



Compliance of Nautel AM Broadcast Transmitters with ITU Recommendation SM.328, Spectra and Bandwidth of Emissions

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Spectra and Bandwidth of Emissions

PURPOSE

These measurements are intended to verify the compliance of Nautel's AM transmitters with ITU Recommendation ITU-R SM.328-9, "Out of Band Spectrum".

DISCUSSION

The recommendation describes measurement of the transmitter output spectrum while it is modulated with noise having a particular spectrum. The resulting out of band power (more than 4500 Hz above or below the carrier) should be less than the limit described in the recommendation.

The transmitter modulation signal is derived using a "white" random noise signal passed through a band pass filter. The band-pass filter is detailed in passive form in annex three of the recommendation. The band-pass filter used in this experiment is an active implementation having identical response.

Due to the wide modulation bandwidth of Nautel's AM transmitters, it is necessary to install an additional filter in series with the ITU standard noise filter. This filter limits the highest frequency of the modulation signal to 4500 Hz (upper limit of the "necessary bandwidth"). The filter used is a 16th order inverse Chebyshev low-pass filter. This is implemented digitally as an IIR filter. The response is -1 dB at 4500 Hz and at least -50 dB at all frequencies 5000 Hz and above.

The transmitter is modulated to 35% average modulation. The modulation power is verified by measurement of the transmitter output current using a true rms voltmeter and a current transformer. With 35% average modulation, the output current increases 3.0%. As the 35% modulation depth is critical to the measurement, an additional verification is made of the average modulation. The transmitter power supply current and voltage are measured with a current shunt and a calibrated DC voltmeter. With 35% average modulation, the power supply current should increase by 6.1% provided there is no change in power supply voltage.

Table 1 Apparatus

Equipment	Model	Use
1 AM Broadcast Transmitter	Nautel XL60	Device under test
2 Network/Spectrum Analyzer	HP 4396A	Spectrum analysis, notch filter response
3 Audio Source/Analyzer	Audio Precision System 1	White noise source, audio filter response
4 True RMS Voltmeter	HP 3400B	RF Voltage Measurement
5 True RMS Multimeter	Fluke 79 III	Power Supply Current/Voltage Measurement
6 Current Shunt	Bach-Simpson, 400A, 50mV	Power Supply Current Measurement
7 ITU Standard Noise Filter	Nautel	Modulation Spectrum Shaping
8 4500 Hz Low Pass Filter	Nautel	Modulation Spectrum Limiting
9 RF Carrier Notch Filter	Nautel	High Q Carrier Notch



The measured response of the three Nautel made filters is shown below:

