order) sees an infinite impedance. The output voltage, Vo, has a D.C. bias caused by the battery, B.

II The "RC coupling" trick. To pass the AC component of a signal without coupling the DC bias circuits:

We want Cc to have a small impedance at the signal frequency and have a large impedance to DC; Rl, Rg to have large impedances at the signal frequency and small impedances to D.C. (Rg may be large.)

III   The "Tank" circuit—Infinite impedance at one frequency, zero at all others.

A. L C

B. C_B L C
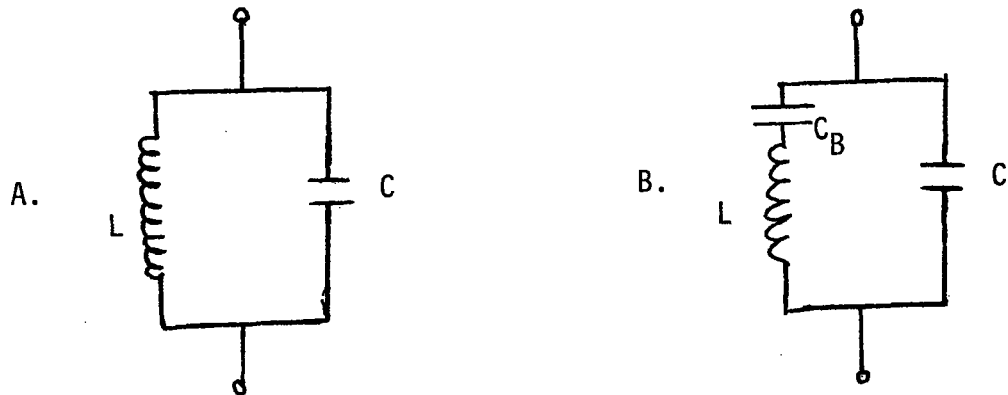
Circuit B has infinite impedance at DC as well as at resonance—Cb>>C. Certainly with modules I and II we could produce an untuned amplifier which amplifies the AC component of a signal, ignoring the DC component. This circuit works O.K.

Vi R_G R_L Vo

C   B
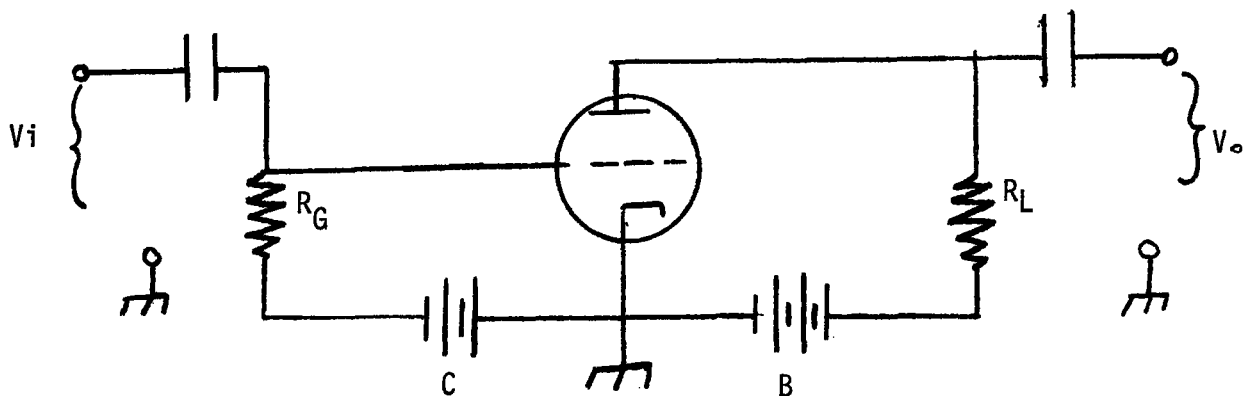
Vo = gain x Vi   for AC voltages Vi, Vo (above some frequency determined by the component values. And within some maximum amplitude.)

The gain is also determined by the component values. If we need more

gain than can be feasibly obtained with one stage we can surely "cascade"

