Frequency Tolerances and Spurious Emission Limitations

ROBERT T. WATSON, MEMBER, IEEE, AND WILLIAM A. LUTHER

Abstract—Appendices 7 and 8 of the WARC-79 Final Acts contain, respectively, the Table of Transmitter Frequency Tolerances and the Table of Maximum Permitted Spurious Emission Power Levels. Decisions taken at that Conference on these two new Tables will eventually touch transmitter manufacturers and users everywhere. Frequency tolerances in most bands are tightened for new equipment effective January 2, 1985. TV broadcast for system M (NTSC) from 29.7 to 2450 MHz and broadcasting in the 535 to 1606.5-kHz bands remain the same. Earth and space services were introduced in the Table for the first time with impact from 4 MHz on up to 40 GHz after 1985. Relatively tight frequency tolerances are those for HF broadcasting, single sideband (SSB), and pulse modulation above 10 GHz. Peak envelope power rather than mean power is shown generally for SSB transmitters limits. The frequency tolerance limits, again, did not reach beyond 40 GHz. New spurious emission limits come into effect on that same date for new transmitters operating between 235 MHz and 17.7 GHz, although radiodetermination and emergency-type transmitters are excluded. There is also a special exception for spurious emissions of transmitters operating above 235 MHz where transmitters feed a common antenna or where an antenna farm exists [see Note 10 of Appendix 8]. Spurious emissions have been significantly redefined. It is suggested those concerned with such limits be familiar with the new definition contained in RR 139 of Article 1 of the Final Acts.

INTRODUCTION

TWO SUBJECTS considered by the World Administrative Radio Conference (WARC-79), with broad impact on the world's telecommunications community, are frequency tolerances and spurious emission limits. Values for both, as fixed by the Conference, eventually will apply to every transmitter used by the International Telecommunication Union (ITU) member nations ratifying their Final Acts, and will affect all transmitters manufactured in the world.

Although the Table of Transmitter Frequency Tolerances, and the Table of Maximum Permitted Spurious Emission Power Levels are found in Appendices 7 and 8, of the Final Acts of WARC-79, their authority is actually drawn from Article 5 (Nos. 304 and 306). Article 5 deals with general technical characteristics of stations in a succinct manner that requires conformance to the two Tables.

New and more strict values of these tolerances and limits become effective after 1985. They do not come into effect along with most provisions of the Final Acts. Delegates to the Conference recognized a potential economic impact with any new Table value, and consciously tried to minimize or eliminate any unnecessary cost increase of a transmitter attributable to the WARC-79 decisions. As different implementation dates apply to both Tables, even to the point of having subsets of dates in Table footnotes, those discussions will be given at more descriptive places in this article.

From the sequence of events leading to final votes on Appendices 7 and 8, the efforts of the International Radio Consultative Committee (CCIR from French translation) with respect to these tolerances and limits could not be overstated. Special discussion is needed, and is included below, on importance of the CCIR to these technical discussions. CCIR Recommendations on these Tables were essentially adopted by the WARC-79. There is some doubt that an Administrative Conference, such as the WARC, could have appropriately considered, within the scheduled time, all of the technical and economic aspects for the numerous individual standards represented by each of the tolerance and limit numbers in these two Tables.

SPECIAL PREPARATORY MEETING (SPM)--TOLERANCES AND LIMITS

To understand how the frequency tolerances and spurious emission limits evolved from the WARC, it is important to understand the CCIR process. In addition to a continuing review of these values over the intervening years between Administrative Conferences, both in the countries of the ITU Member Administrations and at various CCIR meetings, a very extensive effort took place in connection with the Special Preparatory Meeting (SPM) of the CCIR Study Groups.

Pursuant to ITU Administrative Council Resolution 804 and commensurate CCIR Resolution 69, a special joint meeting of CCIR Study Groups—known as the Special Preparatory Meeting—was held in Geneva from October 23, to November 17, 1978, about 10 months prior to commencement of WARC-79. The purpose of the meeting was to prepare technical bases for the anticipated World Administrative Radio Conference. The terms of reference of the Special Preparatory Meeting, in accordance with the Resolution 804, were as follows:

"To prepare a Report providing technical bases for the WARC-79 and for the use of Administrations in preparing their proposals to that Conference. This Report is to be based on the texts approved by the XIVth Plenary Assembly of the CCIR as well as on new contributions submitted by Administrations and other participants in the work of the CCIR; the Report should be presented in a form consistent with the various items of the Agenda of the WARC-79."

