Implementation of Antenna Diagnostic Compatibility for Taoglas Antennas

AntD© (pronounced ant-dee)

AntD© consists of measuring the voltage drop across a resistor embedded in the antenna to detect if an antenna is present or not, as well as several types of cable damage, including being severed or crushed. How this circuitry is implemented on the product is up to the designer, but it always requires the antenna to provide a consistent and known DC resistance for any circuitry to work. There are also certified off-the–shelf cellular AntD modules that have the function inbuilt and Taoglas has off the shelf antennas that are compatible for each model.

Historically, different antenna architectures may be naturally a DC short or a DC open. These 2 extremes however are symptoms of a cut or crushed cable respectively, so there needs to be a middle ground. AntD© ensures that regardless of the antenna architecture, a 10k DC resistance is shown at the antennas connection point. The exact implementation circuit inside the antenna changes with the antenna architecture but always results in the following equivalent circuit:

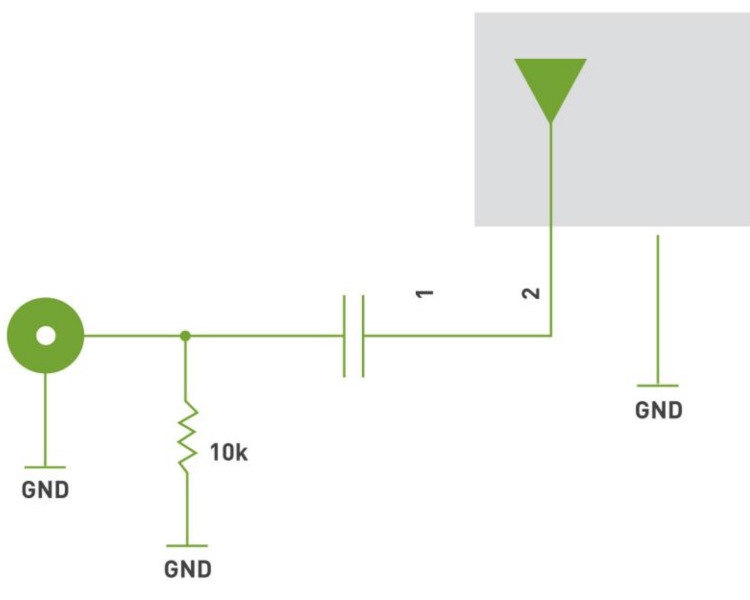

Figure 1 - Equivalent schematic for AntD© compatible passive antennas

An example circuit is shown below for implementing measurement with a simple microcontroller. This functionality can be implemented using any A/D converter and digital logic output. This includes the A/D converters in some radio modules. The module suppliers for instance have references on how to use the A/D's in their cellular modules to accomplish the same measurement. While their circuits differ a little they accomplish the same result. The most stable measurement results will happen when the radio is not transmitting.

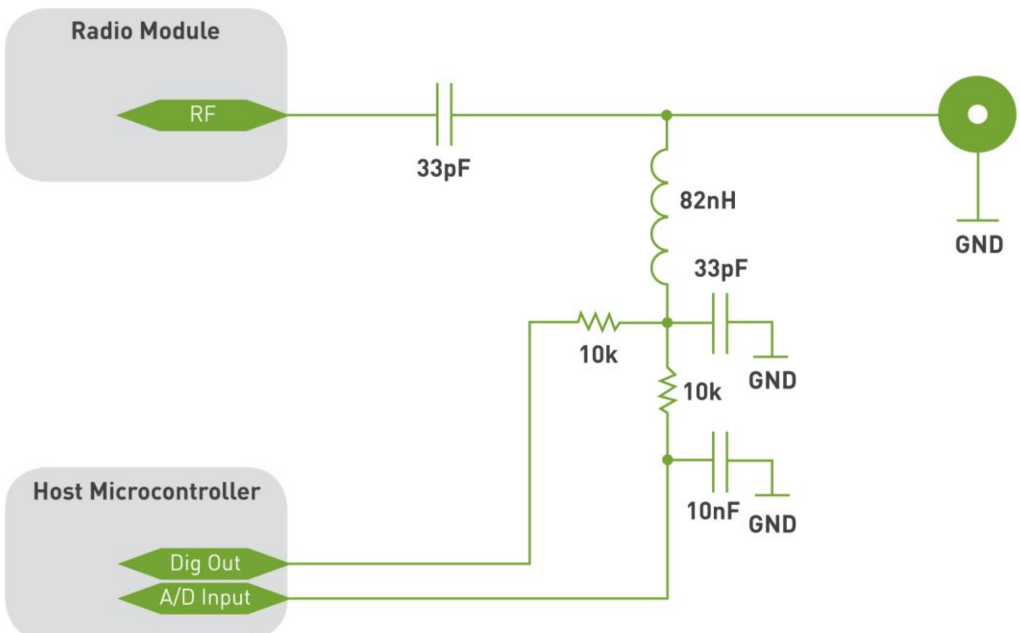

Figure 2 - Example Host Micro AntD© Cellular Implementation including 2.1GHz

Note that the circuit stays the same regardless of the frequencies used, but some of the values would change. The inductor needs to have a self-resonant frequency higher than any of the frequencies used, while having impedance at the lowest frequency used of 300-500 ohms minimum. This typically requires a proper RF inductor, such as the Murata LQW15 series. The 33pF caps would change in value for optimum performance at a particular frequency as well. Consult the vendor's design tools for selection.

