EEC 134AB Application Note
Analog Function Generator and PCB Fixes
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Part 1, Analog Function Generator

The analog function generator shows promise of being considerably lighter and with a lower power consumption than the teensy-based circuit. Additionally, it should generate less noise and be almost absolutely reliable. This made the idea of it immediately appealing, so I made an effort at using such a circuit.

However, I should immediately warn you that it does not work for reasons I wasn't able to determine. The system will work up to the point the audio file is uploaded to the python code, at which point the code will not run. I chose to make this application note anyway because I assume a relatively simple fix could be found based on the work so far.

The triangle wave generator was designed using the following block diagram:

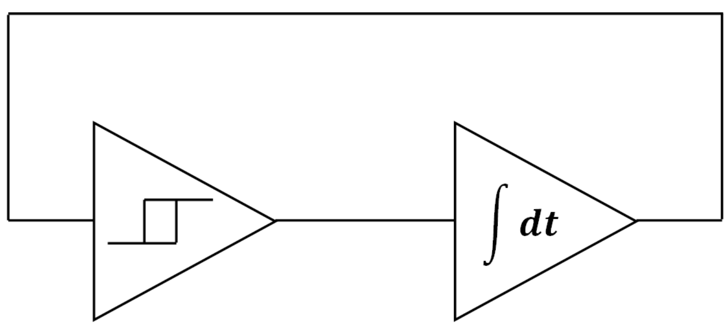

Figure 1, block diagram for triangle wave generator

The Schmitt trigger and integrator form a feedback loop, once the voltage output from the integrator is larger than the positive trigger voltage, the Schmitt trigger output goes to zero and the voltage decreases to the negative trigger voltage, where the output flips again. This is most easily implemented using two operational amplifiers, one for the Schmitt trigger and one for the integrator.

The following schematic shows implementation of just the loop shown in figure 1.

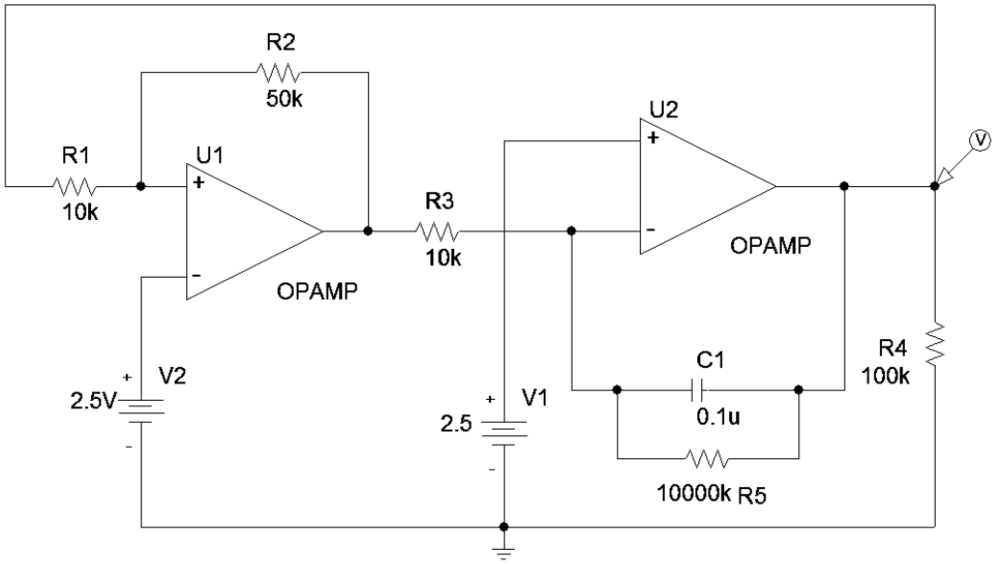

Figure 2, op amp implementation

The simulation output appears like so:

