2101 SUPERIOR AVENUE
CLEVELAND, OH 44114 USA
TEL: +1.216.241.3343
FAX: +1.216.241.4103
HTTP://WWW.OMNIAAUDIO.COM

Omnia.fm Audio Processing Plug-In For The ITU BS-412 Multiplex (MPX) Specification

By Frank Foti, Cutting Edge, Cleveland, Ohio

October, 2000

Introduction

Over the last few years, there has been interest in the European countries and by the ITU regarding FM transmission channel interference. Due to the growing number of available FM frequencies and the 100kHz channel spacing that is employed in most of Europe, interference due to channel spectrum energy has become an item of investigation. One of the topics discussed and evaluated by the ITU is the issue of modulation density and occupied channel bandwidth based upon deviation. This concern deals chiefly with how much channel interference is being generated by modulation density created from audio processing.

The sophisticated processing equipment that is available today is capable of reducing the peak-to-average ratio of a transmission signal to a very small quotient — relatively speaking, a few dB. In this situation, a very dense modulation envelope is created. It is this dense signal that the ITU evaluated, and determined that it does, in fact, exaggerate interference problems of co-channel signals.

The remedy for this situation can be achieved through the use of one of two methods: reduce the peak modulation level, or reduce the density of the modulated signal while maintaining the same peak deviation level. The ITU BS-412 requirement deals with the latter method by establishing a measurable parameter of the MPX signal that will ensure minimal or limited co-channel interference, based upon deviation. This measurement looks at the acquired power level of the MPX signal and averages it over a one minute period. This one minute average power level may not exceed a deviation of 19kHz, while the peak level does not exceed 75kHz deviation. Here follows the BS-412 definition, as written by the ITU:

> "It is assumed that the maximum peak deviation of ± 75 kHz is not exceeded. Moreover, it is assumed that the power of the complete multiplex signal

(including pilot-tone and additional signals) integrated over any interval of 60 seconds is not higher than the power of a multiplex signal containing a single sinusoidal tone which causes a peak deviation of ± 19 kHz."

"NOTE – The power of a sinusoidal tone causing a peak deviation of ± 19 kHz is equal to the power of the coloured noise modulation signal according to Recommendation ITU-R BS.641, i.e. a coloured noise signal causing a quasi-peak deviation of ± 32 kHz."

As stated earlier, audio processing is designed to reduce the peak-to-average ratio. By its very nature, modulation density will be generated, and by the restriction stated above, the BS-412 limit will be exceeded by a significant level — generally on the order of 4dB - 5dB, and that's dB of power! Basically, to conform to this regulation under normal operating conditions of a processor, the audio density is reduced almost in half. Considering that the requirement will affect all rations in a given region, the relative loudness of one station to another will remain the same. The question then becomes, how should an audio processor be set up to conform to this requirement?

Processing For ITU Compliance

It is possible to adjust an audio processor so that it will adhere to the BS-412 regulation. All units have enough adjustment available on them that allow the processing to be reduced in order to keep the modulated signal within the BS-412 limits. Simply speaking, this requires reducing the dynamic action of the compressors and/or limiters so that the dynamic range is increased to a point where the BS-412 requirement is met. We have found through our own testing and observations that this is possible, but there are a few drawbacks to this method.

It must be understood that the BS-412 requirement applies to the entire MPX signal. This means that any significant changes in the audio spectrum between 50Hz and 15kHz, in the stereo sound field as represented by the L+R and L-R signals, or in the amount of high-frequency boost due to pre-emphasis will all have a significant effect upon the MPX power level.

Now consider that most available audio processors for FM, employ multiband processing. This too has a dramatic effect on the observed MPX levels as the interaction of the multiband sections and pre-emphasis can cause inconsistencies of the BS-412 measurement.

