Before the
Federal Communications Commission
Washington, D.C. 20554

MM Docket No. 93-225

In the Matter of

Amendment of Part 73 of the Commission's Rules to Clarify the Definition and Measurement of Aural Modulation Limits in the Broadcast Services

NOTICE OF INQUIRY

Adopted: July 23, 1993; Released: August 12, 1993

Comment Date: November 5, 1993
Reply Comment Date: December 15, 1993

By the Commission:

INTRODUCTION

1. The purpose of this *Inquiry* is to explore the Commission's rules and policies that relate to the definition and measurement of aural modulation[1] limits. Having appropriate limits on modulation, or on the emitted sidebands resulting from modulation, is essential to controlling adjacent channel interference levels. Although the discussion herein focuses principally on the measurement of FM modulation, we welcome comments addressing aural modulation measurement in the AM and TV services.

BACKGROUND

2. Limits on station aural modulation traditionally have been considered among the most important of the Commission's technical standards due to their direct effect on the quality of radio service.[2] Maximum and minimum levels of aural modulation are specified in Section 73.1570 of the Commission's Rules for the broadcast services and are intended to ensure that a quality signal is available throughout the service area. In general, our rules require that loud program material modulate the transmitter at least 85% to ensure reasonable consistency among broadcast stations.[3] However, as a practical matter, undermodulation is seldom a problem in the broadcast services and is not an issue in this proceeding.

3. Limits on aural overmodulation serve a variety of purposes. First, they help to insure that excessive sideband energy is not generated, which could exacerbate adjacent channel interference levels. In the case of AM stations, the limit on positive peak modulation limits the average power to an extent consistent with the authorized carrier power; the limit on negative peak modulation controls distortion. Also, many AM broadcast transmitters handle large negative peaks in a nonlinear fashion and produce out of band emissions when negative peaks near or above 100% are encountered. In the television service, the limits serve to prevent degradation of the video signal and minimize adjacent channel interference in cable TV systems. In receivers, which are designed to receive signals with certain predetermined characteristics, modulation limits help prevent distortion. This *Notice of Inquiry* principally will examine the subject of aural modulation and to a lesser extent, the subject of aural station bandwidth and emission, inasmuch as bandwidth and emission standards are derived primarily from the study of modulation and to a lesser degree, power.[4]

4. Prior to 1983, FM licensees were required to monitor their stations' modulation using modulation monitors authorized by the Commission under its type-approval procedure.[5] Such equipment was required to embody certain design characteristics specified in Section 73.332 of the Commission's Rules (Requirements for type approval of FM modulation monitors). However, as a result of action taken in MM Docket No. 81-698,[6] Section 73.332 was deleted and type approval of modulation monitors was no longer required, nor were modulation monitors. Other rules also were eliminated or modified to give licensees more flexibility in measuring modulation. However, the rules limiting modulation were left essentially unchanged.

5. Section 73.1570 limits FM modulation levels stating that "the total modulation must not exceed 100 percent on peaks of frequent reoccurrence referenced to 75 Khz deviation."[7] Licensees are free to use whatever methods they wish to ascertain conformance with these requirements. Some continue to use monitors which were type approved

[1] Modulation is the process by which some characteristic of a radio frequency (RF) signal is varied in accordance with the changes that occur in a program signal. For example, in FM broadcasting the frequency of the RF signal is made to vary by both the audio frequencies and loudness levels present in the voices and music of the program material. Similarly, in AM broadcasting the program source causes variations in the amplitude of the RF signal. All forms of modulation generate energy in "sidebands" which surround the main carrier. Modulation that exceeds our standards can cause excessive sideband energy, which can interfere with the reception of signals on adjacent channels.

[2] Other fundamentally important operational standards regulate power, frequency stability and out-of-band and spurious emissions.

[3] An exception to this requirement is made to avoid objectionable loudness or to maintain the dynamic range of program material. *See* Section 73.1570(a).

[4] Emission limitations often incorporate a power dependent term to limit harmonic and spurious emissions (emissions outside the authorized bandwidth).

[5] Under type-approval, the Commission tested the modulation monitors to ensure that they complied with the standards in Sections 73.50 (for AM), 73.332 (for FM) and 73.694 (for TV).

[6] *See Report and Order* in BC Docket No. 81-698, 54 RR 2d 435 (1983), 48 Fed. Reg. 36459, August 11, 1983.