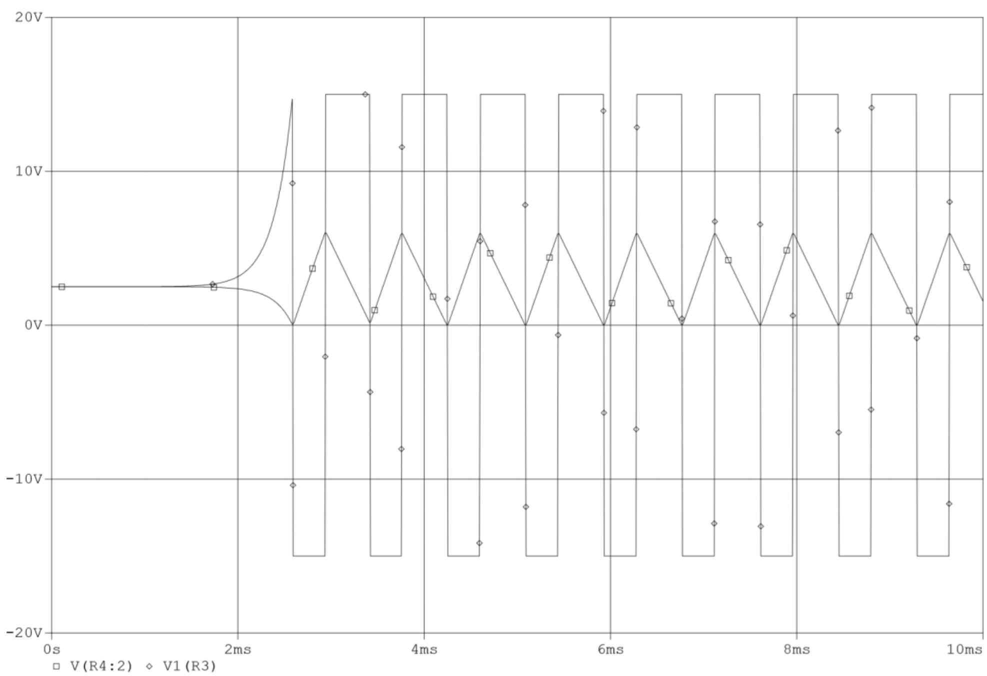

Figure 3, simulation output

The sync output comes from the output of the Schmitt trigger, the triangle wave comes from the output of the integrator. If a quad op-amp is used, such as the TL974, the outputs can be sampled without perturbing the feedback loop using non-inverting amplifiers or voltage buffer configurations due to their very high input impedance. The biasing voltages can be most easily accomplished using a voltage divider with a trimmer so it can be tuned as needed to eliminate the skewing. Getting the sync signal to be exactly 50% duty cycle is the easiest way to ensure the signal has no skew. To adjust the frequency, the hysteresis thresholds on the Schmitt trigger need to be adjusted. Using a trimmer for R2 is the easiest way to do this, but it changes the output voltage as well.

Finally, the output voltage needs to be set, both the center voltage and peak to peak amplitude. This can be done with a non-inverting amplifier and a voltage divider for biasing. Using a trimmer for R1 and R4 allows you to adjust both the peak to peak amplitude and center voltage in that order.

