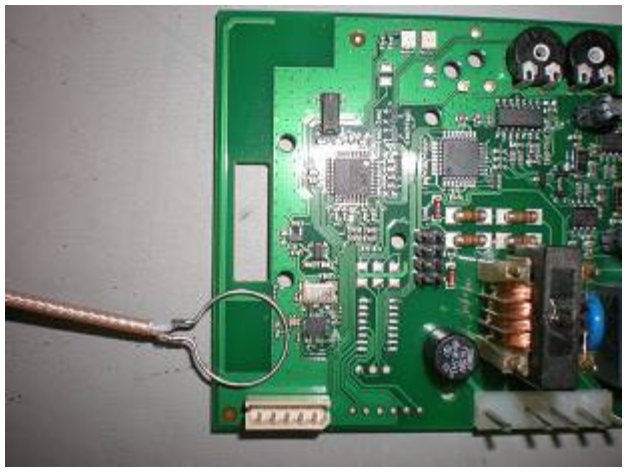
Contactless antenna measurement using a VNA

Sometimes it is desirable to test or verify the operation of an antenna without physically connecting to it. This can be useful for verifying a series of products, in production, or to avoid disturbing the ground current in its 'natural' state.



Antennas are made to interact with their environment and this makes it possible to couple externally to the antenna and measure some properties.

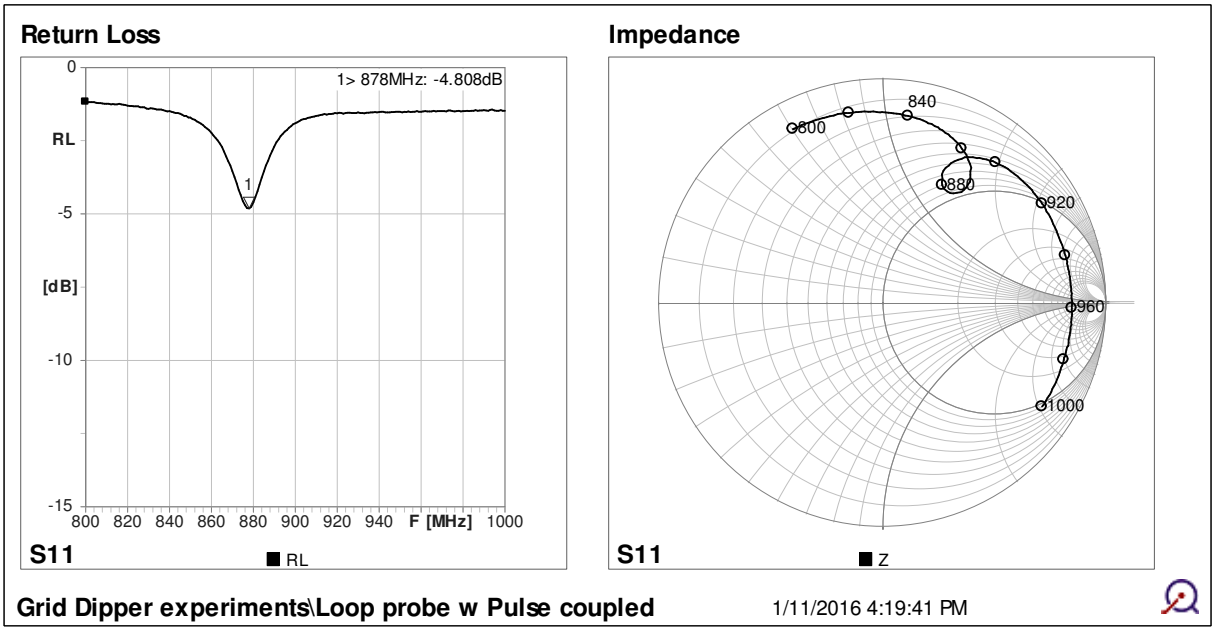
There are two types of antennas, electric (dipole, whip) and magnetic antennas (loop, slot) and we need a different probe for each of these types. Electric antennas are difficult to couple to but a magnetic probe is quite straightforward.