The activities of the SPM were, for the most part, confined to technical matters which would be relevant to the estab
lished agenda of the WARC-79, but economics could not be ignored in some cases. As far as frequency tolerances and spurious emission limits were concerned, the full four meeting weeks of the SPM were required for all of the arguments. Subcommittees at SPM met practically every day on these subjects, with the off-days devoted to evaluating results of previous discussions and preparing for the next days' sessions. By comparison, the WARC-79 deliberations on these two subjects took just a few days using the SPM Conclusions [1] as a primary reference for making decisions. Of course, from about the mid-point of the WARC-79, meetings were being held seven days a week, often taking up to 15 h each day, sometimes longer. Time was precious at WARC-79, meaning that it was important to use every available expedient to maximum advantage. The SPM Conclusions were one expedient used to reach rapid decision. In the case of frequency tolerances, only two of the several hundred values approved were modified from that determined by the SPM. No changes at all were made by the WARC-79 to Table values of spurious emission limits determined by the SPM, although the covered spectrum range was extended from 960 MHz to 17.7 GHz, with limits applying only to certain services.

Most Administrations attending the SPM realized the importance attached to SPM Conclusions in the two highly technical areas of frequency tolerance and spurious limits. Consequently, most prepared their proposals on these subjects as they would normally for an Administrative-type conference. This would explain why only very limited change occurred at the WARC-79. It must be noted, however, that the SPM considered no implementation dates, leaving that matter strictly to the WARC.

SPM APPROACHES TO FREQUENCY TOLERANCE

Scope of Rationale and Quantities of Standards

In the approach taken to frequency tolerances, it was realized that a great many numbers would need to be considered. The services, power levels, and types of modulation proposed by one Administration alone comprised close to 2000 individual cases of frequency tolerance. Furthermore, in order to gain worldwide acceptance, each value needed an adequate technical foundation. To consider the difficulty usually experienced reaching firm agreement on even one standard, corresponding to one tolerance number in this negotiation, suggests the enormity of the challenge.

Special attention was given, not only to the primary technical aspects of spectrum utilization, but also to consideration of the parallel CCIR concerns of operational questions and future consequences as they might affect SPM recommendations to the WARC. Such consideration was to a large extent directed toward the establishment, development, and improvement of telecommunications in new or developing countries. This approach was utilized not only to satisfy the primary stated purpose of the SPM, but also to facilitate ease of understanding by those WARC delegates not fully familiar with the disciplines discussed.

For these and other considerations that were carefully presented in the individual nation input papers to the SPM, a concentrated broad-scope effort backed up proposals for frequency tolerances. In the case of some Administrations, not only were there multiple meetings prior to the SPM seeking tolerance contributions and agreements among the many interested agencies, but advice was solicited from the industrial community, as well as from the worldwide professional society, IEEE. The IEEE consideration also provided an opportunity for the academic community to participate. Taken together, these inputs were utilized not only for the SPM and the WARC, but are also expected to be for post-WARC implementation.

Frequency Tolerances Approach

In deliberating values of frequency tolerance, the SPM consciously considered the following:

a) Appendix 3 of the existing Radio Regulations.
b) CCIR Report 181-2 concerning overall frequency tolerances.
c) Specific CCIR Study Group 9 conclusions concerning problems associated with radio-relay frequency-controlling systems (using a chain of repeaters where final repeater frequency variation perceived is an aggregate from all the individual transmitters in a system).
d) Individual Administrations' proposals associated with sometime special concerns, relating to national criteria for particular tolerances.
e) Ultimate values needed for operational or technical reasons.
f) Economic impact of any change in value from that existing.
g) Safety-related functions of frequency tolerances.

