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Exploring NRSC-G201-A

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A technologically economical explanation of NRSC-5 IBOC compliance

In April of this year the [NRSC](#) released NRSC-G201-A, which discusses in detail the NRSC-5 IBOC emissions mask and recommended methodology used to measure compliance. Many IBOC systems have been up and running for five years now (or more) and so re-measuring compliance with the RF mask, while making use of the recommended methods, represents good engineering practice.

This is a rather long document -- 102 pages. Although I recommend reading the entire thing yourself, the purpose behind this article is to concentrate the information found within NRSC-G201-A, and to present the methods described therein in a technically economical fashion. I'll discuss the following aspects of the measurement methodology:

- The instrument used to make the measurements;
- The sample point at which the RF data is collected; and
- The mask itself.

The measuring instrument

An RF spectrum analyzer is obviously the measuring instrument of choice. While older units can be used, it is necessary to check their specifications and abilities to see whether or not they are appropriate for the job at hand. Unfortunately some of the old classic analyzers (the Tek 2710 comes to mind) are not up to the task.

When looking at the analyzer's specifications, note especially the "1dB compression point" as well as the DANL (displayed average noise level).

The 1dB compression point is important because if you exceed this level of power into the first mixer, you could not only damage the unit, but you'll generate intermod products that could possibly show up in the displayed spectrums. It's also critical to consider all the RF sources that make up the sample. If you were to sample on the wideband output of the combined

system (for example) you would need to consider the total power from all carriers heading out to the antenna.

On the other hand, the document recommends (at minimum) that the DANL be at least 10dB below the lowest mask limit. So, as the instrument user, you need to be sure that you have a strong enough sample signal so that you don't bring the analyzers' own noise floor up too high in the reading otherwise the lowest limit of the emissions mask (-80dBc) will be buried by the instrument's own internal noise.

The final line under this heading in the NRSC document reads as follows: "There is no better way to evaluate the instrument than to try it out on signals whose performance is already known." I take this to mean that if the DANL reads low enough, based on a given RF sample level, and that the instrument's capabilities are correct, then the unit is good enough to take measurements.

Resolution bandwidth (RBW) is one of the most important parameters you will set during your measurement. In this document, the standard RBW used for measuring IBOC in the FM band is 1KHz; in the AM band, 300Hz. The type of RBW filter also affects the readings slightly (check your analyzer specs again). Subtract 0.5dB from your readings if the filter type is 4-pole analog; subtract 0.24dB if the filters are Gaussian/analog. Video bandwidth, can be turned off, or as a rule of thumb, set for 10 times that of the RBW.

The detector type in use by the analyzer is important. It is recommended in this document that the detector be average power (or RMS) type. Again, consult the analyzer specs.

And finally, the number of sweeps taken by the analyzer in the collection of the data should be 100. To comply literally with the recommendations, you must measure at least 100 sweeps and extend the collection time to at least 30 seconds.

So a quick review of our basic spectrum analyzer specs and setup:

- Make sure the total input power to the analyzer is sufficiently below the 1dB compression point, but high enough so that reference power reading is at least 90dB above the DANL;
- Set the RBW for 1KHz (FM band readings). VBW at least 10 times RBW;
- Use average power (or RMS) detector; and
- Leave "sweep time" on auto, and take measurement over 30 seconds minimum with a minimum of 100 sweeps.

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The sample point

The place to take measurements will be on the transmission line that carries both the analog and IBOC carriers. In the event that you use space-combining, or separate antenna feeds, the situation is a bit more complicated. We'll discuss those particulars shortly.

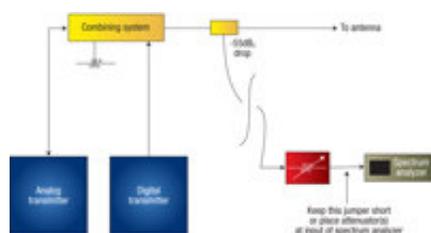


Figure 1. Test equipment setup for a single transmission line system

When both types of carriers share the transmission line, you'll obviously use a line section downstream from a high-level or split-level combiner for simply on the output side of a combined amplifier. Insert an RF sample slug (such as a Bird 553-75) in the line section. The sample level on that particular slug is -55dBc which seems like quite a bit of attenuation. But, even with a sample at 55dB below the carrier level, you've still got lots of power (relatively speaking). For example, if your TPO is 10kW otherwise known as +70dBm, 55dB below that is still +15dBm, which is likely way too much power for the input of your analyzer to handle. Be prepared with at least 20dB of outboard attenuation and connect that to the input of your analyzer before even connecting your sample line! I use outboard attenuators in series typically a couple of -10dB, a single -6dB, a single -3dB and -2dB. Put them physically as close to the analyzer input as possible thereby minimizing the chances of RF pollution getting into leaky coaxes that may otherwise be used to connect the output of the attenuators to the input of the analyzer. See Figure 1 for more clarity.

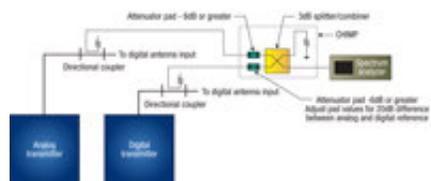


Figure 2. Combined hybrid IBOC measurement package (CHIMP) sampling

FM signals from separate transmission lines

If your analog and digital transmitters do not share a common transmission line, then the measurement technique is more involved. NRSC-G201-A has a section about CHIMP, otherwise known as the Combined Hybrid IBOC Measurement Package, and it's a very straightforward method for measuring mask compliance in this circumstance. (Randy Mullinax of Clear Channel developed it in 2006.) Basically the technique involves the addition of the analog sample, and the IBOC sample, by means of small combiner (such as a Mini-circuits ZFSC-2-2) that subsequently drives the analyzer input. (See Figure 2.) The reference levels are carefully set (more on that below) and external attenuation is used to ensure that the analog sample is 20dB higher than the digital sample. Once this is accomplished, the spectrum display is equivalent to what you would see if the two signals shared one transmission line.