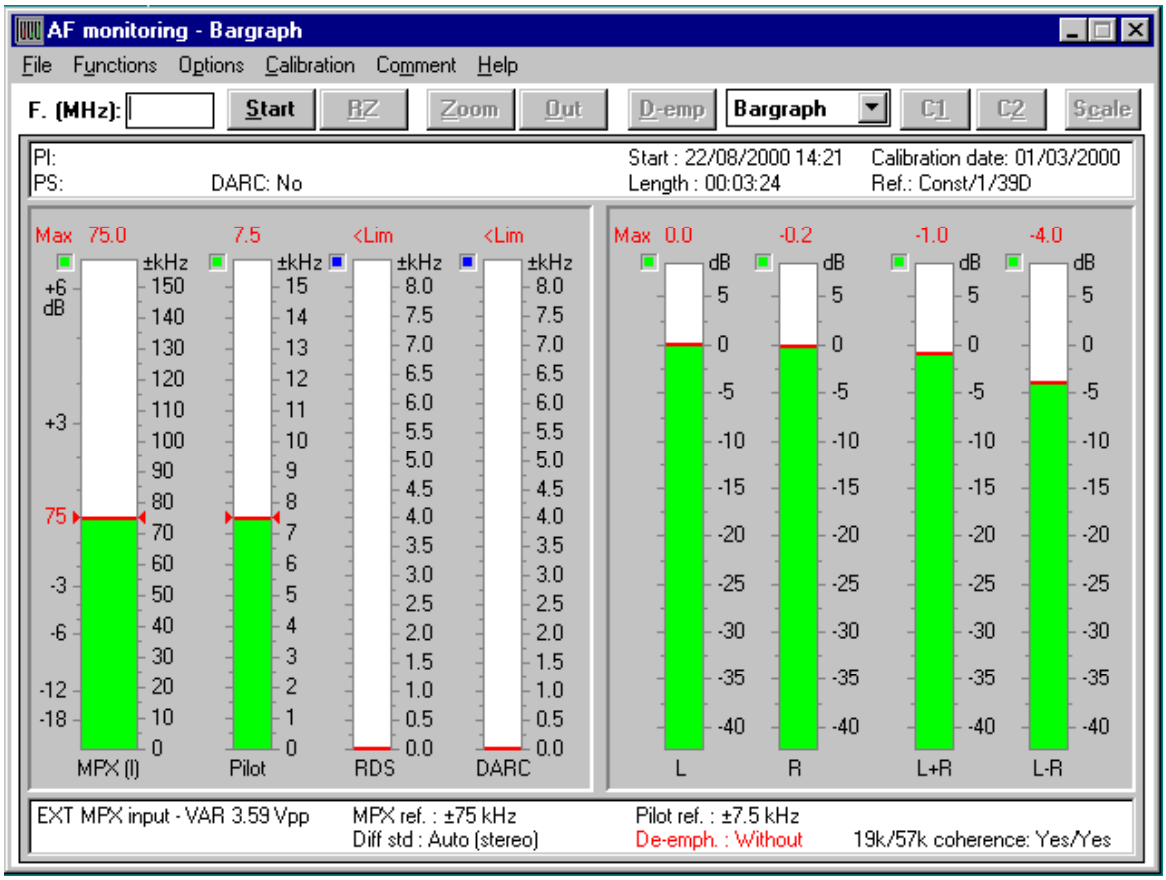
Most dynamic processors don't operate with a processing ratio of ∞:1. (These are the processing sections that are located before the absolute final limiter, or clipper section. That section *must* operate with an ∞: 1 ratio, or overmodulation will result.) There is usually some amount of *bend* in the ratio that is used to maintain a dynamic feel to the program material. This helps eliminate the processors from sounding too tight, or "squashed," as some might say. Because of this *bend* in the operating ratio, it becomes difficult to maintain a specified average density level, even when observed over a long period such as one minute.

Taking each of the previous observations into consideration, it is easy to see that simple adjusting of an existing processor to maintain the BS-412 requirement can be a bit difficult while also attempting to create a processed signal that is acceptable to station personnel. Another problem is that once the system is adjusted to meet compliance, it may not be known if further adjustment will cause the system to fall out of compliance again. What is needed is a processing configuration that allows any type of adjustment, yet maintains compliance with the BS-412 requirement.