SPM DISCUSSIONS—FREQUENCY TOLERANCES

Over a hundred delegates were involved in discussions on the relatively large number of frequency tolerance standards. Dr. Kaji of Japan was chosen as the Chairman of the overall Technical Characteristics Committee, including frequency tolerances, and Mr. George of the Federal Republic of Germany was selected to chair specifically the Frequency Tolerances subcommittee. A total of 11 official documents from Administrations were negotiated in the meeting, involving 87 Administrations.

The SPM considered proposals on a spectrum basis, band by band. The frequency tolerance for each station function, power level, and operational state of readiness was taken up and discussed with a corresponding technical, sometimes other, rationale. Consideration was given to the spectral environment of the particular standard under discussion. Stations receiving particular emphasis included earth and space, radiodetermination, land mobile, maritime mobile, broadcast, emergency, and radionavigation. Within the station environment, functional characteristics were discussed for each appropriate standard including Doppler shift, filter slope factors, channel width requirements, multiplexed carriers, crystals, and oscillators. Frequency-determining elements of a transmitter received particular attention, particularly with respect to temperature variation, frequency/temperature inversion points and high slopes, sealed ovens, temperature-compensated oscillators, aging, cumulative frequency errors in heterodyne systems, and statistical considerations, total translational error, and unin-
tellibility due to frequency errors. All in all, technical component, equipment, system characteristics, and technical feasibility were considered for each standard. Operational and economic variation of the technical characteristics then was discussed as appropriate.

The final, agreed Frequency Tolerance Table may be found in the SPM Report, Chapter 8, entitled "Technical Characteristics of Equipment and Emissions." This chapter also contains introductory comments for the benefit of the WARC delegates. The latter is presented here to better summarize the deliberations.

"In proposing frequency tolerance values for transmitters, the SPM has taken account of:
(1) the need for efficient frequency spectrum utilization,
(2) the operational requirements of the various communication systems,
(3) the technical feasibility of achieving the standards laid down against a background of environmental and economic constraints,
(4) the basic differences between fixed and mobile stations, and especially hand-held equipment, necessitating in some cases a relaxed value of tolerance for the mobile stations,
(5) the accumulation of frequency errors of individual frequency sources in the case of some multi-hop radio relay systems necessitating some relaxation in the overall tolerance limits.

Due consideration was given also to existing CCIR texts, where appropriate."

WARC-79—FREQUENCY TOLERANCES

Few other WARC agreements were reached in as short a time. The most influential WARC input document on frequency tolerances was, as indicated, the SPM Conclusions. Other WARC input documents on frequency tolerances included the very few additions or exceptions submitted by the participating Administrations. It was emphasized in WARC Committee that SPM Conclusions reflected future needs and, therefore, did not always correspond to present equipment specifications. Attention was drawn to the fact that in a few cases, unsupportably loose tolerance values proposed were such that a corresponding actual frequency instability would cause an emission to exceed the limits established for its channel. This was cited as leading to inefficient use of the radio frequency spectrum and a good reason to adopt the well-considered SPM values.

Frequency subdivisions were introduced into the Table where necessary for some services, to clarify the presentation of tolerances. The value quoted for a particular category was normally for the most important service in that category. Other important types of spectrum usage in the same category required special consideration that was contained in explanatory footnotes. In order to distinguish clearly between in-force footnotes carried forward, and the newly proposed ones, the latter were given numerical designations by the SPM to enable a clearer understanding of change by WARC delegates.

No tolerance values were established for meteorological aids nor for the amateur services. It was deemed that these matters could best be handled by national regulations, if appropriate.

Recognizing the continuing development of equipment and systems, and their present tentative nature, no frequency tolerances were established for services operating above 40 GHz.

No presently applicable values of frequency tolerance change until at least 1985, if at all. These present values are all contained in the first tolerance column of the Table contained in Appendix 7 of the WARC-79 Final Acts [2]. Tolerances that do change, or become effective on January 2, 1985, are only for newly installed transmitters. Transmitters installed through January 1, 1985 will retain present tolerances until 1990 or later, of course, if no change is indicated.

WARC BAND-BY-BAND RESULTS—FREQUENCY TOLERANCES

Analysis of significant decisions in the Frequency Tolerance Table follows. This is done on a band basis, as the Final Acts are arranged.