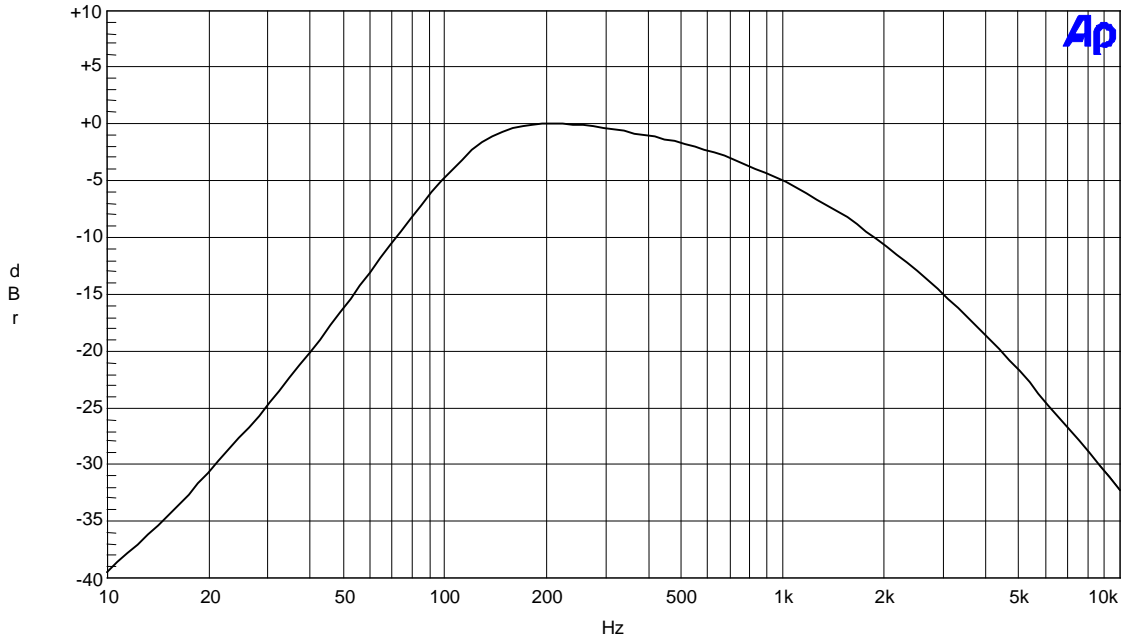


Figure 1 ITU Standard Noise Filter

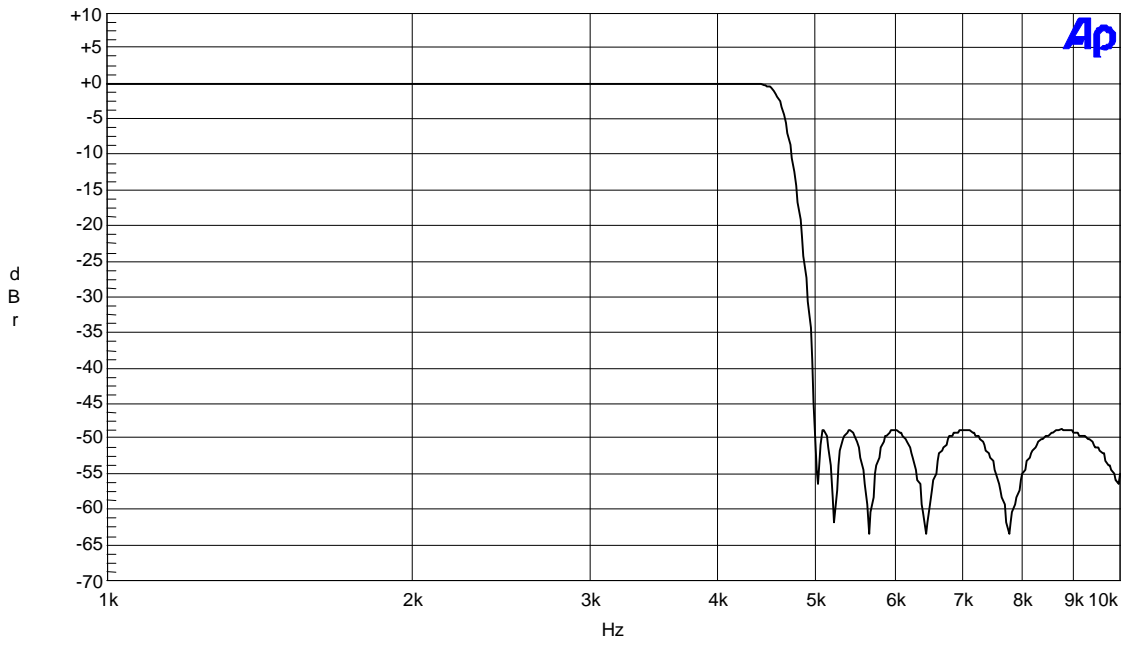


Figure 2 Audio Limiting Filter - 4500Hz



The carrier notch response is tabulated in terms of the attenuation at various frequencies referenced to the center frequency.