[7] An exception is made for FM stations using subcarriers to provide subsidiary communications services, where somewhat greater modulation and deviation are permitted. Stations providing subcarrier services may transmit with peak modulation up to 110%, which is equivalent to 82.5 Khz deviation. We understand that some broadcasters are misinterpreting this provision by assuming that the mere presence of subcarriers permit increasing modulation to 110%. The rule requires that the total

by the Commission in earlier years, while others use a variety of newer devices employing sophisticated circuits which can be adjusted to respond to or ignore modulation peaks of different intensities and durations. Thus, while some modulation monitors may conform to the standards formerly specified for type approval of modulation monitors, they can be adjusted so as to give differing indications for the same transmissions.

6. Many broadcast station licensees choose to keep their average modulation levels as high as possible in order to keep their signal above noise at the limits of their service areas and to attract the attention of listeners who are tuning across the dial.[8] To achieve this objective, licensees use audio signal processing devices that automatically compress the dynamic range of the original program. That is, the quiet passages of music are increased in volume and the very loud passages are suppressed. When used correctly, this improves the listenability of the program, particularly for automobile reception where high surrounding noise levels could exceed low volume program passages. When used to excess, the result is uniformly loud music with little discernible dynamic range and a "flat" quality. Some licensees, by using monitors which disregard very brief or infrequent bursts of high modulation, find they need employ only moderate audio compression to attain reasonably high modulation levels. This approach preserves more of the dynamic range inherent in live music.

7. The marketing of monitors which give different indications is the catalyst for this reexamination of modulation measurement. Some equipment suppliers believe that no modulation in excess of 100% should be permitted. Others, due to differences in interpreting previous FCC rules relating to modulation monitor type approval and automatic transmission system monitoring, have concluded that occasional modulation peaks of very short duration exceeding 100%[9] or occurring infrequently (i.e., less than 10 per minute)[10] do not contribute to interference to adjacent channel stations. The resulting differences in modulation monitor operation can result in significant variations in loudness from one station to another and possibly, differing opinions in the industry regarding compliance with our modulation rules.[11]

8. As the foregoing discussion demonstrates, there is some confusion over what constitutes overmodulation and how it should be measured. Another difficulty is that the methods of modulation measurement used by broadcasters differ from that used by our staff in the Field Operations Bureau (FOB). The most common circuitry in the newer monitors detects peak deviation levels exceeding a user specified level (usually 100%) and flashes a warning light. Our personnel, on the other hand, usually monitor broadcasts by connecting an oscilloscope to an FM receiver's discriminator and calibrating it to display deviation in excess of the legal limit. This basic method is the same one that was used when the Commission mandated type-approved modulation monitors. The different methods can lead to different conclusions which have consequences for broadcasters.[12] All of these factors warrant examination and, if necessary, clarification by the Commission to ensure a proper and uniform understanding of their responsibilities by all licensees.

---

modulation may be increased over 100% in the amount of a half of a percent for each one percent of subcarrier modulation injection, up to a maximum of 110%. Thus, only if 20 percent subcarrier modulation was used at an FM station, could the total modulation be increased to 110%. This exception is permitted so that stations providing subcarrier services do not have to sacrifice the competitive loudness of their broadcast programming.

[8] We are aware that the "loudness" of an FM station depends principally on the modulation level and the audio compression used, and that station revenues often depend on being heard over as wide an area as possible. However, the bandwidth occupied by an FM signal is a direct function of its level of modulation and the mix of modulating frequencies, and all licensees must stay within their assigned channels in order to assure that interference levels will remain within designed limits.

[9] The former Section 73.332 required that the peak preset indicator light, usually set to flash when modulation exceeded 100%, respond to tone bursts occurring at repetition rates from one to ten "bursts" per second. A "burst" consisted of: Ten consecutive cycles of a constant amplitude 10 kHz sinusoid (a 1 millisecond tone burst) and five consecutive cycles of a constant amplitude 1 kHz sinusoid (a 5 millisecond tone burst). This indicator was required for FM modulation monitors designed for use at stations transmitting stereophonic and/or subcarrier signals *only* (but *not* monophonic FM signals). Because sensitivity to the one millisecond tone burst is more demanding than responding to a 5 millisecond burst, and because nearly all FM stations today transmit stereophonic signals (many with additional subcarriers), a "1 millisecond response" characteristic has continued to be used as an equipment design standard by some manufacturers of modulation monitors. However, current rules do not require the use of this test procedure.

