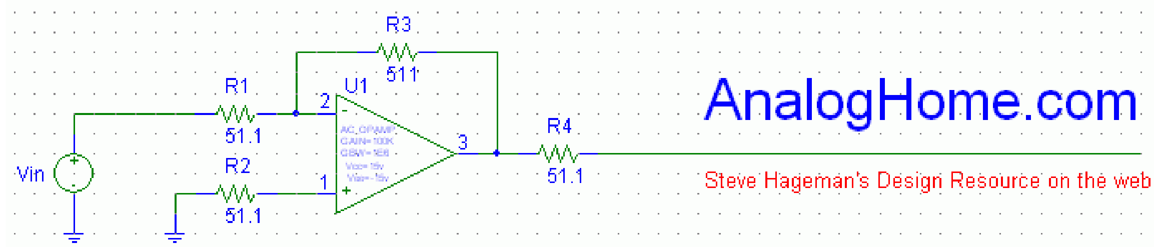


# Squegging - What the heck is that?

Application Note: AN002

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Since I first put the word Squegging on this website I've been amazed at the response. It seems that I'm not the only one who has experienced the joys of squegging and many folks have asked me what I know about it.

My first encounter with squegging was in 1977 as an undergraduate engineering student. We had a linear circuit's lab where the assignment was to build a AC amplifier that had a DC operating point feedback loop. I don't remember the exact circuit but it was something like is shown in figure 1.

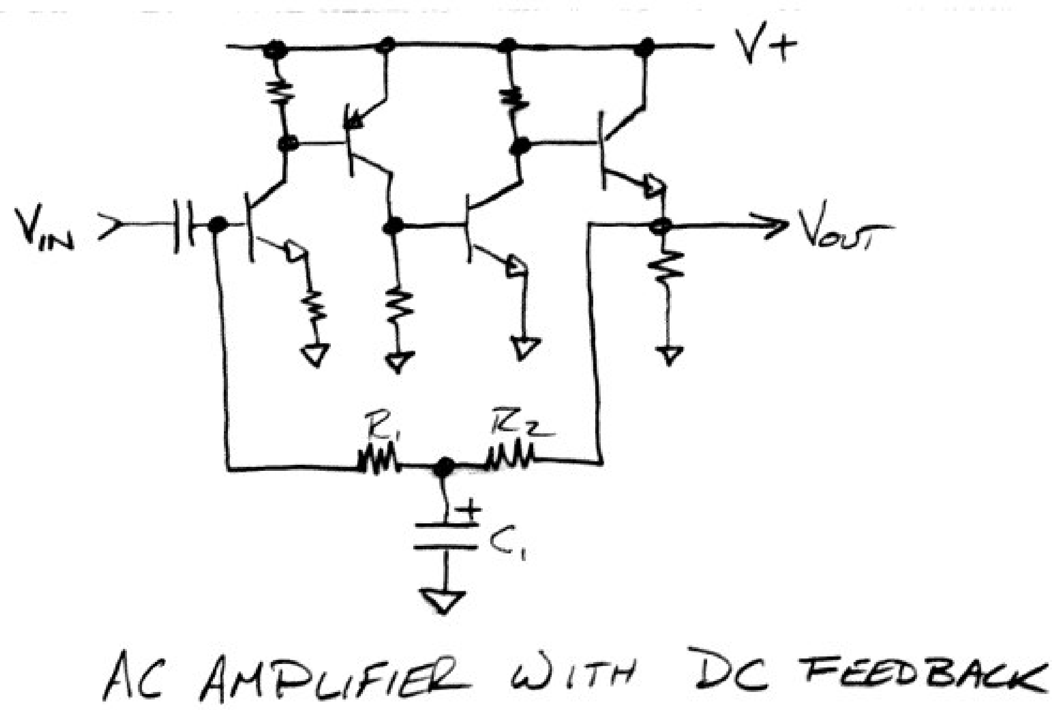
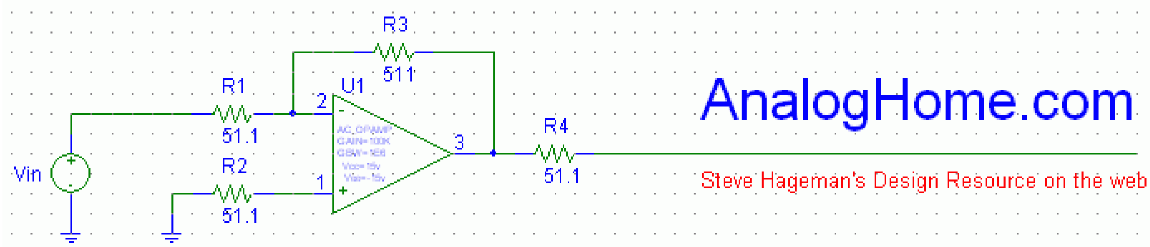



