major driver in technology needs and product requirements. For those of us in the commercial RF semiconductor business, for example, this is critical information. Over the past couple of years, MTT-19 has provided quite a bit of material on air standards and protocols in this Magazine and in IMS forums. This focused issue of *IEEE Microwaves Magazine* is just the latest example. The articles in this issue are a benefit to our members, even those whose work is not directly related to wireless communications.

Most issues of this Magazine include a column on business issues contributed by MTT-19. These columns cover a variety of business areas, including the ones I’ve mentioned above. My favorite columns are those that have been written by entrepreneurs on their experiences building their businesses. I find them to be entertaining, engaging, and educational because they are so personal. MTT-19 has convinced a number of busy entrepreneurs to write these columns and will continue to encourage more. At some point in their careers, many engineers consider setting off on their own on a business venture. These columns can help us understand the costs of starting a business, as well as the rewards. (Surprisingly, the rewards aren’t all financial.) The most clearly business-related information we have provided is also the most personal information.

MITT-19 will continue to bring forward valuable information that benefits the microwave engineering community and you as a member. If you would like to recommend a topic for us, please let us know (mtt.org/committees/mtt-19).

As a member, you receive many benefits from the MTT-S and the IEEE. As an active member, you benefit much more. So consider becoming an active member. Go to Chapter meetings, or if there isn’t a Chapter in your area, organize a new Chapter. Help with a conference or start a new one. See if you can help a TC. Membership is actually its own greatest reward, and the more you put into it, the greater you will benefit.

—Fred Schindler

---

### Feeling Uncertain About Uncertainty?

#### Quality of Measurement Is a Matter of Confidence

So, look no further, go to www.mtt.org/~mtt11 to find out more.

The IEEE Microwave Theory and Techniques Society (MTT-S) “Microwave Measurements” committee has recently set up an online forum aimed at uncertainty and quality of measurement. The “Errors and Uncertainties for VNA Measurements” forum focuses on methods that can be used to evaluate errors and uncertainties in vector network analyzer (VNA) and VNA-related measurements, particularly at high frequencies (1 kHz to 1 THz).

An improved understanding of measurement uncertainty will provide insight that could lead to better measurement methods—it can even lead to a Nobel Prize! Lord Rayleigh’s pursuit of measurement uncertainty between two methods of measuring the density of nitrogen led to the discovery of argon for which he was awarded the Nobel Prize in 1904.

The forum can be accessed through the MTT-S “Microwave Measurements” home page at www.mtt.org/~mtt11.

An IEEE membership is required. On this Web page, you will see several forums covering various aspects of measurement: on-wafer S- and noise-parameters; signal integrity and multi-ports; nonlinear and load-pull; and coaxial VNAs. The uncertainties forum is the newest addition to this group. Moderators are experts familiar with measurement uncertainty and analysis. In conjunction with technical experts from other groups, this forum is geared to assist you in meeting the international practices and standards (i.e., GUM) for analyzing measurement uncertainty. By joining this forum, you will have access to many references and knowledge being created in the area of microwave metrology. With your participation in the discussions and contributions of information, you will gain confidence with your uncertainty and its analysis. This is a great way to improve your quality of measurement.

#### Why Uncertainty?

We are often told that the best way to remove any doubt about what the value of something might be is to measure it. We are also told that with measurements we can check just about...
anything—for example, products to specifications, validity of models and equations, the properties of certain things, etc.

However, there comes a time in most of our lives when we stop and ask ourselves: “But how reliable is the measurement?” This very question can often strike fear into the heart of even the most diligent scientific investigator. The reason is that the role of measurement as ultimate arbitrator is being called into question. How can this be tolerated?

Well, the short answer is that we need to recognize that all measurements contain errors, to some extent—no measurement is perfect or error-free. Once we accept this fact, we need to think about how we can determine and accommodate these errors so that we can regain our confidence in measurements by knowing how reliable they are. The “catch all” phrase for this is that we need to evaluate the uncertainty of the measurement. We have often heard phases such as “I’ve done the measurement, but I’m not sure what the uncertainty is” or “I wish I knew what the uncertainty is in my measurement.” Well, for those working with microwave measurements, some help with these questions is now available. So, why not join in the discussions?

—Nick Ridler, Yeou-Song (Brian) Lee, and David Blackham

Nick Ridler is with National Physical Laboratory, Teddington, United Kingdom. Yeou-Song (Brian) Lee is with Anritsu, Morgan Hill, California, United States. David Blackham is with Agilent Technologies, Santa Rosa, California, United States.

Application Notes (continued from page 127)

added in the ground planes to “short” the parallel-plate waveguide mode so that it will not propagate. The vias must be placed fairly close together if they are to be effective, with a separation of λ/4 in the dielectric being a general rule of thumb. In practice, backside vias have an inductance associated with them and the mode suppression vias should be placed closer to accommodate for this. Although the vias are shown with equal spacing in Figure 20, the most common consensus if that the vias should be unequally spaced so as to not appear periodic, which could in itself cause problems at the resonant frequency of the periodicity.

In cases where a substrate via process is not feasible, an alternate approach to packaging CPW circuits than placing them on a metal ground plane must be adopted. Flip-chipping of CPW circuits is well established. In this case, the CPW circuit is flipped upside down and mounted on a carrier substrate using epoxy or solder on “bumps” placed on the carrier substrate so that there is an airgap between the carrier substrate and the CPW circuit. Depending on the height of this gap and the CPW circuit geometries, this will cause some capacitive loading. A second approach is to place the substrate on either a lower-permittivity substrate (tending to trap substrate energy into the lower-permittivity substrate) or package it so that the circuit is suspended in air, forming a cavity below the substrate. The lower cavity under the substrate can then be lined with absorber to attenuate any energy leaking into the substrate mode. It should be noted that when the CPW circuit is floated in air or placed on another substrate, coupling to the circuit must include a ground connection as well as a signal connection. This means an SMA connector soldered on would work well, as well as a ground-signal-ground probe, but a single wire or ribbon bond connected to the CPW signal line would not. Grounded CPW with a single ribbon or wire bond can operate well to very high frequencies if the substrate vias are well placed near the launch.

Conclusions

In this article, we have provided basic CPW design information geared towards a practicing microwave circuit designer, including the applicability and benefits of CPW transmission line configuration, design and modeling tips, and two microphotographs of implemented CPW MMIC amplifiers. Additionally, we have discussed other undesired modes supported by the CPW geometry (coupled slotline) and modes that can occur for practical implementation of CPW (parallel-plate waveguide mode). CPW has a significant number of applications in microwave design, and we hope this brief tutorial will provide enough of an introduction to aid designers in beginning CPW design.

References