Band: 535 to 1606.5 kHz (1605 kHz in Region 2)
The upper limit had been 1605 for all Regions. Some Administrations wanted to raise the 10-Hz tolerance for broadcast stations to 20 Hz; it had been 10 Hz for most of the world with a 20-Hz Note for the North American Regional Broadcasting Agreement (NARBA) countries. The NARBA exception was maintained.

Band: 4 to 29.7 MHz
New separate listings were made under Fixed Stations for 1) single-sideband and independent-sideband emissions (recognizing the predominant modulation types), 2) class FIB emissions, and 3) other classes of emission. The Mobile Ship Station Class A1 emission was changed from 200 ppm to 50 ppm. Space and Earth station values are new to the band after 1985.

Band: 29.7 to 100 MHz
For Fixed Stations, while power levels remain the same at 200 W for the immediate future, these are reduced to 50-W levels in 1985. Space and Earth stations, after 1985, are new to the band.

Band: 100 to 470 MHz
Land Stations classified as Base Stations have been split into the subbands of 100-235 MHz, 235-401 MHz, and 401-470 MHz after 1985. The same subbands are found after 1985 for Land-Mobile Stations. Also new in the band are Earth and space stations.

Band: 470 to 2450 MHz
Space and Earth station tolerances after 1985 are the only changes.

Band: 2450 MHz to 10 500 GHz
Again, post 1985, Earth and space station tolerances take effect.
This could be avoided if the frequency tolerance were flexible enough. For such stations, the tolerance is 10 Hz. In the Table for broadcasting stations, frequency spectra over an extra broad channel because of the range of frequencies. Above 10.5 GHz, the tolerances are more tentative. This is due to factors such as system M (NTSC) the tolerance is 10 Hz. However, for low-power transmitters using this system note (24) applies.

**NEW TABLE FOOTNOTES**

Based upon SPM Conclusions, the WARC introduced 23 new footnotes to the Table of Frequency Tolerances. This was in addition to the 13 qualifying notations in the current Radio Regulations. The new ones are listed in Appendix 7 as footnotes 1, 4, 5, 7, 8, 10, 12, 13, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 32, and 36.

**HIGHLIGHTS—FREQUENCY TOLERANCES**

In going from the current tolerances to those to be phased in after 1985, the range of values is from no change, tightening down to around 5 percent of the current values, depending upon requirements of the service.

Earth and space services were introduced in the Table for the first time with impact from 4 MHz on up to 40 GHz after 1985. In the interim, power flux density limits tend to minimize any interference that might be caused by radiation of frequency spectra over an extra broad channel because of a loose tolerance.

Out of the many frequency tolerances decided, it is believed that the Table has no unnecessarily tight tolerance areas. Generally, the tight tolerances were required by operational or interference considerations. It is recognized that some of these may take special attention to meet.

Three of the areas having relatively tight tolerances are those of HF broadcasting, SSB emissions, and pulse modulation above 10 GHz (above 10 GHz being inherently more uncertain at this time).

To better understand the tighter broadcasting tolerances, a listing of them is presented in Table 1. Above 10.5 GHz, the tolerances are more tentative. This is due to such factors as 1) less developed art in this band, 2) for a given percentage of frequency tolerance to carrier frequency,
a higher actual frequency variation results, and 3) higher costs for the same amount of power. In the 10.5 to 40-GHz band, three new classes of stations need to eventually comply with tolerances while the existing two station types also have tightened values. Finally, it is noted that broadcasting comes under some tolerance control in 1985 in the highest band, generally applicable to the Broadcast Satellite service.

Taking a broad look at the 1979 WARC Frequency Tolerance Table, it may be stated that the state of the art in almost every case comports with agreed tolerances, except perhaps above 10.5 GHz. State of the art here implies a worldwide operationally and economically useful technical specification.

Regarding the perceived impact on world users, these new tolerances should provide a significantly improved spectrum efficiency in terms of a harmful interference-free environment. Due to the economic, operational, and technical considerations given, along with the somewhat politically oriented WARC decisions, these tolerances will have wide acceptance and promote a broader use of telecommunications than could have otherwise been possible. While costs resulting from the tougher specifications may be somewhat higher to the more developed nations, overall costs will be significantly lower than would have been the case if only technical considerations had prevailed.

