

# Tips for Digital RF Power Measurement

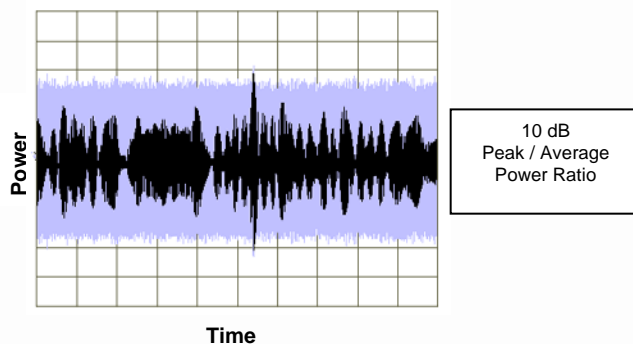
By Lynn Strube

Bird Technologies Group Applications Engineer

## Introduction

Now that analog TV is following the slide rule, phonograph and the typewriter to the museum of antiquated past technology, it is time to ensure your digital broadcast transmitter is operating to its maximum potential. In order for that to be achieved, you must have the correct equipment to make reliable RF power measurements. If you think that you can simply move the power measuring equipment you have been using on your analog equipment and install it on your digital system, then your measurements will be incorrect. When measuring any digital modulation with conventional RF power meters, you will find that the meters cannot respond to the associated high crest factor. Digitally modulated waveforms typically have a 5-6 dB crest factor, which can be even higher in a combined system. Conventional meters and associated line sections with elements will usually display a reading higher than the actual power being transmitted in a digital transmission system. If you relied on a meter reading like this, then you may elect to reduce your total power output to conform to your own or regulatory limits. As a result of this incorrect reading, you may unnecessarily lower power and, correspondingly, reduce coverage.

### Crest Factor



### Tip One:

#### Use the Correct Meter

In order to correctly measure RF power of a digital transmission, the meter will need to be a square-law based or thermal instrument. Both of these will adequately respond to the modulation format and give reliable, accurate readings. However, there are a few disadvantages connected with the use of thermal

devices. Thermal devices are complicated to use and are dependent upon a user-driven calibration of the sensor. Typically, these devices are also relatively expensive. The other choice of meter is a square-law based instrument. These instruments will give the same results as the thermal instruments in all measurement situations. Square-law instruments operate in a region where the rectified output is proportional to the square of the RF signal input regardless of the signal content. According to [Microwave Encyclopedia](#), "For a certain range of power levels, a detector's output voltage is proportional to its incident power measure in watts. Why is this called 'square law'? In 'linear' operation, Ohm's Law says that voltage will be proportional to the square-root of power, in the square-law region; power's relationship to voltage has been squared." If the diode in the detector is kept to an approximate level of -20 dBm, the detector will exhibit the following transfer function:

$$V_{out} = \left( \frac{V_{in}}{5.77} \right)^2$$

This relationship will hold true regardless of the input waveform characteristics. The dynamic range of this power measurement is bound by approximately -20 dBm on the high side and the noise floor on the low side.

### Tip Two:

#### Measurement Location and Tracking

In the 21<sup>st</sup> century, internal transmitter metering has very sophisticated displays and control systems. It can display RF power levels at multiple stages of transmission and track them over time. Typically, directional couplers are placed at different transmission stages and are linked to a display through a control system. Ideally, transmitter manufacturers would incorporate precision directional couplers with high directivity for the most accurate metering, but they can be very costly. Some suppliers elect to save money by installing inexpensive couplers, leading to less than precision measurements. To ensure accurate RF measurements, external directional couplers should be used. An excellent placement of the precision

# Tips for Digital RF Power Measurement

By Lynn Strube

Bird Technologies Group Applications Engineer

directional couplers would be right before the mask filter and right after the mask filter. This way the output power of the transmitter is identified before the filtering and power into the antenna is identified after the filtering. Taking RF power measurements and recording the levels in these locations allows engineers to track system performance. Power measurements should remain fairly stable over time, typically not varying by more than +/- 0.25 dB. If RF power measurements from one time period to the next are changing, then you need to determine the reason.

## Tip Three:

### Use an Independent Reference

Transmitter power measurement is very dependent on where directional couplers are placed in the system. Internal directional couplers are used as detectors and report information back to the display panel and it may not be clear where a measurement was taken or if allowances were made for system parameters, such as line loss or filter loss. Conducting a transmitter independent, external, NIST-traceable power measurement will show output power solely at the position in the transmission line where it is located. You can be assured that no line loss or filter loss allowances have been made. In systems where two or more digital transmission channels are combined, an independent reference power measurement is the only practical method to show total power output.

### In Summary

Square law detectors installed in numerous places along with a NIST-traceable, independent, external RF power measurement will ensure that your digital transmission is being measured accurately. This will help realize optimal performance from your transmitter allowing it the longest life and providing your customers with the broadest coverage.