stages:
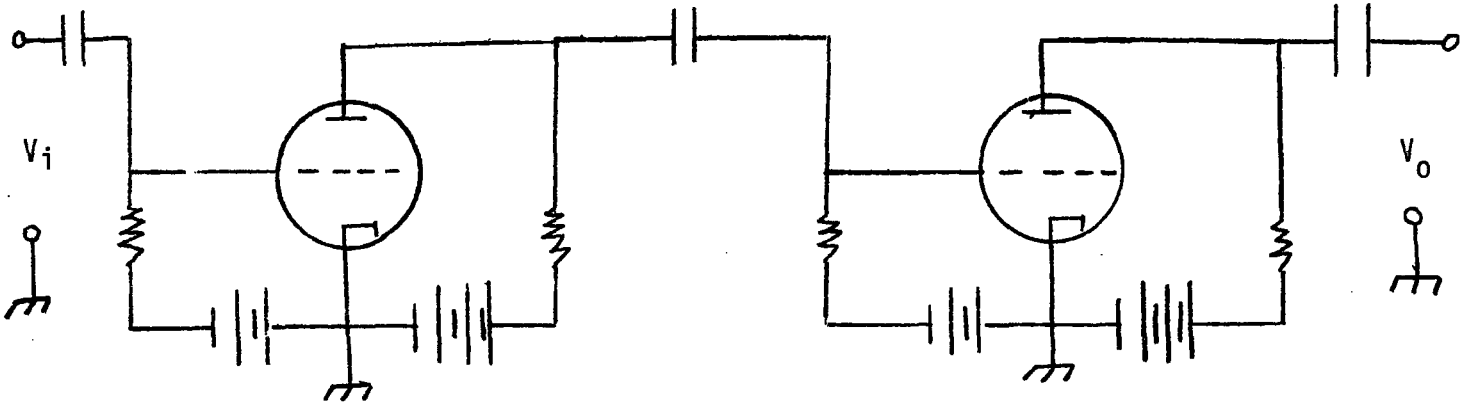
Suppose, however, we want to build a tuned amplifier-- one that amplifies

at only one frequency. Surely we can replace our Rg, Rl with tank

circuits which will short to ground all frequencies except the desired

one. Type A provides a good DC path as well:
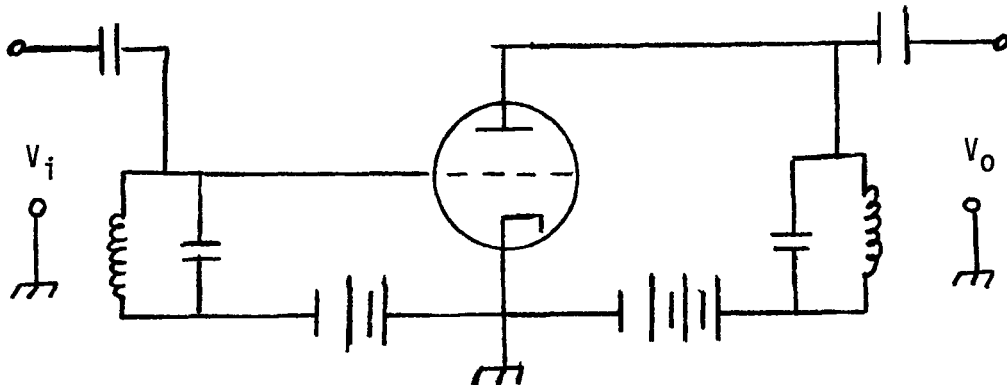
This works well enough up to some frequency like 1MHz. Above that

frequency the circuit oscillates rather than amplifies. We have a "bug".

Why does the circuit oscillate? In planning we used a coarse description

of module I, the basic amplifier; we ignored such effects as inter

electrode capacitance. In more detail, the tube looks like:
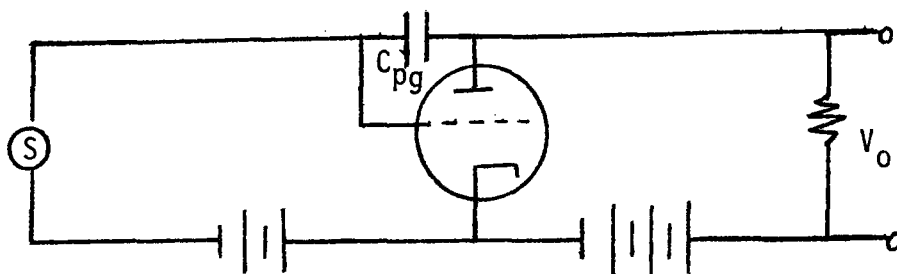
Cpg is very small, say 1 - 10 pf, so it has little effect at low frequencies, but at high frequencies there is feedback through Cpg which causes the spurious oscillation.