[10] Former Section 74.342 contained special rules pertaining to modulation monitoring and control devices used at stations under automatic transmitter control. Section 73.342(a) permitted no more than 10 bursts of modulation per minute in excess of 100%. For the purposes of this requirement, a sequence of repetitive instances of modulation exceeding the prescribed limits occurring within a single 5 millisecond interval was to be considered as one burst. However, this rule was never invoked by the Commission as comprising a general definition of the term "peaks of frequent reoccurrence." Nevertheless, it has been used as such a definition by some modulation monitor manufacturers.

[11] A case in point occurred several years ago when a well-known equipment manufacturer marketed a state-of-the-art television stereo modulation monitor which could detect overmodulation transients as short as several microseconds. Traditional modulation monitors only detected and indicated peaks that had a much longer duration. Engineers using the more sensitive monitor noticed that when their stations' operating parameters were set using this device, their average modulation (i.e., the loudness of their TV stations' aural signals) was noticeably less than that of stations using older monitors. Attempts to resolve the discrepancy between traditional versus state-of-the-art methods of modulation measurement were unsuccessful. Ultimately, an electronic "correction" was made to the new monitor to make its indications match more closely those of modulation monitors made by other manufacturers.

[12] However, we note from our enforcement experience that instances of overmodulation do not commonly involve borderline judgments; stations which overmodulate tend to do so in an egregious manner which is apparent from any measurement method used.

THE INQUIRY

9. We seek comments on two basic issues: (1) What should be the definition of overmodulation (including whether new emission limitations should be adopted in lieu of an overmodulation standard); and (2) What methods or procedures are necessary to implement any proposed limits on modulation levels.

10. *Definition of overmodulation.* As noted above, the current definition of permissible modulation sets out frequency deviation limitations and states that these limitations must not be exceeded by "peaks of frequent reoccurrence." No definition of this phrase is given in the rules. Should this rule remain unchanged, or should it be modified or interpreted with more specificity? In particular, should consideration be given to the amplitude of the modulation peaks beyond 100%, to the time duration of such peaks, or to the number of peaks within a given span of time? Experience indicates that a few overmodulation peaks per minute can be tolerated without causing perceptible adjacent channel interference. Such peaks may even be unavoidable if a station seeks to promote fidelity and a natural dynamic range without excessive signal processing. Thus, while some engineers might argue that no overmodulation should be tolerated, such a rigid rule could pose considerable problems with respect to compliance. Therefore, we seek information on what maximum peak overmodulation amplitude, frequency or duration (or some defined interrelationship between these three parameters) should be considered overmodulation capable of causing harmful adjacent channel interference.[13] We also note that theory tells us that peaks of very short duration result from high bandwidth baseband signals and can result in excessive sidebands for reasons other than overmodulation. Are there other relevant modulation parameters which should be considered as well? We request that commenters consider submitting empirical or theoretical data to support their views in this area.

11. We also wish to examine a different approach to resolving the overmodulation issue. Namely, should we eliminate specific limits on modulation *per se* and replace them with a new emission limitation (or standard) designed to prevent harmful adjacent channel interference? Traditionally, emission limitations have taken the form of "step-function" formulas relating transmitter output power to transmitter bandwidth, with permissible power dropping in steps as the bandwidth increases. These "step function" limitations, however, were developed decades ago, are extremely simplistic approximations of signal envelopes and, for this reason, do not afford adequate adjacent channel protection. However, in recent years more sophisticated versions of these limits have been developed which use continuous power "roll-off" formulas derived from Bessel function analysis. These newer emission standards provide a readily quantifiable degree of adjacent channel protection. It may be possible to develop analogous formulas for FM and TV aural signals which could replace the current modulation limits and avoid the definitional problems inherent in the current regulations.