Omnia.fm BS-412 Limiter Plug-In Module

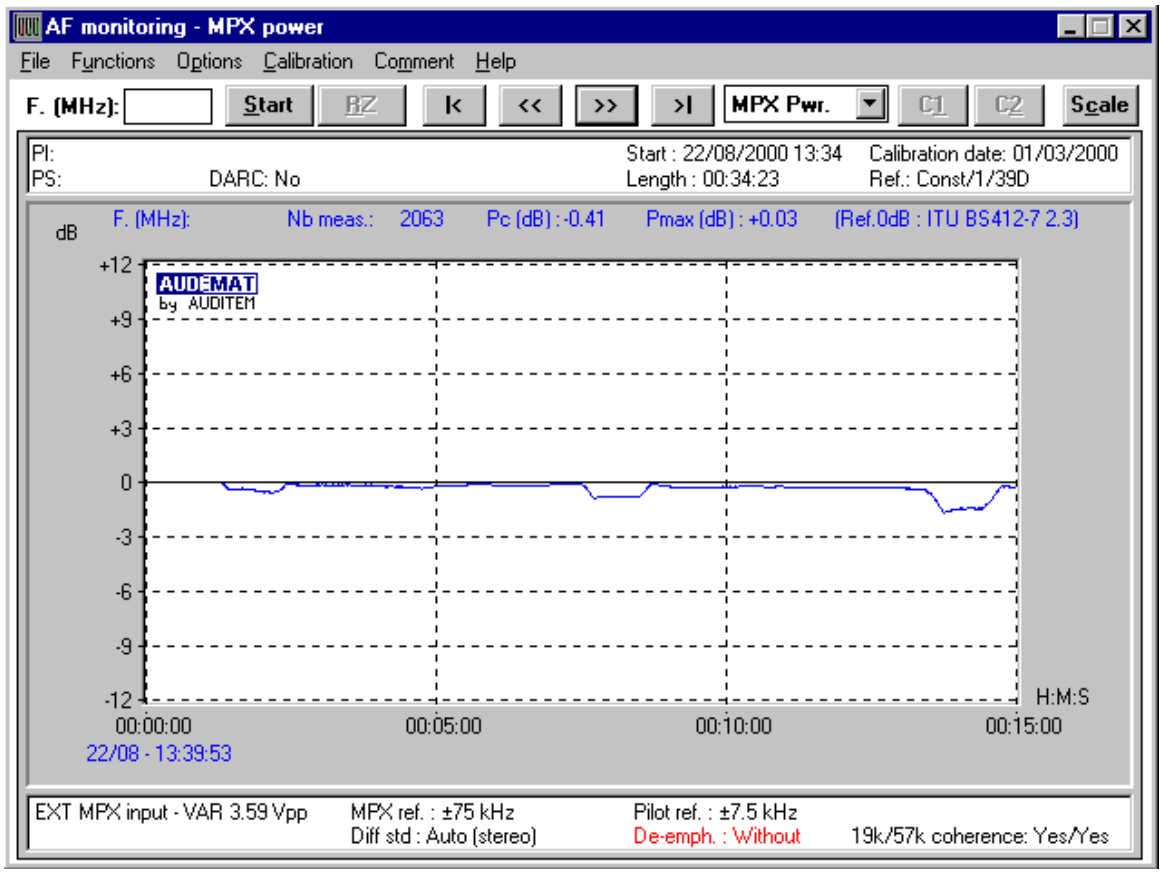
The concept around which the BS-412 Limiter module for the Omnia.fm processing system was designed is that the power level of the processed signal should be measured and analyzed *after* multiband processing, so that the system can continue to comply with the ITU requirement even as subsequent adjustments are made. This is easier said than done! A limiter algorithm was developed that essentially mirrors the BS-412 measurement method and employs the collected information in a reciprocal manner, so that it can be applied to the processing system. The module that contains this algorithm is located between the multiband processing section and the final limiter. As processing is employed, this limiter adjusts the relative amount of density that can be passed on to the final limiter. This function is both frequency and density dependent. The interaction of the BS-412 Limiter and the final clipper ensures that proper peak deviation is maintained, while limiting the power of the MPX signal to the required level. This is how compliance is maintained.

Following are two screen captures of an actual measured MPX signal running through an Omnia.fm with the BS-412 Limiter module, showing that the BS-412 requirement is adhered to. The first diagram shows that MPX levels for peak deviation are within the acceptable range:



Peak Measurement Of MPX Signal With Omnia.fm Processor

The next illustration is of the measured MPX level over time. The display shows a window of measurement of 15 minutes. This test was done using a CD that was allowed to track, so the three dips that are observed are due to the pauses between the tracks on the CD; those dips are factored into the rolling average of the measurement. As can be observed on the diagram, the MPX level *never* exceeds the ØdBu level limit. (This is the reference level that indicates the 19kHz average power deviation level.)