**FUTURE CONSIDERATIONS—FREQUENCY TOLERANCES**

As far as future frequency tolerance efforts are concerned, the WARC-79 issued Recommendation 69 which invited the CCIR to pursue study in the following four areas:

1) to continue its study of frequency tolerances with a view to the reduction of the frequency space required for a given channel;
2) to consider whether or not in certain cases it is possible to predict ultimate values of tolerances, which it would not be necessary to make more stringent under currently known conditions of operation and to state what these tolerance values might be;
3) to report upon the possibility of achieving such ultimate values of tolerances consistent with economic and design requirements and other practical considerations;
4) to indicate which, if any, of the tolerances specified in Appendix 7 have already attained these ultimate values.

**SPURIOUS EMISSION LIMITATIONS**

To put spurious emission limitations into perspective, it must be realized that these emissions are only half of the story. The general category of unwanted emissions is comprised of two basic subparts, spurious emissions and out-of-band emissions. Article 5 of the WARC-79 Final Acts states that every effort should be made to keep unwanted emissions at the lowest values which the state of the technique (for doing so) and the nature of the (transmitter) service permit.

Out-of-band emissions are those resulting from the modulation process and which are found immediately outside the transmitted necessary bandwidth. They would include both transmitter noise and modulation splatter closely associated with the fundamental radiation. These are much more difficult than spurious emissions to either control or measure because of presence of the energy associated with the fundamental emission, energy that is usually about 99 percent of all radio frequency energy produced by the transmitter. Out-of-band emissions always exist when the fundamental frequency radiation is turned "on" with normal modulation. Their level is only dependent upon purity of the oscillation, linearity of the modulation process, and response characteristics of the final amplifier, subsequent tuned filter, and in minor part, the antenna, none of which are perfect. As they are always found to one extent or another, account is usually taken of them in the frequency assignment process so that no other special consideration by the system user is needed, unless adjacent channel interference is caused. In an effort to limit adjacent channel interference,Article 5 of the Final Acts addresses limits for out-of-band emissions as they are promulgated in the Radio Regulations for specific services (by general or specialized administrative conferences). At present, out-of-band emissions have specified maximum permitted power levels only for transmitters of the SSB radiotelephony Maritime-Mobile service operating in the MF and HF bands, as well as for transmitters of the aeronautical-mobile (route) service operating between 2.85 and 17.97 MHz. The limits of Appendix 17 and of Appendix Aer2 are for unwanted emissions, which of course, include both the out-of-band and the spurious.

Spurious emissions, on the other hand, have much greater potential for causing interference to radiocommunications systems, and so have received the greater attention. Spurs may occur from a transmitter in literally any portion of the radio frequency spectrum, often far removed from the fundamental emission, and even sometimes with no predictable or calculable mathematical relationship to the fundamental frequency.

The latter situation has been found when components of a transmitter inadvertently form a resonant circuit with some coincidental feedback mechanism that derives fundamental transmitter energy and oscillates at whatever the incidental resonant frequency happens to be. This particular occurrence does not happen often, but has been experienced. Radiated levels of these and other spurious emissions are relatively simple to detect and measure with appropriate equipment such as spectrum analyzers, good attenuators, and calibrated field-strength meters. Given the propensity for some spurious emissions to cause interference anywhere in the spectrum, and their relative importance, it is necessary for frequency managers to be aware of their potential. Happily, these do not often exist to the point of creating interference.

Spurious emissions were redefined at the WARC-79 based upon previous work of the CCIR. They include particularly harmonic emissions, parasitic emissions, intermodulation products, and frequency-conversion products, none of which occur, by definition, immediately outside the transmitted necessary bandwidth as a result of the modulation process. It would be possible, however, for a spurious emission to result from a parasitic oscillation, or from a third-order intermodulation product, and be sufficiently close to the nec-
necessary bandwidth that it might mingle or be confused with otherwise ordinary out-of-band emissions. This situation does not occur often at all, so it is not a significant problem to worry about distinguishing between out-of-band emissions and spurious emissions.