12. For example, in the 1970s, Motorola, Inc. requested that the Commission amend the rules in the private land mobile services to provide for the use of what is popularly called F3Y ("digitized voice") emission.[14] This led to the development of a new emission limitation, custom-tailored to permit digital modulation without significantly increasing adjacent channel interference.[15] The new emission standard became the primary means of limiting adjacent channel interference, while providing land mobile licensees with considerable flexibility in using digital modulation. The same standard recently was adopted for use in the Remote Pickup Broadcast Service.[16]

13. In addition, the Commission recently adopted in MM Docket No. 88-376, a new emission limitation for AM broadcast stations.[17] This new emission standard is intended to reduce levels of adjacent channel interference in the AM service while giving licensees considerable flexibility in program audio signal processing. While modulation limits in the AM service were retained, their practical function is

FCC MAIL SECTION
AUG 12 1 06 PM '93
DISPATCHED BY

[13] Generally, discussions on overmodulation have not focused on the degree or percentage of overmodulation. Usually, individuals debate whether peaks of less than 1 millisecond duration are inconsequential, and whether a small number of peaks (such as less than 10) within a one-minute period are significant.

[14] F3Y was the original emission designator for "digitized voice modulation." To conform with current International Telecommunications Union (ITU) specifications, it should now be termed F1E (frequency modulated single-channel digital telephony) or G1E (phase modulated single-channel digital telephony) emission. However, the old terminology persists and is used in Sections 74.462 and 74.482 of the Commission's Rules. For the sake of consistency, we will use F3Y here to refer to the F1E and G1E emissions. The signal comprising this emission was incompatible with the low pass audio filtering requirements that, along with modulation limits, were the principal means of preventing adjacent channel interference at that time. There was (and still is) a very broad emission limitation specified for land mobile transmitters but its adequacy was questioned. (Whereas normal voice emissions fell far below the emission limits, the F3Y emission, containing a higher than normal fundamental modulating frequency with attendant harmonics, approached it much more closely.) This created the need for a more exact emission limitation for digital modulation.

[15] *See First Report and Order* in Docket No. 21142, 42 RR 2d 355 (1978) and *Second Report and Order* in Docket 21142, 46 RR 2d 937 (1979). The emission limitation developed in that proceeding was based on a Bessel function analysis of the emitted signal based on the use of a low-pass audio filter to attenuate high frequency components of the modulating signals. The low-pass filter requirements were deleted for transmitters which comply with this derived emission limitation. Its efficacy in preventing adjacent channel interference was proven by over-the-air tests conducted at the time and have since been confirmed by years of operating experience.

[16] *See Report and Order,* MM Docket No. 90-499, adopted May 22, 1991, released June 11, 1991, 56 Fed. Reg. 28497, June 21, 1991.

[17] *See Notice of Proposed Rule Making* in MM Docket No. 88-376, 3 FCC Rcd 5687, 1988 , *Report and Order* in MM Docket No. 88-376, 4 FCC Rcd 3835 (1989) and *Memorandum Opinion*

to limit the average transmitter output power.[18] The new emission limit is controlling with respect to limiting interference caused by excessive sidebands.[19]

14. Inasmuch as a station's total power output does not change with modulation in the case of FM and TV aural transmitters, it is possible that appropriate emission limitations could be developed for those stations which could render specific limits on modulation unnecessary. The rationale for this approach would be that the interference potential of these transmitters is determined by their occupied bandwidth. Therefore, a carefully defined limit on occupied bandwidth could be effective in preventing interference and give licensees more flexibility in audio processing as well as the use of multiplexed subcarriers.

15. However, signals broadcast by FM and TV aural transmitters are much more complex than those typically transmitted in the land mobile services and in AM broadcasting. Comment is requested on whether anyone has developed mathematical models for FM or TV aural multiplex signals. Should there be uncertainties or disagreement over how such a task should be approached, an empirical approach may provide the solution. Radiated emissions of FM and TV aural transmitters transmitting different kinds of programming and multiplexed subcarriers could be measured using spectrum analyzers to develop an emission profile that would accommodate all current transmission system configurations not deemed to cause more than the normally expected amount of adjacent channel interference. Comment is requested on the desirability of developing more precise emission limitations for FM and TV aural transmitters, and whether an analytic or empirical approach would be preferable.

16. *Instrumentation.* In MM Docket No. 81-698, referenced above, the Commission deleted the requirement that the modulation monitoring equipment used by each station be FCC type approved. This deregulatory action was meant to provide licensees with some flexibility in achieving compliance with modulation limits and to eliminate a burden (equipment authorization) on equipment suppliers and the Commission. It was not meant to excuse licensees from using whatever means were necessary to ensure compliance with the modulation limits. This will continue to be the case if the current modulation limits are retained or revised, i.e., we do not expect to type approve monitoring equipment or specify what type of equipment licensees should employ to maintain their compliance with any modulation limits that may emerge from this rulemaking.