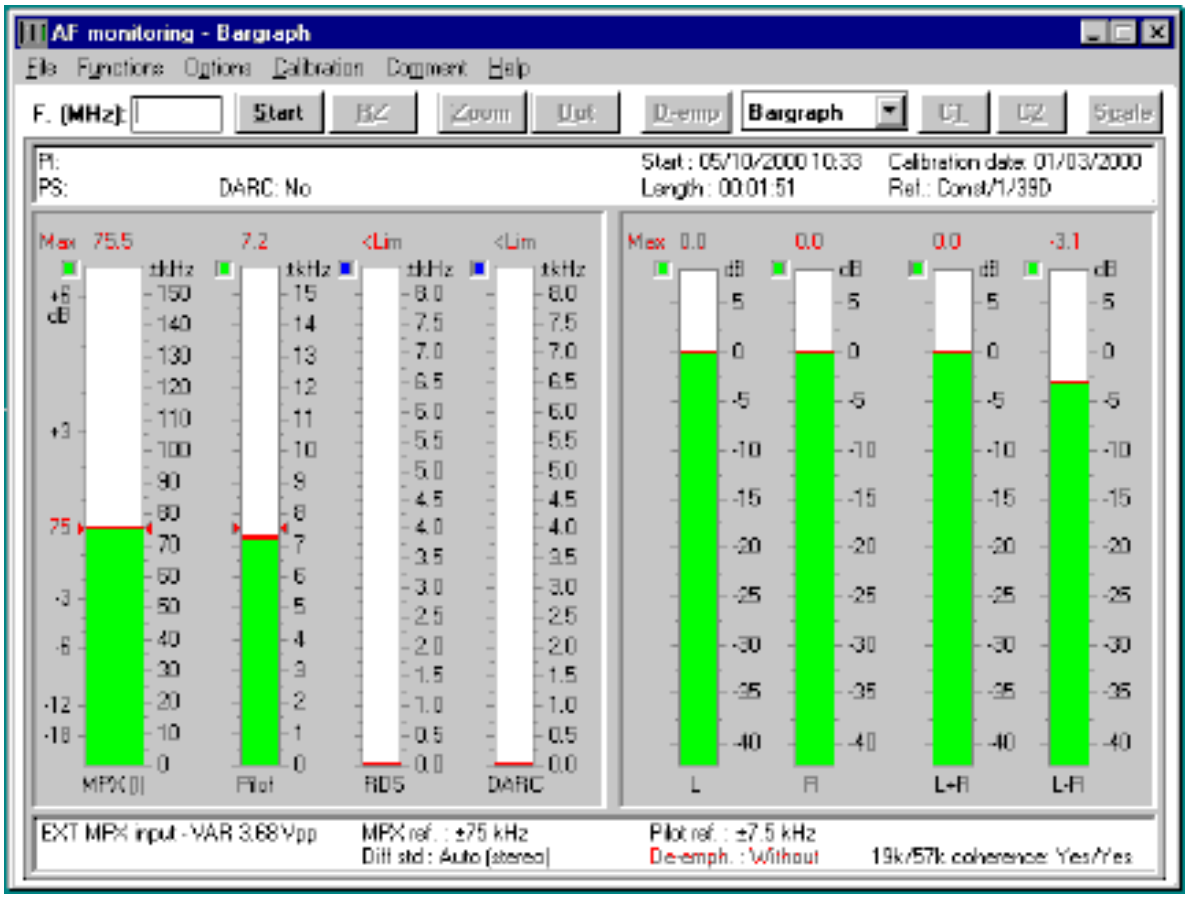
BS-412 Measurement Over 15 Minute Period With Omnia.fm Processor

The BS-412 measurement results shown above will be achieved no matter what type of processing adjustment is applied to the Omnia.fm system. What is illustrated here is that with the Omnia BS-412 Limiter system, a signal can be processed quite heavily, yet still fall within the BS-412 specification. If additional dynamic range is desired, it can be easily gained by simply reducing the amount of processing used.

