Agilent Technologies

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Washington, D.C. 20554

In the Matter of Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands	 ET Docket No. 03-237

COMMENTS OF AGILENT TECHNOLOGIES, INC.

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Introduction

Agilent Technologies, Inc. ("Agilent") submits these comments on the Notice of Inquiry ("*NOI*") and Notice of Proposed Rulemaking ("*NPRM*") on the establishment of an interference temperature metric.[1] Agilent is a leading supplier of semiconductors, test and measurement equipment, design software, and test services. Agilent's products and services are used in a wide variety of applications, including radio design, manufacturing testing, type certification, interoperability testing, network operation, and spectrum management. Agilent's products have been used in the development of almost every new radio format and service, including cellular, DTV, MMDS, LMDS, Wi-Fi, Public Safety, satellite, and military and aeronautical applications. As one of the leading suppliers of measurement equipment and RF components, Agilent is uniquely qualified to comment on the several aspects of the interference temperature concept.

Many, including Agilent, have raised questions about the technical merits of the interference temperature concept. While many questions remain unanswered and require further study, Agilent believes that there is a specific implementation of the interference temperature concept that has a reasonable chance for success. This implementation would combine the interference temperature concept with the concept of frequency servers and be limited initially to one secondary use model that assumes a mobile device communicating with a fixed access point connected to the Internet. Like all successful spectrum management approaches, this one would be practical and cost-effective to implement.

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[1] *See In re Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands*, Notice of Inquiry and Notice of Proposed Rulemaking, 18 FCC Rcd 25309 (2003) ("*Interference Temperature NOI/NPRM*").

Trends in RF and RF Applications

Wired networks, both copper and photonic, offer tremendous capacity and reliability, as well as ever increasing accessibility. As these networks continue to expand, so too will the application space they enable. The growth in wired networks is a major growth driver for wireless data communications. Wi-Fi serves as an excellent model for the future of wireless data communications. In this model, mobile devices communicate to (or through) wired IP networks via fixed wireless access points. While many RF applications, such as scatter nets, do not fit this model, the model encompasses a significant percentage of the recent growth in wireless communications. New frequency management techniques, like interference temperature, are more likely to succeed when applied to growth markets.

All current license holders must deal with the unstoppable trend of ever-increasing data capacity requirements. Therefore, while it may be possible to establish an interference temperature threshold, this presumes that current license holders will never desire to improve system throughput. Unless the interference temperature threshold can be adjusted, a successful implementation of interference temperature concept could preclude the primary user from increasing system capacity.

The Interference Temperature Metric

In addressing the question of whether interference temperature is a practical measure, it is important to remind ourselves that it is commonly the case that social, political and economic progress is made on the basis of compromises that begin their lives with uncertain practicality. We have all become accustomed to the widespread utilization of certain legally defined measures even in the presence of continuing debate about their underlying practicality and enforceability. For instance, highway speed limits are for the most part intended to serve as limitations on unsafe driving practices, but, of course, highway speed is a very imprecise measure of driving safety, nor is it monitored with perfect consistency and accuracy. Nevertheless, highway speed remains an important guiding principle in our efforts to control the safety of highway travel. In addition to the many quantitative laws that pertain to highway speed, there are yet others that contain conceptual references, such as "speeds in excess of those prudent for prevailing conditions."

With respect to the interference temperature, there remains an open debate whether it should be applied *quantitatively* or *conceptually*. Given the evolving nature of RF technology and applications, it may well be prudent to begin with a conceptual approach rather than a quantitative one. This allows for crafting specific measures that satisfy the detailed requirements and characteristics of the bands that the Commission has proposed. Over time, it may be possible to evolve a direct quantitative implementation of the interference temperature. Until then, the underlying concept can be used advantageously as a guide to develop procedures to extract more value from the RF spectrum..

Of the two specific bands to which the Commission proposes to apply the new interference temperature approach,[2] FSS operations appear to be most readily amenable to unlicensed spectrum sharing by means of a rather simple application of the interference temperature concept, as discussed below in detail. For other operations, such as FS point-to-point links, it appears that more complex procedures will be necessary in order to allow for spectral sharing without appreciably impairing the quality of the existing point-to-point links. For these links, the primary system receiving antennas are highly directional, and information about their response behavior cannot be readily conveyed to the prospective secondary transmitters. For

[2] *Id*. at ¶ 35.

this reason, it is difficult to envision a system based on the interference temperature alone that would efficiently share spectrum with a secondary user while maintaining high reliability in the primary service. A system that provides for the dissemination of information about the geographic distribution of the various participants may well be adequate to serve the intended goals, but cost and complexity tradeoffs for such schemes will require a somewhat more protracted process than would be feasible within the time limits of the pending *NPRM*.

Frequency Servers: Making Interference Temperature Work

Specific implementations of the interference temperature concept must take into account geographic scale. When considering unlicensed devices operating on a satellite uplink frequency, one must allow for a system that involves thousands of devices. On this scale, the presence or absence of any single device will have an insignificant impact on the overall noise temperature at the satellite receiver, so an individual device cannot reasonably determine its impact on interference temperature. This suggests the possibility of unstable interference levels, as large groups of devices independently respond to the interference temperature metric.

Three interference temperature implementations are described in the *NOI*:[3]

1. Interference temperature is measured within a device.
2. Interference temperature is measured at the receive sites of license holder.
3. Interference temperature is measured by a grid of monitoring stations.