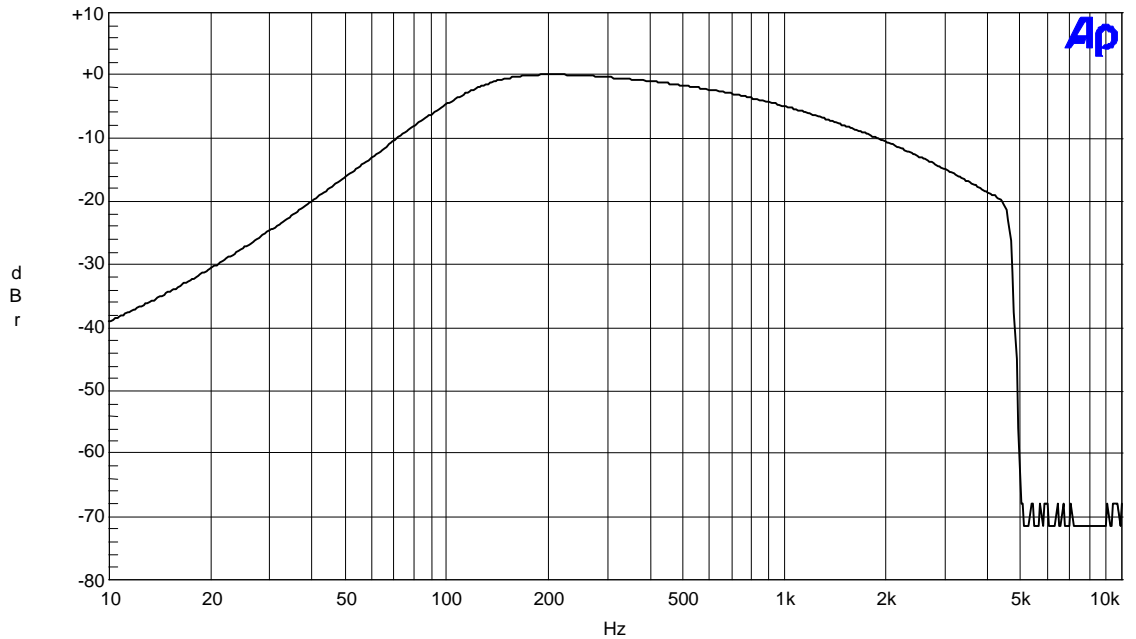


Figure 3 Cascaded

Table 2 ??

Frequency	F-Fcarrier	Response
620 kHz	0 kHz	0 dBc
621 kHz	1 kHz	5.31 dBc
622 kHz	2 kHz	10.1 dBc
623 kHz	3 kHz	13.1 dBc
624 kHz	4 kHz	15.1 dBc
625 kHz	5 kHz	16.6 dBc
626 kHz	6 kHz	17.6 dBc
627 kHz	7 kHz	18.4 dBc
628 kHz	8 kHz	19.0 dBc
629 kHz	9 kHz	19.5 dBc
630 kHz	10 kHz	19.9 dBc
635 kHz	15 kHz	20.9 dBc
640 kHz	20 kHz	21.3 dBc
650 kHz	30 kHz	21.6 dBc
>655 kHz	>35 kHz	21.8 dBc



PROCEDURE

The transmitter was adjusted to 60 kW carrier power. The two audio filters were connected in series between the white noise source and the transmitter audio input.

While turning the modulation signal on and off, the change in transmitter input and output power was measured. Modulation depth was adjusted so that the rms power increased 6.1% with the modulation signal on. This corresponds to 35% average modulation as specified in the recommendation.

The output power measurement was made with a true rms voltmeter and a transformer in the transmitter RF output. The DC power supply output power

measurement was made with a calibrated current shunt and a True RMS reading multimeter. Both measurements showed an increase of 6% when the modulation depth was properly adjusted.

The spectrum of the transmitter RF output was then measured using the carrier notch filter and spectrum analyzer.

RESULTS

Using the carrier notch filter, three spectrum measurements were made having frequency span of 20, 100 and 688.9 kHz. The transmitter pdm frequency is 68.89 kHz so the final measurement shows the transmitter pdm tones aligned with lines on the grid. The three plots are given below:

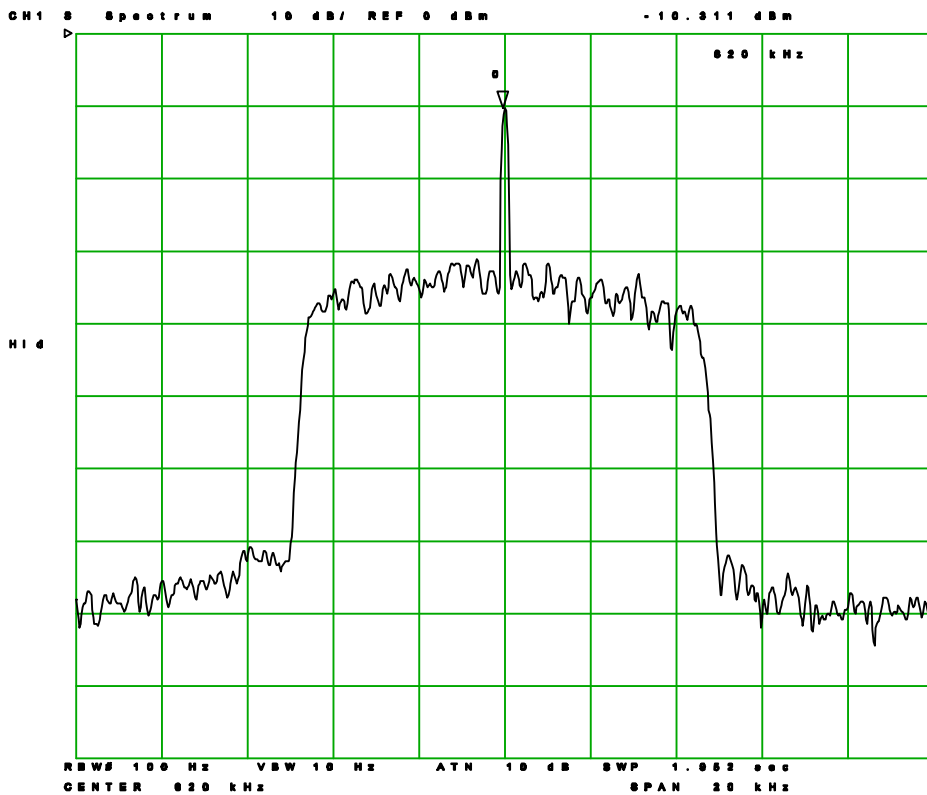


Figure 4 ??



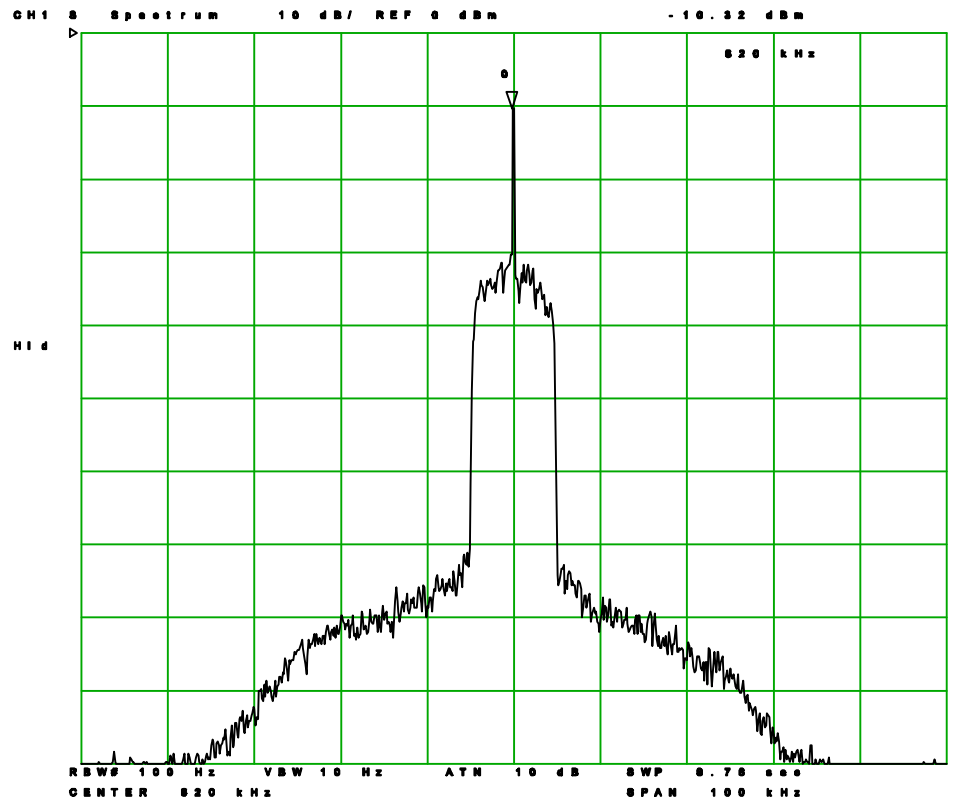


Figure 5 ??