To use the circuit, apply a voltage by setting the digital output high. A simple resistive divider is then formed between the series 10k resistor and the 10k resistor in the antenna. Measure the voltage in the middle of the divider with the A/D converter. The 10k resistor and 10nF cap form a filter, which should provide for consistent DC values. The sensing voltage can be left on all the time, or set high only as needed, to minimize power consumption.

If the A/D reads a voltage near the logic high value then the antenna isn't connected, or the coax has a break in the shield or center. If the A/D reads near ground then the coax center is shorted to the jacket, which is consistent with a coax cable being crushed.

Active antennas implementation are handled differently as they require DC to power the electronics in the antenna. GPS, FM/TV and actively tuned antennas are the most common forms of active antennas. These products aren't marked as AntD© compatible because the detection circuit is different and they already directly support detection and diagnostics. For these products instead of measuring the DC resistance of the antenna, the product circuitry needs to measure the current draw. The current draw of the active antenna is known and stated in the datasheet.

An example circuit is shown below for implementing measurement with a simple microcontroller. This functionality can be implemented using any A/D converter. Some GPS modules have internal antenna diagnostic capability; consult your product's datasheet.

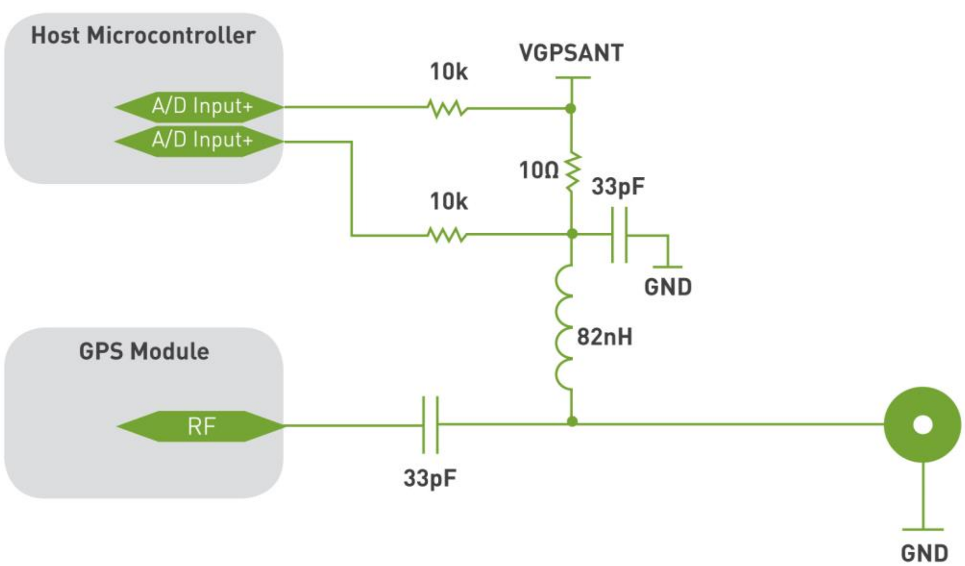

Figure 3 - Active Antenna Diagnostic Example

Again, the circuit stays the same regardless of the frequencies used but some of the values would change. The inductor needs to have a self-resonant frequency higher than any of the frequencies used, while having impedance at the lowest frequency used of 300-500 ohms minimum. This typically requires a proper RF inductor such as the Murata LQW15 series. The

33pF caps would change in value for optimum performance at a particular frequency as well. Consult the vendor's design tools for selection.

The circuit is simply measuring the differential voltage across the 10 ohm sense resistor. Most active antennas use very little current so a 10 ohm sense resistor doesn't represent a meaningful voltage drop with regard to running the antenna circuitry. This also means that the voltage differential the A/D sees is quite small. For this reason it may be desirable to add an op-amp circuit that amplifies the differential across the sense resistor or to set the + and – A/D references to maximize the dynamic range of the measurement.

The typical current draw for the GPS antenna is stated in the datasheet. It would be safe to assume that a current lower than 10% of the typical value would indicate the antenna isn't connected or the coax has a break in the shield or center. If the current is more than double the typical value then it can be assumed the coax center is shorted to the jacket, which is consistent with a coax cable being crushed.

It's important not to get too precise with the current measuring judgment in software. There can be unit to unit variation in current consumption at the same voltage. There can be variation in the supply voltage, which for many active antennas can cause a change in the current draw. Different versions of a similar active antenna (e.g. 15dB gain vs. 30dB gain) can have different current draws. Work through the system level use cases when a customer uses a different antenna than you were expecting and ensure it draws more or less current than the antenna you had designed the system around.