In its Comments, and Reply Comments on the Spectrum Policy Task Force Report,[4] Agilent noted that the first method suffers from several technical challenges, including oversimplification. The second and third methods potentially require a

[3] *Id*. at ¶¶ 11-12.
[4] *See* Comments of Agilent Technologies, Inc., ET Docket No. 02-135 (Jan. 27, 2003); Reply Comments of Agilent Technologies, Inc., ET Docket No. 02-135 (Feb. 28, 2003).

broadcast mechanism for communicating the interference temperature to the devices. Besides the investment in broadcast infrastructure, these approaches also add cost and complexity to the secondary use devices in the form of a broadcast receiver. Agilent believes that a workable, cost-effect solution can be created by combining the interference temperature concept with the concept of frequency servers. In this context, the frequency server would process interference temperature measurements (how ever and where ever they are collected) and then issue, or deny temporary licenses.

In practical terms, this model can be first implemented for mobile-clients with fixed-access-points connected to the Internet. This would allow easy access to a frequency server on the Internet and would permit a frequency management system to be designed that has the following attributes:

1. The frequency management system can be easily implemented without significant investment in infrastructure, and without adding significant cost to the unlicensed devices, as existing communication channels are used.
2. Frequency management techniques other than interference temperature can be simultaneously used.
3. More sophisticated interference temperature algorithms are possible as servers generally have an advantage over inexpensive unlicensed devices in terms of both computational capacity and access to information.
4. Flexibility for future adaptation is provided, as the secondary use devices are not required to implement an interference management strategy. This is implemented at the server where it can be refined and managed.
5. Real-time adjustment to the overall interference levels is supported. The *NOI* seeks comment on what value to assign to the interference temperature

limit.[5] If this question cannot be answered with confidence, it is prudent to have a knob, or at least an on-off switch.

6. Shutdown modes to accommodate emergencies or temporary "quiet periods" for measurements and troubleshooting.
7. Spectrum utilization can be easily tracked in aggregate, or by individual wireless device. This provides an accounting mechanism that enables primary users to be compensated based on secondary usage. This could be in the form of tax credits (assuming the general population is the beneficiary), or through direct compensation by the secondary users.

As applied to the FSS uplink band, the frequency server might simply control the number of active transmitters based on transmit power and the approximate transmitter locations. As noted in the *NPRM*, appropriate models exist today for computing link budgets.[6] During normal operation, access points would request a license from the frequency server over the Internet. The license issued could have terms that limit power levels, transmit duty cycle, modulation characteristics, and license duration, for example. The satellite would periodically report to the server the observed interference temperature. Based on the observed temperature, the frequency server could increase or decrease the number of licenses available, the power level per license, or the transmit duty cycle. The interference temperature reported by the satellite could be measured directly, or it could be inferred from some existing, readily available metric, such as bit-error rate.

Characteristics of Unlicensed Devices and In-band Considerations

As noted above, political and economic progress is made on the basis of compromises that begin their lives with uncertain practicality. While it may be hard to justify the standardized width of a lane on a freeway, for example, there is little

[5] *See Interference Temperature NOI/NPRM* at ¶ 21.
[6] *See id.* at ¶ 38.

doubt that everyone benefits from that standard even though it places limits on the types of vehicles that can be developed. Standards reduce risk and lower costs. More importantly, when applied to spectrum management, standards can reduce complexity and aid in enforcement. Thus while there may be little technical merit to choosing a 5 MHz channel plan over a 6 MHz channel plan, having a channel plan for unlicensed devices would benefit everyone from component suppliers to spectrum managers.

To simplify the task of predicting and managing interference, Agilent suggests that the following transmitter signal characteristics be defined for non-UWB signals:

1. Standard channel plans. Devices could use multiple channels when more bandwidth is required.
2. Noise-like temporal characteristics with controlled turn-on/turn-off transient characteristics as observed through a measuring receiver with a standard channel bandwidth—centered on-channel, and on adjacent channels.
3. Uniform PSD over the occupied channels.
4. Standardized preamble that includes identification information (license number, for example), transmitted with a specified modulation fidelity.
5. Out-of-band emissions regulated as before.
6. EIRP.

Enforcement & Monitoring

Agilent continues to believe that the Commission must give careful consideration to the enforcement issues that are likely to accompany greater spectrum utilization. The same advances in technology that provide for greater spectrum utilization have the potential to increase monitoring and enforcement efficiency. Properly designed, a permanent grid of monitoring stations could measure interference temperature, as well as observe, locate and document infractions and spectrum utilization.

Conclusion

By incorporating the concept of spectrum servers, and applying the concept to the systems with Internet access, Agilent believes that a stable, relatively safe and practical implementation of the interference temperature concept is possible. Of the two proposed bands, the FSS uplink band would be preferable for experimenting with the interference temperature concept, as many of the technical issues surrounding the interference temperature concept are minimized with distance. However, before the interference temperature concept is expanded beyond the experimentation stage, Agilent believes that a comprehensive and ongoing survey of the spectrum is warranted. The initial survey would establish a baseline against which future spectral measurements can be compared. Without a baseline to compare against, the success or failure of new spectrum management techniques will be difficult to quantify.

Respectfully submitted,

/s/

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