Magnetic probe

We can use an inductor to couple the magnetic RF field to the VNA. It is necessary to use an inductor with a fairly large surface to couple to an antenna, while at the same time the inductance needs to be such that it presents a reasonable impedance to the VNA, in the order of 50 Ohms.

The inductor is connected to the VNA and we sweep the return loss. It is not really necessary to perform a cable calibration when the VNA has port calibration.

By itself the return loss measurement is not very interesting as it shows the value of the inductor (and its cable). But, if we approach a (loop) antenna a dip starts to appear in the return loss graph. This dip marks the resonance frequency of the loop antenna.



The Smith chart shows that the probe by itself is inductive (near the upper edge of the top half circle), but that the antenna pulls the impedance toward the center (50 Ohms) at its resonance.

As we get nearer the antenna the dip will get deeper but at some distance it also starts to shift, either upwards or downwards. This is because our probe starts to affect the frequency of the antenna. We should keep the distance where the dip is visible but the antenna is minimally affected.

The graph was measured with a Pulse loop antenna on TI test board. The antenna is connected to the second port of the VNA only to verify that the actual resonance is the same as the 'coupled' resonance.

The original frequency, without the probe nearby, is 873MHz, so there is a shift of 5MHz to 878MHz in the antenna resonance.

Antenna types

The magnetic probe is well suited to couple to different variations of loop antennas and other magnetic antennas as long as we couple to the area where the current creates the electromagnetic field.

But the magnetic probe can also be used to measure a (electrical) PIFA antenna by coupling the probe to the ground loop of the PIFA while avoiding the tip of the antenna, as shown in the cover photo.

Contactless measurement

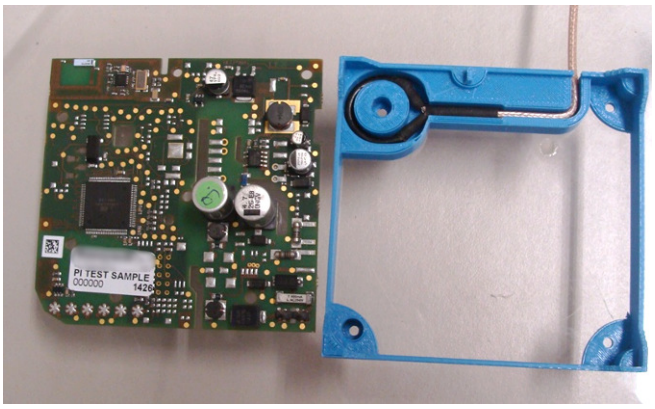
A good application of this technique is with (small) PCBs that are severely affected when a cable is connected for antenna measurement. In some designs there is a lot of ground current in too small a ground plane and it's looking for a way out.

This current is affected by a VNA cable and the cable will participate in the radiation and alter the overall RF properties of the PCB. A ferrite choke around the cable can reduce this effect but the contactless loop measurement can be used to verify that the conducted measurement is valid. When the contactless measurement changes too much when the VNA cable is connected directly, then there is a severe effect on the PCB by the VNA cable.

Test fixture

For individual tests we can just approach the antenna and watch the dip getting deeper, until the point that it starts to shift. We can also use this test to check the antenna of a production series, but then a

test fixture needs to be made to couple the probe consistently, so that the frequencies can be compared. The activity of the antenna can also be compared to others by comparing the depth of the dip.



The picture shows an 868MHz PCB with an Ethertronics Savvi loop antenna in the upper left corner. On the right is the loop probe in a 3D-printed test fixture.

Conclusion

- With the contactless method we can get a quick impression of the frequency and activity (Q) of different kinds of magnetic antennas and some electric antennas that have a current loop in their feed.
- The contactless measurement can be useful to measure ground-sensitive antennas.
- This method is also suited for a production (pre-) test to quickly screen the antenna frequency.