UNIVERSITY OF CALIFORNIA, DAVIS
Department of Electrical and Computer Engineering

EEC 134A/B, Senior Project Design
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Student's Notes

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Areas of contribution:

PCB design
PCB realization (stenciling)
Matlab code (first draft)
Field-testing

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Intro The following is a brief collection of observations related to the realization of the radar built for the EEC134 senior project design at UC Davis. The goal is to point out a few simple tips that - when considered at the beginning of the project, could facilitate a successful realization of the project. Particular attention is given to good practice in wiring and testing the radar's prototype.

Prototype The design and implementation of the final PCB is not possible without successful realization of the radar's prototype on the breadboard; therefore, wiring a working prototype is of fundamental importance. The prototype provides the main reference for the determination of the radar's behaviors under different conditions. Field-testing (i.e. range and Doppler measurements) performed with the prototype allows proper positioning of the transmitting and receiving antennas, optimum gain adjustments, and useful feedback for code debugging. Moreover, a working prototype is a convenient "back-up plan", in the case the final PCB does not work properly.

Sources of error Thorough the first EEC134A quarter, team Hertz spent approximately 6 hours to wire the breadboard prototype. Due to a number of problems, we spent approximately 80 hours in troubleshooting, rewiring, and re-testing the prototype. In our case, loose wires were probably one of the main sources of error. Poor electrical connections in different nodes of the network caused random circuit's behaviors and misleading measurements. The unrepeatability of the measurements, together with the frustration caused by hours of tedious troubleshooting, introduced more sources of errors like short and open circuits. Ultimately, the short circuits affected the performance of some of the integrated circuits and RF components causing more uncertainties in the measurements.

Wiring: a few tips It is crucial to have the overview of the complete breadboard prototype from the start; this awareness will allow a more effective wiring, testing, and interconnection of the different sections of the network. It might seems obvious at first, but a few wiring good practices could prevent most of the problems encountered in this project; the following are a few tips:

- planning a proper layout of the electronic components
- establishing and follow a consistent wire color coding
- limiting the length of wires between components
- avoiding crossed wires

It is worth noting that adoption of these simple wiring practices requires an up-front payment in the form of time, patience, and consistency. Probably, this is the reason why many of us involved in the project followed the path of less resistance and wired the breadboard more “loosely”.

Nevertheless, these are some of the advantages of color-coded, short wires:

- Prevention of unintentional disconnection of wires
- easy to follow the path of the current
- better electrical connections

Additional benefits could include smaller mounting area, better transportability, and nicer looking.

Figures 1 and 2 show the comparison between two different wiring styles.

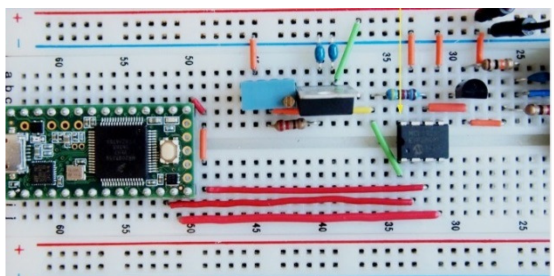

Figure 1: wiring with color-coded, short wires
source: EEC134A course material, *“Lab 1: Elements of Electronic Systems”*

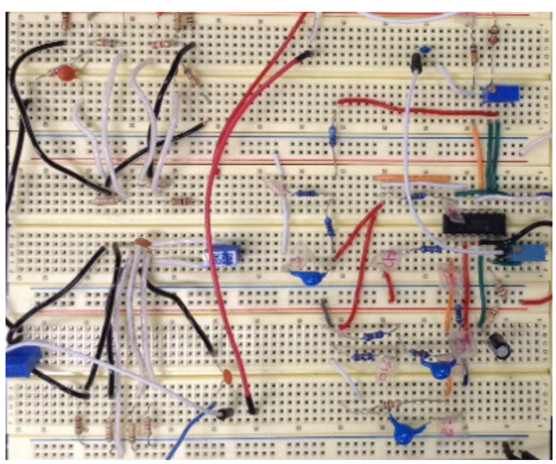

Figure 2: wiring with multiple colors, long, crossed wires

Testing Equipment The laboratory's instrumentation is used extensively. Probably, the weakest point of a measuring instrument is the cable utilized to connect oscilloscopes, function generators, and power supplies to the circuit to analyze. In several occasions, we found that the cause of inconsistency in our measurements was due to poor electrical connection between probes, banana connectors, compression type terminals, and the cable. It is a good practice to check the continuity of the cables before performing the measurement; in particular, the continuity test should be performed under some form of mechanical stress (i.e. while gently waving the wire in different directions).

Testing As mentioned in the previous section, it is very important to have an overview of the final prototype's layout. Essentially, the radar is made of two networks: baseband and the RF. For wiring purposes, the baseband circuitry is the core and the more complex part of the radar; therefore, it requires more attention. The successful realization of the prototype baseband network depends on proper wiring and methodical testing. Voltage regulation, signal's gain, and quality of the output signal (noise level) constitute the three main measurements to perform. Again, it might seems obvious at first, but the measurement of these parameters should be performed right after the realization of the section of network, before wiring the next building block. The idea is to gain confidence about the proper functionality of the different parts of the network before assembling the prototype. For this reason, it is very important to place test points at the input and output terminations of the different networks.

Conclusion Many factors contribute to the success or failure of a project like the radar built for the EEC 134 course. Among the many, a methodical approach to wire and test the prototype, and developing the habit of verifying the integrity of the measuring equipment were identified as effective and relatively easy to adopt.