How can we correct the bug? We can try two possibilities--remove Cpg or cancel Cpg. We can remove Cpg by substituting a tetrode for a triode (not always the best choice because a tetrode has a higher noise figure and the bias circuitry becomes more complex). A tetrode is a tube which has a Faraday shield between the control grid and plate:
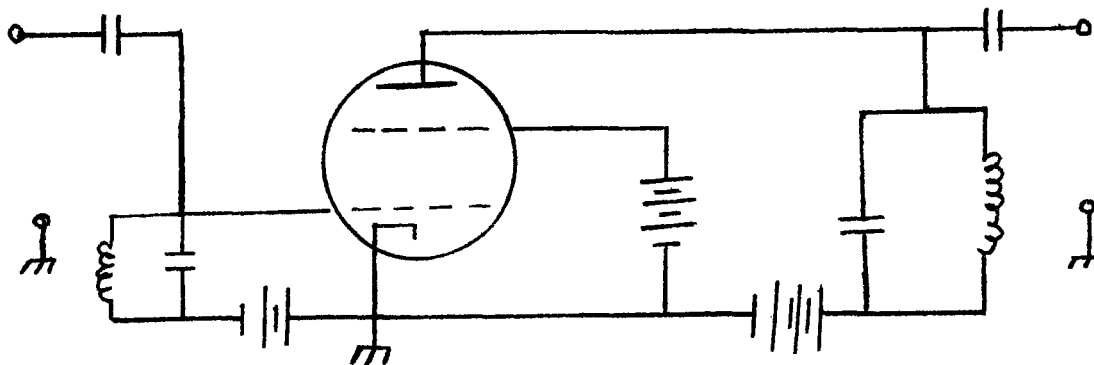

This is one possible answer which works. We haven't considered the problems of replacing all of the bias supplies by a bias network and one supply.

We can also try to cancel Cpg. We can always make the impedance across a capacitor infinite (open the capacitor) at one frequency by

bypassing it with an inductor at that frequency (using our tank circuit idea). Furthermore, we can prevent shorting out our power supply through the inductor by using a D.C. blocking capacitor as in ciruit II B. This new circuit is called a "neutralized tuned amplifier":
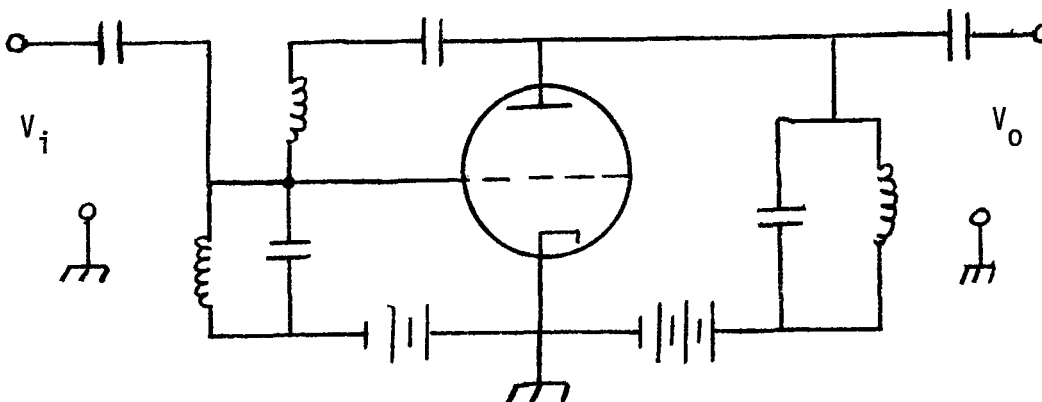
If we want to be clever, we can even "bum out" the plate blocking capacitor on another pass:
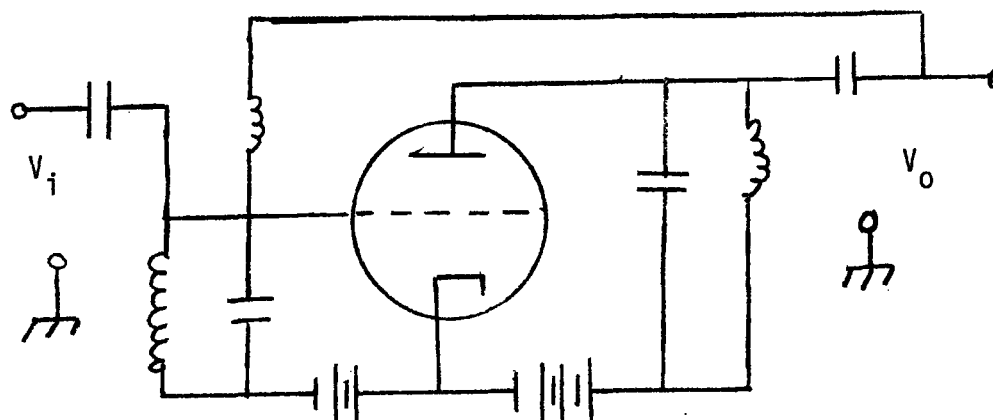
This circuit is used extensively (with an appropriate D.C. bias network superimposed) as a linear RF amplifier.