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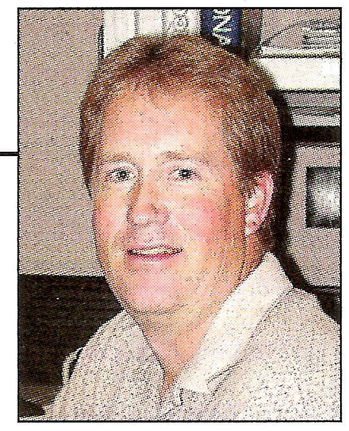
By Mark Finstad

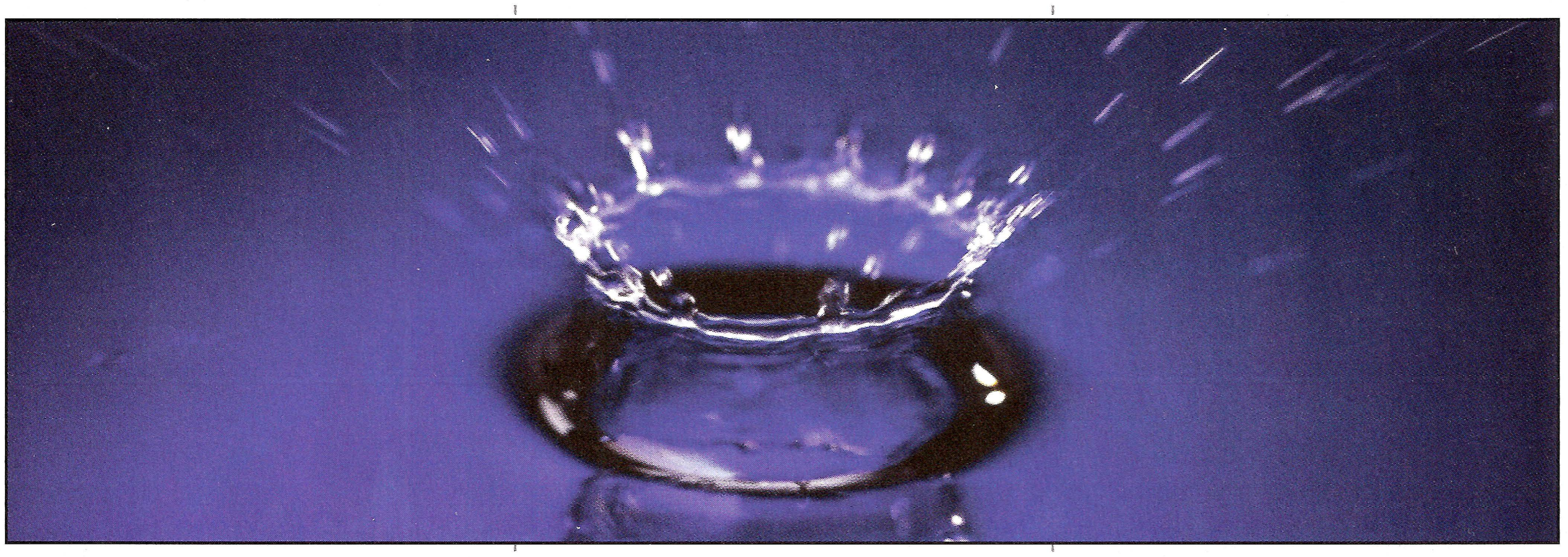


Immersed in Flex Circuits

Q: ***I would like to know if a flex circuit can be made so that it can be immersed in water.***

A: I am starting to sound like a broken record because with virtually every question I answer, I have to start with "it depends on the application." My questions for this application would be:

- Will the immersion in water be permanent or temporary? If temporary, for how long will it be immersed?
- What is the highest voltage potential between adjacent conductors, and will there be any high speed signals requiring controlled impedance?
- Will this be straight fresh water, or will there be salt or other dissolved chemicals in the water?
- Will the solution (and circuit) be static or dynamic?
- What is the water temperature?



Plain water will not attack polyimide film or acrylic adhesive, which, along with copper, are the usual components of a flexible circuit. However, these materials are very hygroscopic, so they will quickly absorb water whether it is from humid air or actual submersion. As the materials absorb water, their electrical properties (namely dielectric strength and dielectric constant) change. This is why I asked the first two questions on the duration of the submersion and the voltage. If the circuit will only be submersed for a few seconds, and will then return to a dry environment, you have nothing to worry about. However, the circuit materials absorb moisture very quickly, so any submersion over twenty to thirty minutes could affect the way the circuit performs. Now it will depend on the voltage that the conductors will be carrying and/or the need for controlled impedance. For instance, as the moisture content of polyimide film rises to saturation (approx 2.8 percent water), the dielectric strength drops from 8,600 volts/mil to 6,800 volts/mil. This is still very respectable, so unless your application has extremely high voltage, you probably will not have any issues. The dielectric constant is another matter. As the moisture content of polyimide rises, the dielectric constant also rises. At 0 percent relative humidity, the dielectric constant is 3.0 and at 100 percent relative humidity, the dielectric constant is 3.8. This can have a significant effect on the impedance of the circuit and should be accounted for during the design process.

As I mentioned earlier, plain water will not attack most flex circuit materials. However, any elements dissolved in the water that would cause the solution to become extremely alkaline, can attack the circuit. Also, the solder at termination areas is very prone to corrosion when exposed to acids, bases, salts, and a host of other compounds. If you are unsure of the water purity, it would probably be a good idea to conformal coat the entire assembly after installation.

My final questions on your application would cover mechanical issues. If the water is still or the flexible circuit is securely anchored, you should not have any issues on the mechanical front. However, if the water is dynamic, and the circuit is allowed to move with the water, it too, will be dynamic. If this is the case, you will need to examine what type of motion the circuit will be subjected to and ensure that your design does not have any stress concentrating features that could result in a failure due to this motion. My last question had to do with the water temperature. If the water temp is between freezing and normal air temperatures, you should not have any problems. But, elevated temperatures will make the circuit very fragile. As the circuit becomes fragile, the effects of any mechanical forces, such as water motion or handling, can result in damage to the flex.

So, the answer to your question is yes, you can design a flex circuit that can be immersed in water. It is just important to weigh all of the factors that can impact the performance of the flex and then design accordingly. □

The Flexperts are Mark Finstad and Mark Verbrugge