πTesting Bonding Resistance

How do you know your ground system is intact and working? Most often the weakest link in a grounding system is the bonding from one conductor to the next. This would be from the ground wire/cable to the bonding clamp, and the connection from the clamp to the ground rod (sometimes called an electrode). In RF environments, multiple antenna systems, ground rods, and ground radials may be involved so naturally they all must make proper connection. These bonding points can degrade with time due to vibration, climatic changes, weather moisture causing galvanic corrosion, and other reasons.Your ground connections should be checked periodicThere are several ways of checking the integrity of bonding conductors in a grounding system.

First, visually inspect the entire site, looking for loose connections, broken connection points and corroded connections: repair any of these.

Secondly, do a mechanical inspection, physically stressing each connection looking for less obvious loose or broken tie points.

Lastly, do an electrical bond resistance test. [Check below on how to make your own tester, easily!] Here the most appropriate instrument to employ is a micro-ohmmeter . The micro-ohmmeter is far more effective in checking the quality of a resistive bond than a multi meter or other resistance-measuring device. The micro-ohmmeter conducts the test with a higher current. In this way, the quality of the bond is electrically stressed, eliminating the appearance of good resistance from weak connection points, such as a connection point where a single strand of wire is the bonding point. In this case, the multi meter using low current would potentially show this single strand bond as a good connection. The micro-ohmmeter will quickly identify it as a poor bond by actually causing the single strand connection to open. Before reviewing the actual testing process, let's first examine the components of a grounding electrode. Notice the figure to the left shows a typical grounding electrode with three major bonding points: the ground electrode, the bonding clamp and the lead wire. All three points should be checked with respect to each other.

The 10-amp micro-ohmmeter is an effective tool for testing any grounding bonding system. It employs a low voltage, typically 8-10 volts DC and a high current, typically adjustable from 1 to 10 amps. A commercial micro-ohmmeter, such as the AEMC Instrument consists of a test instrument, and a set of heavy test leads. Once the leads are attached to the connection, a button is pushed and the connection resistance is read directly. (See below for an inexpensive way the ham operator can test his bonding connection)

A good resistive connection will be in the micro-ohm region and at worse case the milli-ohm region. This test procedure should occur for every bond along the grounding system from the tower and all equipment right down to each and every grounding rod. This testing of the bonding system should be conducted quarterly or at very least annually to ensure a good quality grounding system.

How to Make Your Own Milli-Ohmmeter

The micro-ohm meter is not a test instrument that the typical ham will have, of course. But you can easily approximate the function by following the steps I have done, below:

Locate a fairly inexpensive automobile battery charger in the 6 to 10 amp charging range. I used both a very old K-Mart charger rated at 6 amperes and also a newer "Starline 404" by Starline Products, Minneapolis, Minn. It also was rated a 6 amps, but the meter reads to 8 amps. I used an automotive charger since it has relatively high internal resistance and will endure momentary shorts repeatedly. You could use bench DC power supply that has current limiting. Set it for 10 to 20 amps current limit and measure all day long! The automotive charger can be found at garage sales and flea markets for just a few dollars and makes a great piece to test gear.

Locate or borrow a high current ammeter, and with caution, determine the maximum current the charger will deliver in a short circuit condition. I found that the Starline would deliver 35 amps when I shorted the clip leads together. Of course this is for a split second, since prolonged short will open the internal circuit breaker.

Next, place one charger lead on your ground rod, (see figure above) and then momentarily touch the other lead to first the bonding clamp and then to the lead ground wire. Of course, small sparks will fly as the 35 amps goes through the connection. This exercise will prove that the connection is electrically sound: if it can pass 35 amps, it can pass your RF with little attenuation, and should the need arise, the connection can safely pass lightning surges to ground.

To estimate the resistance of the connection, place a DC voltmeter across the connection to test. For example, place one volt meter lead on the ground lead wire, and the other connection on the ground rod. Verify the meter connections are secure and then momentarily place the battery charger leads at the same location. Watch the volt meter move up slightly as you pass about 35 amps thru the connection. If the connection is poor, then less current will flow, resulting in a poorer "short" to the battery charger. This will allow the measured voltage to raise indicating higher resistance and more voltage drop at this connection.

When doing my tower and ground system, I found very good repeatability in my readings and measurable variances in the different connections. I found all my connections which have been in place for over 4 years would handily pass 35 amps. In fact, I found I could quickly verify all connections simply by tapping one lead to each ground connection of my radial fan-out. By listening to the battery charger meter "ping" across the scale with the high current flow, I was assured that this connection was intact.

For experimentation I did continue and measure the voltage across selected connections to see what I measured. The following table shows sample readings. Assume 35 ampere current flow (admittedly this value will be inaccurate, but I have no way to determine high currents at various loads).

Connection	meas. volts.	calculated res.
a	0.1	0.00285 ohm
b	0.17	0.0048 ohm
c	0.28	0.008 ohm
d	0.13	0.0037 ohm

This simple process will verify connections are good and also you can identify good connections and better ones. I found several that looked robust and well made, yet they measured poorly. This summer after my other projects are done, I will come back to that connection and see if I can improve it. ---Brian Davis, W9HLQ