**Figure 1 – This was the approximate schematic of the circuit that gave me my first encounter with squegging. R1, R2 and C1 were *supposed* to form a low frequency self bias network. But something went wrong causing the characteristic squegging oscillation.**




It can be seen that with proper selection of the R1 and R2 the circuit can be made to self adjust its own DC bias point. C1 is chosen to roll off this DC feedback loop to be well below the signal frequency.

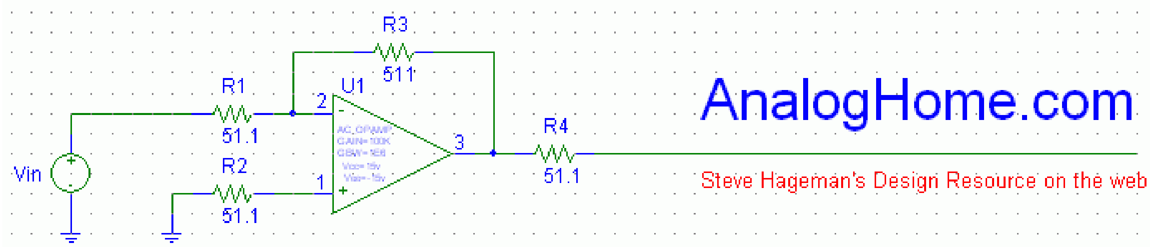
Basically the problem was confounded by the long lead lengths we had with the breadboard. With extra inductance everywhere and the pretty hot 2N2222A's we were using it was easy to make a VHF oscillator. When the circuit oscillated the DC bias point circuitry was thrown off and alternately forced the entire amplifier between cutoff where no oscillation could happen and a more linear region where oscillation readily occurred.

The first notice my lab mates and I had of this problem was the output had nonlinear waveform on it even without any input signal present.

Our sage old professor came over took one look at our Tektronix 535 scope display and said: "Hmmmm.... It's squegging." He then explained that we had a high frequency oscillation that was driving our amplifier nonlinear and since we were in a linear circuit's class so this was not allowed! After shortening the leads our circuit worked better and we finished the lab.

From that humble beginning I have experienced squegging several other times in my career. I'll recount some of the details here.....

It is relatively easy to get a DC/DC converter control loop to squege. You can observe this when you see the switching transistor drive go for several cycles then completely cutoff for several milliseconds then repeat (See figure 2).