Spurious emissions have specified, maximum permitted power levels in all radio services (except radiodetermination) operating with fundamental radiation up to 960 MHz (after the implementation schedule of Appendix 8—only up to 2.35 GHz at present). Frequencies above 960 MHz, up to 17.7 GHz, are included in the future but exceptions are made in this band for systems using digital modulation, space services, again the radiodetermination service, and certain transmitters intended for use in emergency situations where the object is to attract aid, whatever the means.

Of all the types of spurious emissions encountered, by far the ones found most often, and which are cause for greatest concern, are harmonics and third-order intermodulation products. In the experiences of the authors, these two types of undesirable emissions together account for nine out of ten cases of spurious emission interference to radiocommunication services.

SPM DISCUSSIONS—SPURIOUS LIMITS

A fewer number of SPM delegates were involved in spurious limit working groups than for frequency tolerances, and discussions took substantially less time because there were fewer values to consider. It is significant, however, to realize that all of the SPM Conclusions in this matter were adopted at WARC-79, without change to limits, much like occurred for the frequency tolerance values. W. Kilpatrick of the USA headed the Spurious Limits Working Group. A comparable number of input documents from Administrations were negotiated, ultimately involving the 87 countries, and including ITU recognized private operating agencies, international organizations, and scientific groups.

Agreements on spurious emission limits were easily achieved, except above 960 MHz. Protracted discussions ensued and it became impossible for the SPM to reach any conclusion in the following two important areas:

a) above 960 MHz in any service
b) the bandwidth in which a spurious emission is measured, except that the measuring equipment should have a bandwidth “...sufficiently wide to accept all significant components...”

Inability to establish limits above 960 MHz was a result of “last minute” data provided from Fixed-Satellite service interests that indicated existing satellite technology could not achieve a third-order intermodulation reduction of 30 dB, throwing into question the entire matter of spurious emission limits for space services in the microwave frequency range, i.e., above 1 GHz. Measurement bandwidths were discussed in terms of how to measure wide-band emissions. As it was generally conceded that wide-band emissions do not especially occur below 960 MHz (the highest frequency where SPM agreement on limits was possible), the discussions on how to make measurements were concluded with the understanding that all the significant spurious emission limits would be included in the measurement equipment bandwidth.

The final, agreed Table of Maximum Permissible Levels of Spurious Emissions will be found in the SPM Report, Chapter 8, immediately following Frequency Tolerances. Other, related technical guidance was provided to the WARC, excluding as before, any mention of implementation dates, considered to be exclusively the domain of the forthcoming Administrative Conference.

WARC-79 SPURIOUS LIMITS

Only a short time was needed to adopt within the Final Acts, the Conclusions of the SPM on spurious limits, notwithstanding ten formal submissions from Administrations on the subject having a range of variations. It was, however, discussion on adding to the SPM frequency range for limits, that led to spirited interchange. Fortunately, the WARC was able to agree upon spurious emission limits that carry up to 17.7 GHz, although exclusion was provided for several significant uses. It was clear that insufficient data were available to find appropriate limits for the important space services, and systems usually found above 10 GHz using digital modulation. The Conference delegates readily agreed that these unresolved matters required immediate attention and that study should be undertaken of them, especially of space services, on an urgent basis.

In the case of spurious emission limits below 235 MHz, there was no tightening by WARC-79 of the basic values already existing. In fact, effective in 1985, under Note 9 of the Spurious Emission Table (Appendix 8 of the Final Acts), Administrations may move from a 1- to a 10-mW level for spurious emissions of transmitters operating in the range 30-235 MHz with mean power over 25 W, unless harmful interference is caused by the lessened restriction. Furthermore, considering the types of power levels of typical frequency modulated maritime-mobile radiotelephone transmitters operating above 30 MHz, the general absence of related serious interference cases, and the complicating special requirements of Note 5 to Appendix 8 (Spurious Limits) for such transmitters, the WARC-79 took the conscious decision to delete Note 5 at the end of 1984. It would be possible, of course, for the 1982 Mobile WARC to reconsider this action in Appendix 17, if believed necessary at that time. With this relaxation of the limits (deletion of Note 5), basically all communications transmitters operated up to 960 MHz will have the same requirements, regardless of the service in which they are used.