Taking the measurement

As mentioned earlier, when taking the IBOC measurements, you'll make use of the average power (or RMS) detector in your spectrum analyzer. Set the RBW for at least 300kHz for the reference set * that way you'll be telling the analyzer to include all the RF from your analog carrier regardless of the modulation. NRSC-G201-A recommends removing all sub-carriers and stereo pilot for this measurement, and modulating the carrier at 100 percent with a 1kHz tone, by the way. The reasons given are twofold: The results are more repeatable and demanding against the mask limits than either pink noise or normal program audio. Obviously this will require the station to be off-air in the middle of the night. (I prefer not to work in the middle of the night unless it just can't be avoided.)

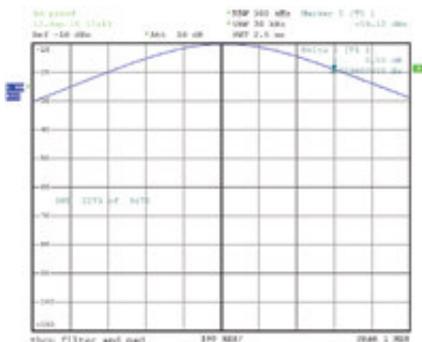


Figure 3. Setting the reference: get the trace as close to the top of the display as possible.

With the RBW set at 300kHz, and external attenuation in place ahead of the analyzer input, connect the sample signal, and take a look at how much power is making it into the analyzer. (Let the analyzer average out this power reading as well set the reference level after 15 or 20 sweeps). A good rule of thumb is aiming for 10dB below the 1dB compression point. If the input signal is too low, remove some of the external attenuation until you get a level you can easily work with, and change the attenuation in the analyzer (1dB steps) to get the trace as close to the top of the display

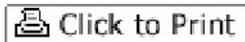
as you can. (Figure 3 shows an example analyzer display.) Strive to get the power reference right at a value that's a multiple of 10 (like -10dBm) because this will make it a bit easier later on to evaluate your performance with respect to the mask.

Setting reference levels while using CHIMP is a little more involved. First, using the output of the little power combiner, set your analog reference level with the sample with the IBOC signal removed. Make a note of the level. Then take a look at the IBOC-only level, with the analog signal removed. Add or subtract attenuation on the analog sample input to the combiner so the two samples, after being combined, hit the input of the analyzer exactly 20dB apart in level.

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After setting your reference level, change the RBW to 1kHz (for the FM band). As I mentioned previously, use the average power (or RMS) detector in the analyzer, and let it sweep at least 100 times (leave the sweep speed on auto) and for at least 30 seconds.

What can we expect to see for results?

Another common feature in newer analyzers is the ability to set "limit lines" on the display to quickly judge whether or not the emissions you measure are in compliance. Take a look at Table 1 to see those limits keeping in mind those refer to 1kHz RBW on the analyzer.

Frequency Offset relative to carrier (kHz) Level relative to carrier (dBc/kHz)

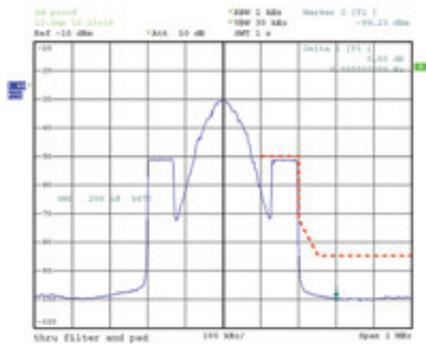
100 - 200	-40
200 - 250	$(-61.4 - [\text{freq. in kHz} - 200]) * 0.260$
250 - 540	-74.4
540 - 600	$(-74.4 - [\text{freq. in kHz} - 540]) * 0.293$
>600	-80

If your analyzer meets all the other requirements mentioned herein but won't accommodate limit lines, then when printing out the results (or otherwise generating a hard copy of the results) you'll need to add the limit lines yourself.



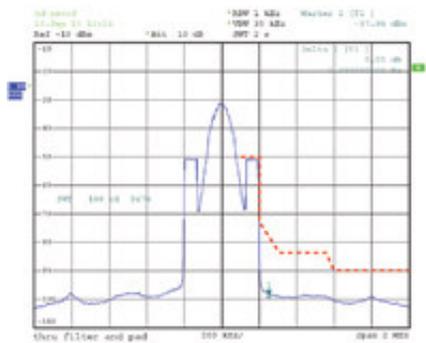
Figures 4. Results with a span of 500kHz.

During the measurement process, I first look at a span of 500kHz. I then go up to 1MHz, and finally 2MHz. See Figures 4, 5 and 6 for examples.



Figures 5. Results with a span of 1MHz.

By making your input reference level as close to one of the 10s as possible (like -10dBm) and then adjusting the span so that each division is a multiple of 100kHz you'll find evaluating your performance with respect to the mask is made easier.



Figures 6. Results with a span of 2MHz.

IBOC measurements are easy to do if you have the correct instrumentation. Make notes on the particular details of how it is done in your case, and file the results in a well-known spot (one you won't forget about between measurements) and you'll have gotten one more of your job functions completely under control.

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