The end-user will notice two differences in this processing architecture as compared to the non-BS-412 configuration. First, there are no available clipping parameters to adjust. Those parameters have been preset internally, and the drive to the clipper section is set by the BS-412 limiter. If the processing is adjusted for aggressive operation, the BS-412 limiter becomes more active and reduces the drive to the clipper. Second, a bar graph indicator has been added to the limiter screen. This indicates the amount of MPX power level adjustment.

Comparative Measurements (Orban 8400)

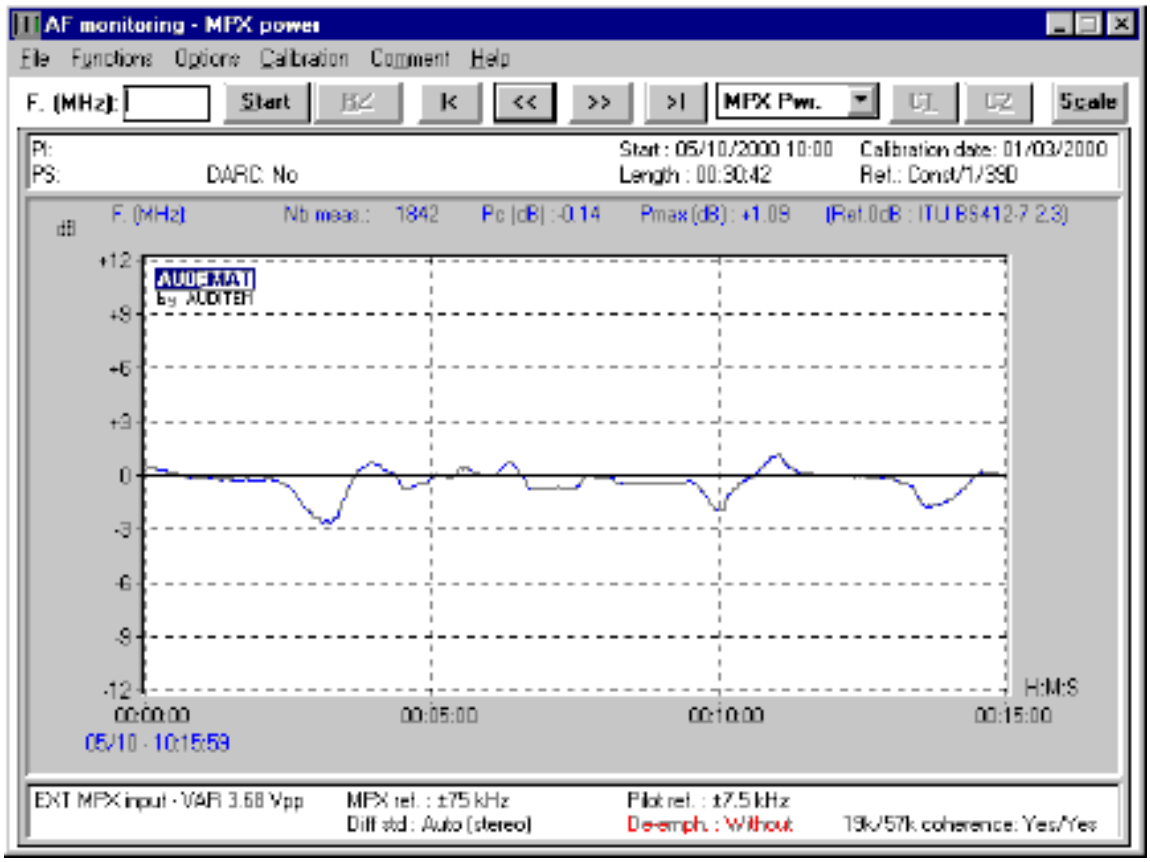
An interesting comparison of how the ITU BS-412 requirement is adhered to can be illustrated by examining an example of the performance of another audio processor and how it handles the MPX power level. The Orban Optimod 8400 employs a special limiter that is designed to maintain the MPX power level within the ØdBu level. The same test applied to the Omnia.fm processor was also applied to the Optimod 8400. The 8400 was set up exactly as described by the Orban operating manual. As the results revealed by the following graphics show, the Optimod's adherence to the BS-412 requirement appears to be a very loose interpretation of the standard, to say the least. The 8400 was tested using normal program material with pre-emphasis set to 50µs.