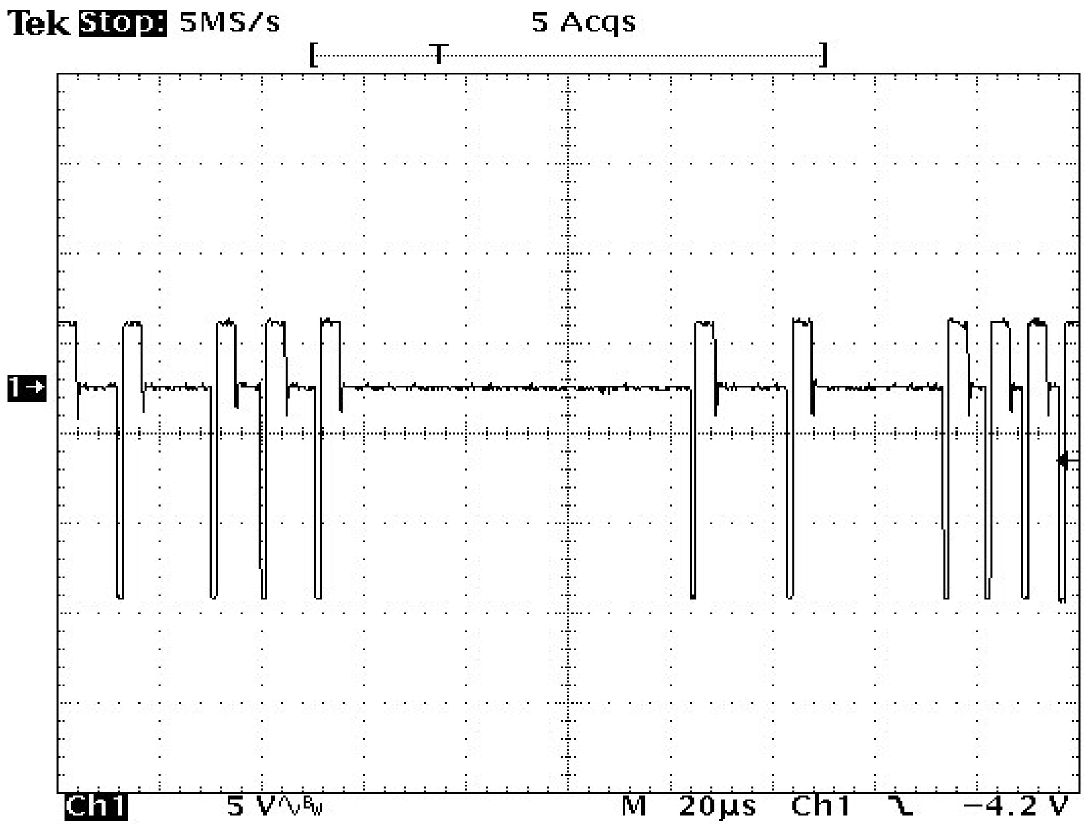




**Figure 2 – A scope shot of an actual squegging DC/DC converters switching transistor node. These kinds of problems are commonplace with improperly implemented power supplies! The converter runs for a few cycles then shuts off for many cycles.**

Even though the output voltage is correct and you may get the full rated output from the power supply the situation is less than ideal. This is mainly because the output ripple and noise will be higher than if the converter is operating in a more stable mode. The usual cause of this type of squegging is that the control loop has insufficient phase margin because: 1) The loop bandwidth is set to high or 2) The loop bandwidth is way to low. Typically the loop bandwidth for a modern 100 kHz – 1 MHz switching frequency will be on the order of 500 to 5000 Hz. Anything too high or too low can lead to instabilities. Many times improper layout leads to noise coupling past the loop shaping circuit directly to the control node effectively causing a higher loop bandwidth than planned. The solution is to fix the loop bandwidth shaping values or fix the layout.

The last example I have here of squegging is a common Tripler output circuit (figure 3).