Limits are newly applied, of course, for most transmitters operating between 235 and 960 MHz. These are effective for transmitters installed after January 1, 1985, and to all transmitters, regardless of installation date, after January 1, 1994. Exclusion is provided by Note 10 where more than one transmitter feeds a common antenna, or at an “antenna farm,” where it is difficult to realize the limits when intermodulation products result from induced RF voltages, because transmitters are so close to one another. In any event, it is clear from the WARC-79 Final Acts that spurious emission power should be kept as low as practicable, not only in this one case, but in all cases, and on all frequencies.

The first conversion date of January 2, 1985 found by WARC-79 is exactly the same first new date under the Fre-
frequency Tolerance Table. However, because providing greater spurious emission suppression involves much more than changing a component, as for example, a crystal oscillator in the case of frequency tolerances, the Conference determined that a decade and a half would be needed for any new spurious emission limits. A final, applicable date of January 1, 1994 was determined, effectively applying to transmitters operating only between 235 MHz and 17.7 GHz.

FUTURE CONSIDERATIONS–SPURIOUS LIMITS

The WARC-79 recognized the need to continue examining transmitter spurious emission levels in a number of areas, especially where agreements could not be reached. As the CCIR is the mechanism for conducting technical studies between ITU Administrative Conferences, Recommendation 66 of the Final Acts was specially addressed to that organization. Four specific areas of study were established by WARC-79 with the intent of eventually having appropriate recommendations for consideration at future Administrative Conferences:

a) Spurious emissions from space services transmissions.

b) Spurious emission levels in all frequency bands in general, emphasizing those frequency bands, services, and modulation techniques not presently covered.

c) Measurement techniques for spurious emissions, including the determination of reference levels for wide-band transmissions as well as the applicability of reference measurement bandwidths.

d) Categorizing of emissions (of any type) in terms of “mean power” to facilitate the interpretation and measurement of “mean power” as it applies to the various classes of emissions.

REFERENCES


Spectrum Allocations Above 40 GHz
WEST E. KATZENSTEIN, ROBERT P. MOORE, AND HAROLD G. KIMBALL

Abstract—The 1979 World Administrative Radio Conference (WARC-79) significantly revised the International Table of Frequency Allocations above 40 GHz to reflect a high level of interest and activity in this portion of the spectrum. The new Table of Allocations was created with the objectives of stimulating development of this spectrum resource by providing guidance and protection to users and of providing such potential user bands in all parts of the spectrum suitable to his charter. Thus propagation phenomena played a major role in defining the new table—as did the desire of some Administrations to add services such as Fixed and Mobile.

This paper discusses the approach used in creating the new table, summarizes the allocations, discusses some bands of special interest, indicates how future refinement of the table will likely occur, and addresses the challenge presented to the frequency manager by this part of the spectrum.

I. INTRODUCTION

USE OF THE REGION of the electromagnetic spectrum above 40 GHz represents both a large expansion in spectrum resources and the development of new capabilities [1]. The 1979 World Administrative Radio Conference (WARC-79) revised the International Table of Frequency Allocations to reflect increased interest and activity in this spectrum. WARC-79 was the first conference since 1959 which was competent to treat the region above 40 GHz. The objectives of the new Table above 40 GHz were to represent all potential users and to provide guidance and protection for development. Propagation phenomena played a major role in the definition and assignment of bands, and the desire to provide flexibility (e.g., adding Fixed and Mobile) was also important. This latter aspect is reflected in the high degree of band-sharing which is embodied in the new Table. Increased usage above 40 GHz will provide unique challenges to the spectrum manager and will likely reveal opportunities for more efficient use of the spectrum in the future.

II. SUMMARY OF SPECTRUM ALLOCATIONS ABOVE 40 GHz

Table I summarizes the allocations above 40 GHz. The total width of the spectrum allocated (235 GHz) indicates the extent of this new spectrum resource made accessible by advances in the state of the art of telecommunications equipments. There are some striking differences between the approach to allocation above and below 40 GHz [2]. For example, there are no bands allocated exclusively. This reflects

U.S. Government work not protected by U.S. copyright