Peak Measurement Of MPX Signal With Orban 8400 Processor

This graphic illustrates that correct peak level deviation is occurring. This test was performed with the Orban BS-412 MPX limiter engaged.

The following screen graphic shows the performance of the MPX limiter over a 15 minute time period:



BS-412 Measurement Over 15 Minute Period With Orban 8400 Processor

Notice how the level is not maintained as consistently near the ØdBu reference marker. This indicates that the Orban 8400's MPX power is not being held to a maximum of 19kHz deviation over the one-minute measurement period. In fact, as the measurement by the Audemat system shows in the above graph, the MPX power controller algorithm in the new Orban Optimod 8400 allows the ITU BS-412 regulation to be exceeded by a power level of +1.09dB!

It should be stated that the tests performed on both processing systems were done with aggressive processing settings. Compare this illustration with the earlier graph. Notice the flat-line appearance of the Omnia graph, which indicates a signal that will be perceived as being louder, yet which remains within the ITU regulation. The results of these tests easily show the significantly greater performance and BS-412 adherence of the Omnia.fm processor compared to that of the Orban Optimod 8400.

Please note that the Omnia algorithm employed in these tests is already included in the new Omnia-6fm processor. The BS-412 algorithm can be easily applied to the *existing* Omnia product line as well, and Software Plug-In modules for the Omnia-3fm and original Omnia.fm audio processors will be made available as well. This is an example of the flexibility inherent in Omnia's innovative hardware platform, whereas the older Orban Optimod 8200 and Optimod 2200 units are not upgradeable, and will require replacement in order to conform to the ITU regulation.

Processing Considerations And The BS-412 Limiter

The BS-412 Limiter Module is added to an original Omnia.fm processor by replacing the PC Card and adding one more DSP circuit (please refer to the Omnia-fm manual with regards to making hardware changes to the system). Upon completion of this exercise, the unit will contain the new functionality.

The BS-412 presets provided apply the BS-412 limiter automatically; it is *not* a function that can be bypassed or defeated. All other processing parameters normally associated with Omnia.fm are left intact and function as normal. It is recommended that when making initial adjustments to the system, the end-user try to get a "feel" for the operation of the BS-412 limiter, and understand that there will be a reciprocal reaction by the limiter to certain processing adjustments that are made.

For example, increasing the output of the HF Band in the *MIXER* section can cause the BS-412 limiter to become overly active. This can, in turn, reduce the overall density as the BS-412 limiter must recognize the employment of pre-emphasis to the overall signal. In other words, make final *MIXER* adjustments in small amounts and then observe how those interact with the BS-412 limiter. In testing in our lab, we have found that EQ adjustment of the *presence* and *high frequencies* has a more dramatic effect on the BS-412 measurement. This has to do with the added high frequency density that is created by the 50µs pre-emphasis boost.

Trying to create a dense and compressed signal will activate more BS-412 limiter action. There is a point at which the limiter will recognize a significant amount of density and reduce the overall level to the clipper. At this point there is very little, if any, gain in loudness. This same effect can be realized if the time constants in either the multiband AGC or multiband Limiter sections are set for faster operation. It is possible to create the effect of heavy density and compression, but it will be done so while maintaining the proper deviation density as defined by the BS-412 requirement.

It is recommended that a factory preset be used for initial operation; from there, *EQ* and processing adjustments can be employed to achieve the final desired sound. Initially, care should be taken to insure that the proper peak deviation is being observed, as this will also affect the overall test measurement of the MPX level. The use of one of the accepted BS-412 test systems is recommended. In our lab, we have found the Audemat System by Auditem to be very useful and reliable (screenshots shown in this white paper were generated using the Audemat System). Adjustment of peak modulation without the use of an accepted modulation monitor or BS-412 analyzer will result in improper operation. We suggest that the use of input meters to exciters, or PPM meters connected to a receiver not be employed, as they generally do not have the peak response and ballistics that are required by most broadcasting authorities.

Frank Foti

October, 2000