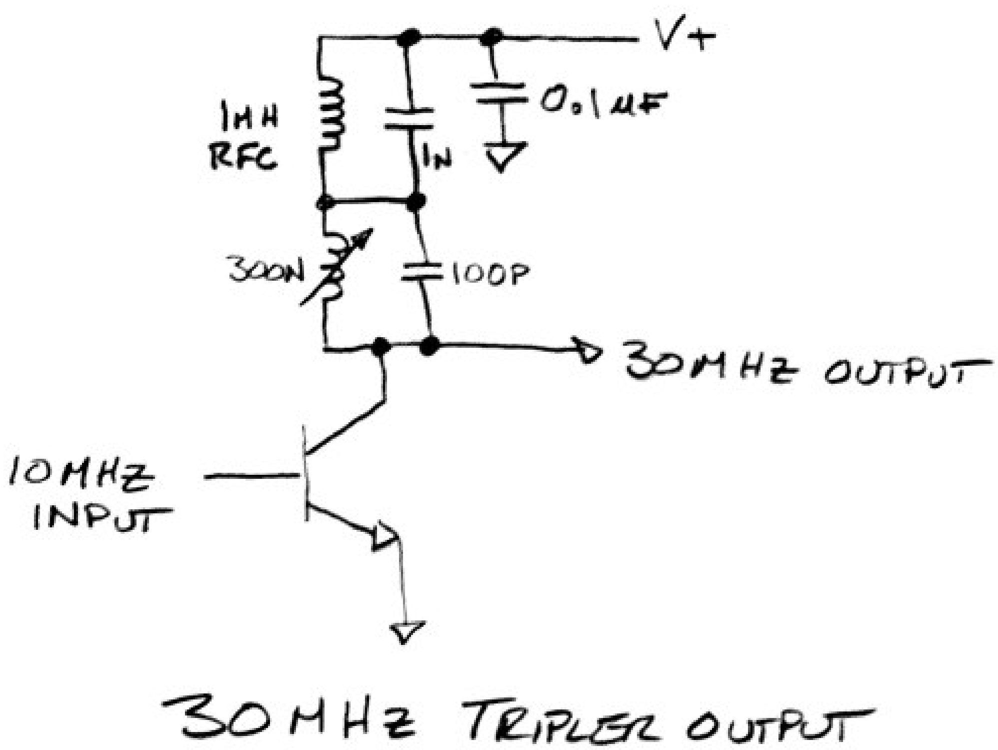



**Figure 3 – This common Tripler output stage uses the 300 nH inductor and the 100 pF capacitor to peak the desired 30 MHz output. The 1 nF capacitor series resonates with the 300 nH inductor to notch out the 10 MHz fundamental. What could go wrong with this? Well read on to see….**

This circuit takes in a 10 MHz square wave and the 300nH || 100pF tank circuit resonates at 30 MHz to pass that frequency component. To remove the 10 MHz fundamental frequency component to a lower value, a 1nF capacitor is added in series with the 300 nH inductor to form a 10 MHz series resonant circuit. However, this capacitor also resonates with the 1 mH RFC at around 159 kHz causing a low frequency response pole as shown in figure 4.

How this led to squegging in this case was the power supply decoupling was not sufficient at 150 kHz to dampen the response peak. This allowed the 150 kHz to feed-back through the power supply rail into the sensitive 10 MHz driver circuit and you know the rest – yes, the circuit had a nonlinear oscillation at 159 kHz. The solution to this problem was to add more low frequency filtering to the sensitive 10 MHz driver circuit on the power supply rail.