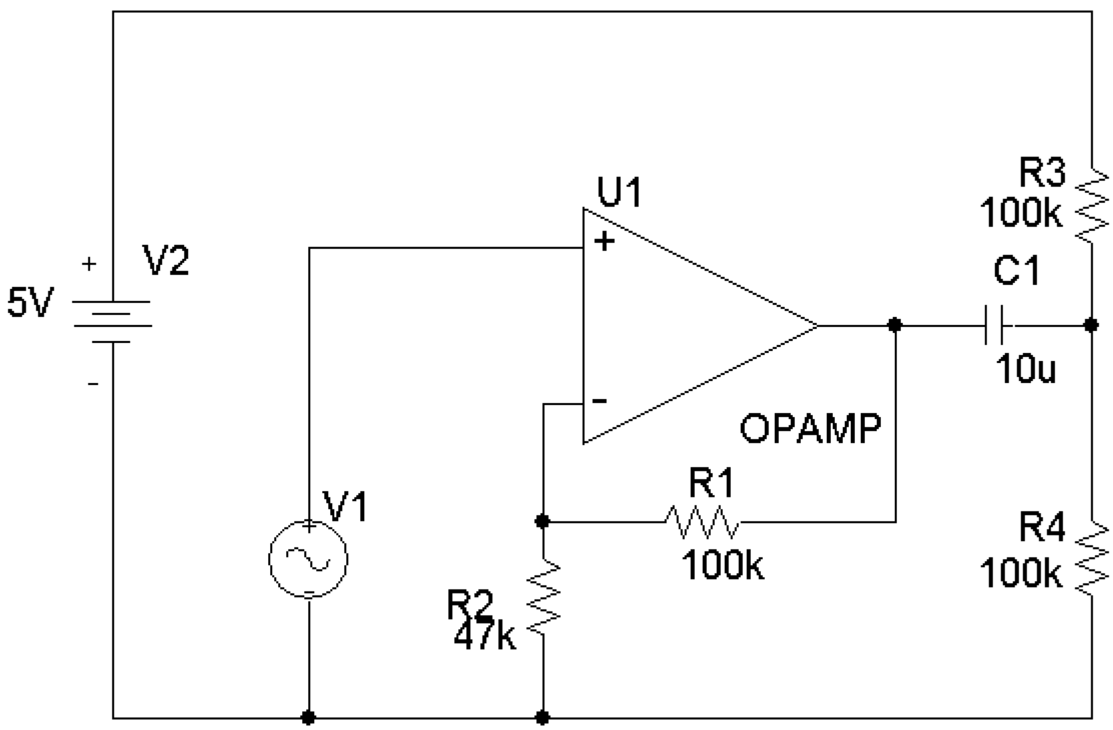

Figure 4, triangle wave amplifier

The generator worked best for 100Hz signals, for 25Hz the voltage would begin to droop and become nonlinear near the switching thresholds even for very large integrator capacitors and small switching thresholds.

Part 2: PCB Fixes

So it's week 10 and you've discovered an error in your PCB design. Is there anything you can do? If it's on the baseband lines, the answer is definitely yes, you can jury rig connections as necessary. In some cases, if it's on an RF trace, you can still fix it, such as to insert shunt elements to ground. All that's required is a razor blade or exacto knife, a magnifying glass or low-magnification microscope, and a pair of very steady hands.

In my case, I needed to insert several surface mount parts onto my PCB that were not called for in the PCB design, or make connections not called for in the design. An example of both is shown below from the final RF PCB:

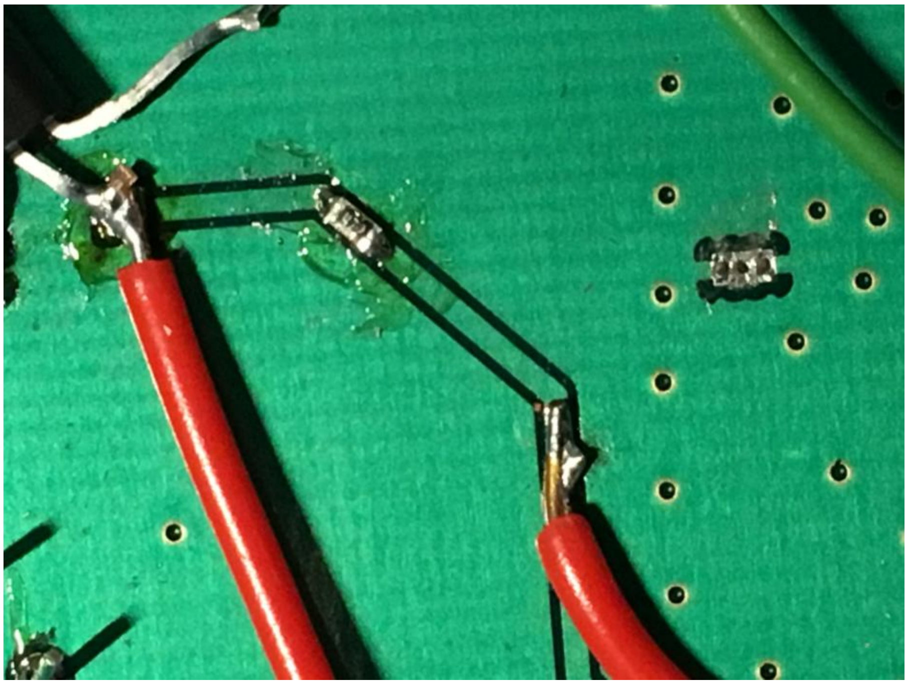

Figure 5, improvised SMT pad and fly wire connection

For the surface mount part, a part of the copper must be removed from the PCB to intentionally break the trace. The copper can be removed by first severing the trace in both sides, and using the blade to scrape and pry the copper off the surface. Then, the solder mask on both sides of the break needs to be removed. It is absolutely vital that the solder mask on the adjacent ground planes is not damaged during this. The exposed copper can then be covered with solder, and a resistor soldered into place. To solder a fly wire as shown in parallel, the trace needs to only have the mask removed, the copper covered with solder, and the wire soldered into place. This connection is very delicate, mishandling it will cause the copper to delaminate from the PCB. As a side note, if at all possible, insert fly wires on the bottom side of the PCB. This would prevent the fly wires from accidentally coupling with the RF traces, the ground plane provides shielding to the fly wires.

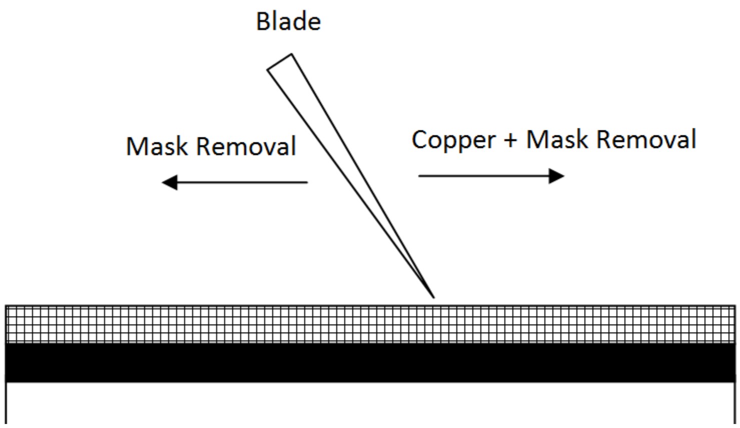

Figure 6, Scraping direction for material removal

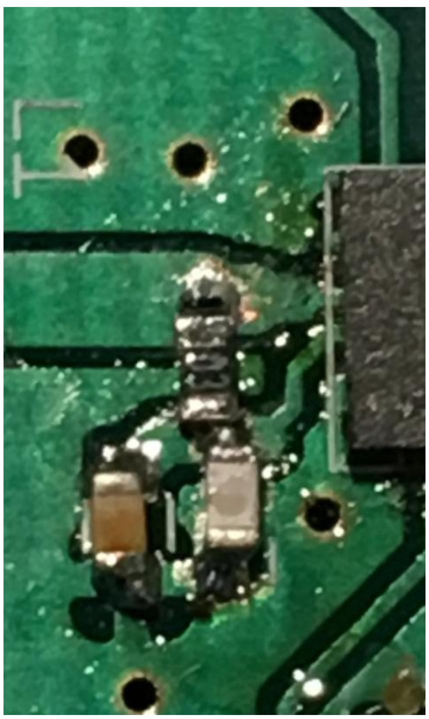
Figure 7, RF trace shunt elements

I would also point out that vias can be inserted after the fact as well, especially if you only need to tie the ground planes together. With a very small drill bit, drill a hole through the PCB, and then scrape the adjacent solder mask off with a razor blade. A piece of copper wire with roughly the same diameter can be inserted into the hole, then soldered to the PCB on both sides. Trim the excess wire off, and you have yourself a via. Harbor Freight in Woodland sells extremely small diameter drill bits for about $10, but they're extremely delicate, so practice it on a spare board first.

Link:
https://www.harborfreight.com/20-pc-carbide-rotary-micro-bit-assorted-set-62379.html

Best of luck with your design, I hope you don't have to use this part.