EEC 134 App Note: Debugging RF PCBs

Sam Wagner

Saturday 25th March, 2017

This app note describes a way to debug RF PCBs, specifically ones designed for this course, explores the theory behind using a coaxial probe, and provides a debugging checklist for a transmitter.

Coaxial Probe

A coaxial probe is a coaxial or SMA wire with the outer plastic sleeve, outer mesh conductor, and dielectric sleeve pulled back such that only the center pin conductor is exposed. An example of peeling apart a pin is below in Figure (1).

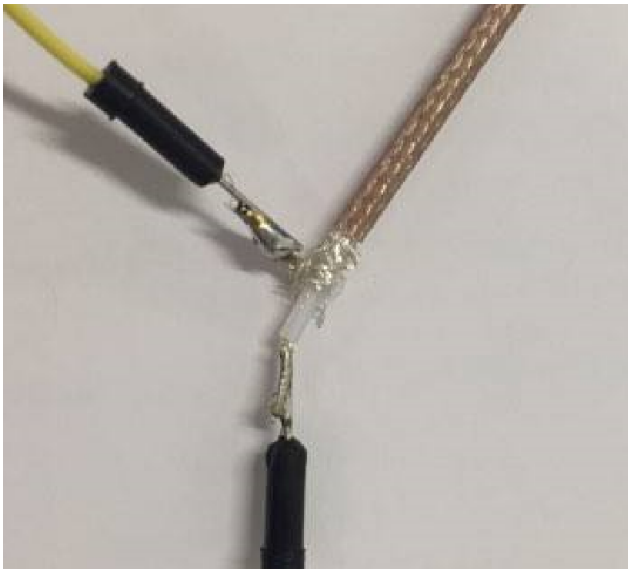

Figure 1: Coaxial cable with plastic pulled back. Two wires are soldered onto the conductors. A traditional probe would not have these wires.

In order to use the probe to debug, simply hold the center conductor near a trace on a PCB board. To find the best way to hold the probe, we must look at the field patterns of commonly used transmission lines. Grounded coplanar waveguide is used here.

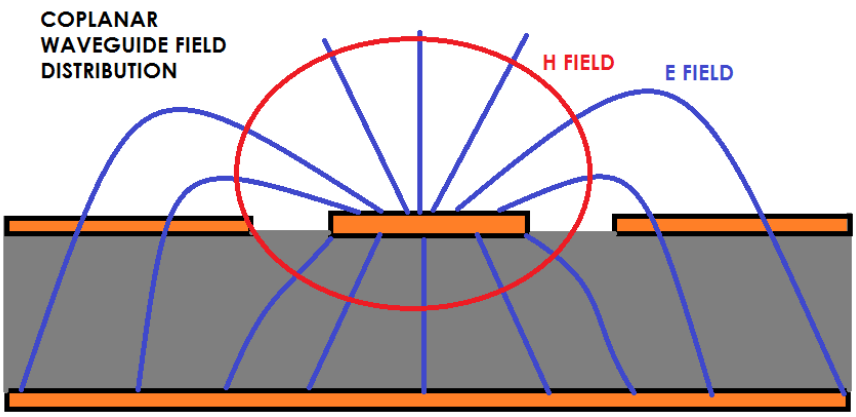

Figure 2: Quasi-TEM mode of CPWG field lines

If we want to probe the field at some distance, we want to maximize the current. We can approach a coaxial pin placement from two different views:

1. We think of the coaxial pin as an inductor. An inductor will have a current created on it by the expression $V = -L\dfrac{dI}{dt}$.
2. We think of the coaxial pin as a coupled transmission line. The current on it will be described by Ampere's Law, $\nabla \times H = J + \dfrac{\partial D}{\partial t}$

Both cases logically lead us to the conclusion that the conductor should be parallel to the line to maximize coupling, as shown below in Figure (3).

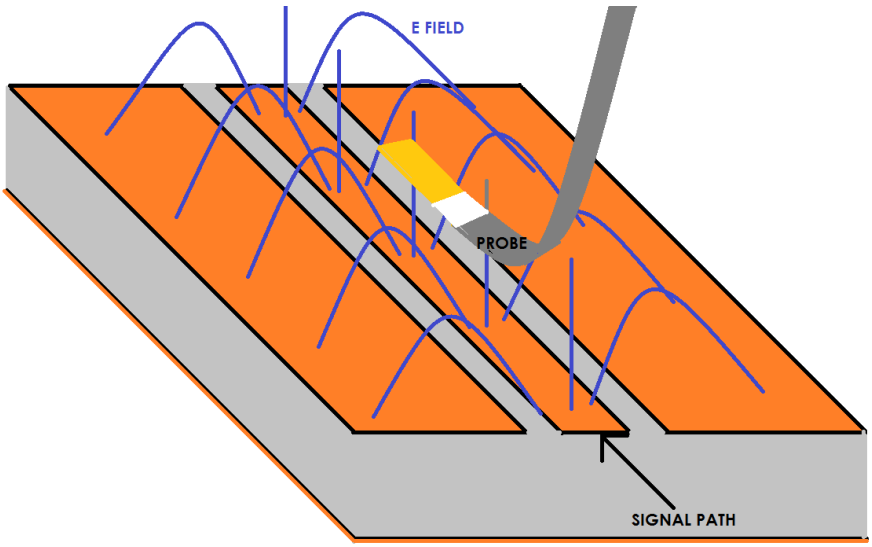

Figure 3: Quasi-TEM mode of CPWG field lines

Now, we examine some limitations of the coaxial probe:

- **Cannot accurately determine power**. The coaxial probe, especially in a complicated system with many transmission lines in close proximity with varying angles, cannot accurately determine the power in a trace.
- **Cannot determine phase**. Unlike a VNA, the coaxial probe cannot measure phase. It is best used as a binary indicator or presence of signal.

Finally, I present a debugging checklist for a combined transmitter/receiver PCB.

Table 1: EEC 134 Debugging Checklist

	All power traces connected?
	VCO signal present? (coax probe)
	All amplifiers - power draw, amplification? (coax probe)
	Power splitter - equal split on both sides?
	Transmit power correct?
	Antenna on transmit and antenna on spectrum analyzer - correct power received at 1m?
	TPI Synthesizer into receiver - power received?
	VCO on static frequency, TPI Synthesizer input to receiver, mixer working?