17. It is possible that the equipment needed to determine compliance with emission limitations may be more expensive than that used to make traditional modulation measurements.[20] We seek information on what equipment would be required, its costs, and the skills needed to operate it properly. If the emission limitation approach is adopted, what devices (other than spectrum analyzers) would be suitable for detecting excessive bandwidth?[21] We note that even the use of such devices may not eliminate some of the problems facing the current generation of modulation monitors, because a limit may be necessary on the time duration and recurrence rate of peak tolerable out-of-band power. Lastly, if we adopt new emission limitations, should we continue to allow the use of conventional modulation monitors as an alternative?[22]

SUMMARY

18. In this proceeding we seek to obtain information that will enable us accurately to set meaningful modulation limits on peak amplitude, peak duration, peak recurrence rates and the time interval over which the peaks are to be counted. Finally, we wish to examine an alternative concept -- that emission limitations can replace modulation limitations. We seek information on this concept's application to modulation, modulation measurement, the control of interference and its implications for broadcasters, equipment manufacturers and the Commission's enforcement efforts.

Procedural Matters

19. This Notice of Inquiry is issued pursuant to authority contained in Sections 4(i), 303 and 403 of the Communications Act of 1934, as amended. Pursuant to applicable procedures set forth in Sections 1.415 and 1.419 of the Commission's Rules, 47 CFR 1.415 and 1.419, interested parties may file comments on or before **November 5, 1993,** and reply comments on or before **December 15, 1993**. All relevant and timely filed comments will be considered by the Commission before taking further action in this proceeding. To file formally in this proceeding, participants must file an original and four copies off all comments, reply comments and supporting documents. If participants want each Commissioner to receive a personal copy of their comments, an original and nine copies must be filed. Comments and reply comments should be sent to the Offices of the Secretary, Federal Communications Commission, Washington D.C., 20554. Comments and reply com-

and Order in MM Docket No. 88-376, 5 FCC Rcd 2598 (1990).

[18] The nature of amplitude modulation limits acceptable negative modulation to 100% if significant signal distortion is to be avoided. Section 73.1570(b)(1) limits positive peak modulation to 125%. This permits licensees to take advantage of asymmetries in human speech waveforms without increasing the average output power to the point where co-channel or adjacent channel interference would occur.

[19] We note that the existing FM broadcast emission standards in Section 73.317 may be ambiguous with respect to actual signals since the measurement resolution bandwidth is not specified. By contrast it is specified in the corresponding AM standard in Section 73.44.

[20] Broadcasters should note that our final decision adopting the new emission limitation in MM Docket No. 88-376 gave little weight to such a possibility, since nothing prohibits licensees from sharing more expensive measurement equipment, or subscribing to over-the-air monitoring services, or depending on their consulting engineers to provide necessary equipment measurement capabilities.

[21] About the time the new AM emission was adopted, a so-called "splatter monitor" (a homodyne receiver followed by a high pass filter) was marketed for slightly over $2000. Essentially, it measures all out of authorized emission bandwidth power. Depending upon the capabilities provided, spectrum analyzers cost five to ten or more times as much. Similarly less expensive emission monitoring equipment may be possible for FM and TV use.

[22] In MM Docket No. 88-376, we permitted AM licensees to omit periodic measurements to determine compliance with the then-developed emission limitations for a period of 5 years, provided they installed audio equipment that conformed to the ANSI NRSC-1 specifications (*see* Section 73.44(e)) and further provided there was no other evidence of non-compliance.

ments will be available for public inspection during regular business hours in the FCC Reference Center (Room 239) of the Federal Communications Commission, 1919 M Street N.W., Washington D.C., 20554. For further information contact James E. McNally, Jr., Engineering Policy Branch, Policy and Rules Division, Mass Media Bureau, Federal Communications Commission, Washington D.C., 20554, telephone (202) 632-9660.

FEDERAL COMMUNICATIONS COMMISSION

William F. Caton

William F. Caton
Acting Secretary

FCC MAIL SECTION
AUG 12 1 06 PM '93
DISPATCHED BY