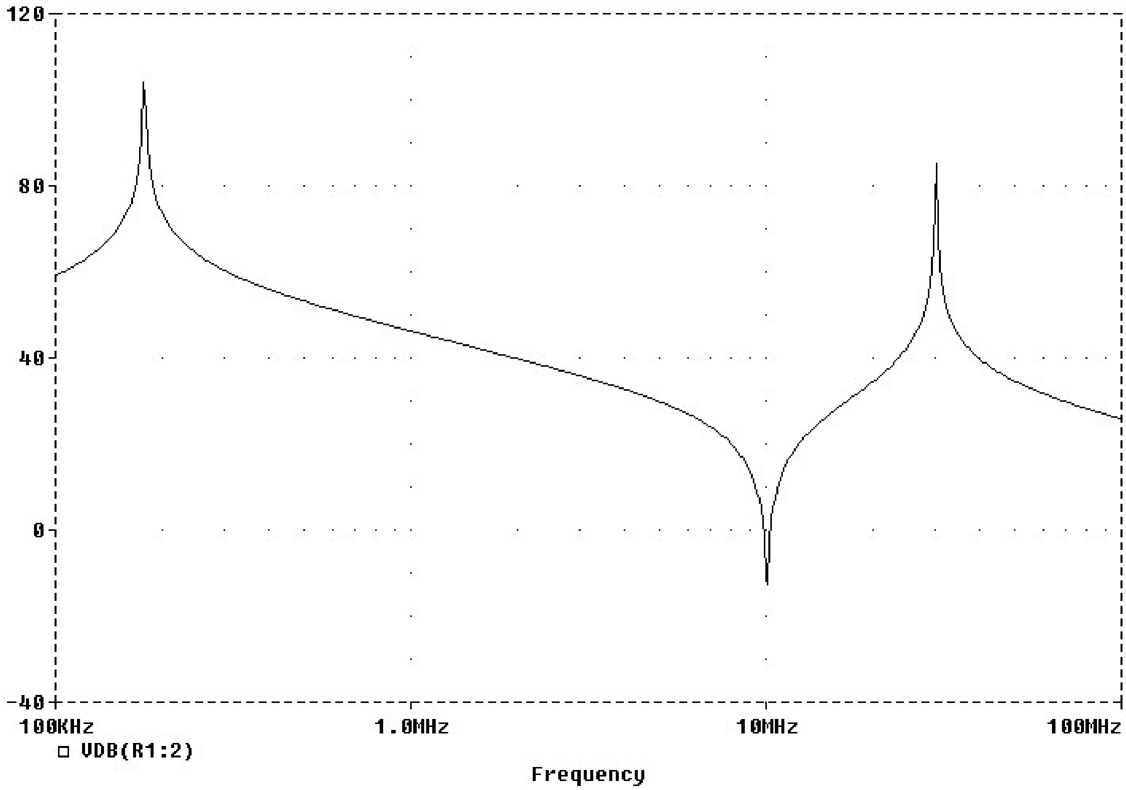
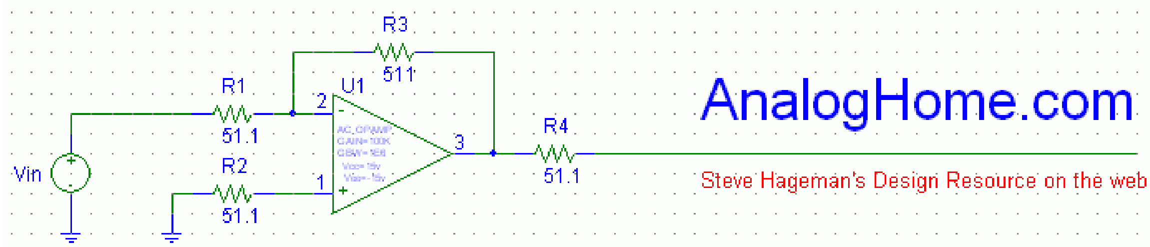



**Figure 4 – Here is the response of the circuit shown in figure 3. The peaked response is clearly shown at the desired frequencies of 30 MHz and 10 MHz. The undesired response is the result of the 1 mH RFC resonating with the 1nH capacitor. In this case the response fed back through the power supply to the driver circuit causing a squegging oscillation.**




So there you have it – all I know about squegging in a few pages. I have presented squegging in a negative light, as an undesired characteristic. However I know of two useful squegging circuit configurations:

1) A regenerative receiver basically has a built in squegging action.

2) If you search around the web you can find some information on Wildlife Tag Transmitters that use a simple squegging action to gate the RF locating signal on and off.

You will probably encounter the dark side of squegging, as an undesired effect. Whenever you get an off frequency non-linear oscillation on a supposedly linear circuit you are probably faced with a form of squegging. The solution is to look for: Improper loop bandwidths or feedback mechanisms in your layout and even unintended feedback loops in the power supply lines. By fixing the loop bandwidths or removing the unintended feedback paths the squegging can probably be cured.