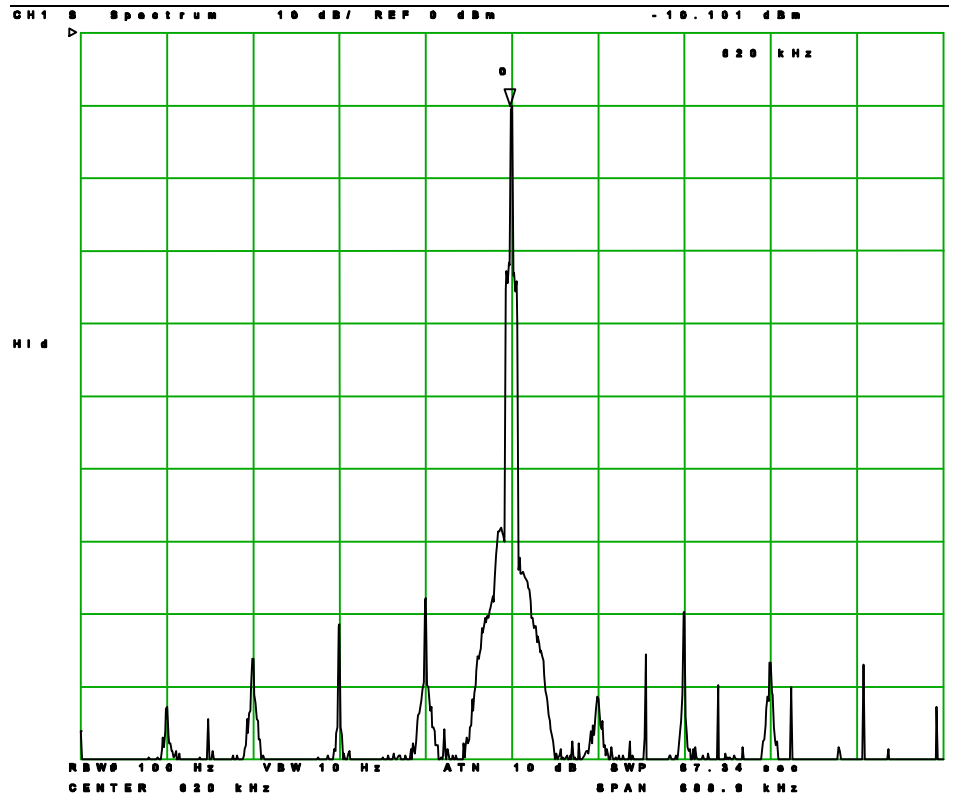


Figure 6 ??



Table 3 Out of Band Spectrum

Frequency (kHz above carrier)	Measured (dBc)	Correction (dB)	Result (dBc)	Limit (dBc)
4.5	-30	-16	-46	-31.7
5	-62	-16.6	-78.6	-42.7
6	-64	-17.6	-81.6	-61.7
7	-65	-18.4	-83.4	-68.5
8	-68	-19	-87	-70.8
9	-68	-19.5	-87.5	-72.9
10	-68	-19.9	-87.9	-74.7
15	-70	-20.9	-90.9	-81.8
20	-73	-21.3	-94.3	-86.8
25	-76	-21.5	-97.5	-90.6
30	-85	-21.6	-106.6	-91.7

Table 4 Spurious Emissions

Frequency (kHz above carrier)	Measured (dBc)	Correction (dB)	Result (dBc)	Limit (dBc)
-68.9	-67.6	-21.8	-89.4	-61
-137.8	-71.2	-21.8	-93	-61
-206.7	-76	-21.8	-97.8	-61
68.9	-80	-21.8	-101.8	-61
137.8	-69.6	-21.8	-91.4	-61

The measurements were made and the limits calculated with the following constants:

Necessary Bandwidth 9000 Hz
 Measurement Resolution Bandwidth 100 Hz
 Measurement Video Bandwidth 10 Hz

The tabulated notch response is used to correct the measured spectrum at a given frequency. For example, the result for Fc + 10kHz is shown below:

Carrier -10 dBm @Fc
 Spectrum (Noise) -78 dBm @Fc+10 kHz
 Measured Result -68 dBc @Fc+10 kHz
 Response correction -19.9 dBc @Fc+10 kHz
 Final Result -87.9 dBc @Fc+10 kHz

The recommended limits are tabulated with the measured and corrected results in Table 3.

The results clearly show the transmitter meets the recommended limits. The minimum margin is 6.9 dB at a frequency 25 kHz above the carrier.

Also visible on the last spectrum plot are spurious emissions (see Table 4) at the transmitter modulator switching frequency and its harmonics. The limit for these emissions is 50 mW (ITU Rec. ITU-R SM.329), or in this case -61 dBc. Again the results clearly show the transmitter meets the recommended limits.

CONCLUSION

The Nautel XL60 transmitter complies with the recommendation. All Nautel AM broadcast transmitters use the same modulator, modulator filter and RF amplifier circuitry. As a result, the results will be similar for all Nautel AM broadcast transmitters.

