Before The
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In The Matter Of Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems	)))))	ET Docket No. 98-153

COMMENTS OF RF METRICS CORPORATION IN REPLY TO THE MEMORANDUM OPINION AND ORDER AND FURTHER NOTICE OF PROPOSED RULE MAKING, SECTION X: STAFF RESPONSE TO COMMENTS RECEIVED IN REGARDS TO THE FCC OFFICE OF ENGINEERING AND TECHNOLOGY (OET) TECHNICAL RESEARCH BRANCH (TRB) EMISSIONS MEASUREMENT REPORT

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Summary

The staff response to the RF Metrics Corporation's submission regarding the Technical Research Branch's Emissions Measurement Report contains comments that are both inconsistent with standard system design practices and fail to address the primary objections of the RF Metrics Corporation. Specifically, we respond to:

1. FCC comments suggesting that passive components do not add to overall system noise figure and should not be modeled as such.
2. FCC comments suggesting that front-end attenuation in the spectrum analyzer does not add to the analyzer's noise figure.
3. FCC comments suggesting that LNA overload and/or non-linear behavior can only be induced by input signals residing in the passband of the measurement system's preselection filter.

Introduction

The Federal Communications Commission released a memorandum entitled "MEMORANDUM OPINION AND ORDER AND FURTHER NOTICE OF PROPOSED RULE MAKING" on 12 March 2003 containing "SECTION X: STAFF RESPONSE TO COMMENTS RECEIVED IN REGARDS TO THE FCC OFFICE OF ENGINEERING AND TECHNOLOGY (OET) TECHNICAL RESEARCH BRANCH (TRB) EMISSIONS MEASUREMENTREPORT." This response addresses the comments of several organizations, including RF Metrics Corporation, in defense of the TRB's Emissions Measurement Report (referred to as the TRBEMR in these comments).

It should be noted that the bulk of the staff response pertains to the calculation of system noise figure and gain shown in Appendix A of the RF Metrics Corporation comments[1]. This calculation is an *estimate* of the system noise figure based on the reported system configuration in the TRBEMR and the manufacturer's data sheets for the devices. As such, we acknowledge that the actual component values may differ from the values used in the calculation. However, the difference between the estimate and the system noise floor as plotted in the TRBEMR is larger than can be accounted for by component gain and noise variation if the manufacturer's specifications are to be believed.

We fully agree with the statement in the TRB's response that the system parameters are best measured instead of modeled. The central theme of our objections to the report is that the full characterization of the measurement system, specifically noise floor performance and out-of-band discrimination, was not reported quantitatively. Without this information the significance of the measured noise data is severely undermined.

Comments

1.1 *"The results of the computer-aided analysis of these parameters are presented in Appendix A of the RFM submission. Since the source code for the model is not*

[1] RF Metrics Corporation, *Comments of RF Metrics Corporation on Report of the Staff of the Office of Engineering and Technology Project 02-02*, ET Docket No. 98-153, November 22, 2002.

provided, a substantive assessment of its accuracy cannot be performed. However, we do note several potential factors that may have led to the stated discrepancy.[2]*"*

The calculations for system noise figure (nf_s) may be verified using the cascaded noise figure equation adapted from Skolnik[3]:

$$nf_s = nf_1 + \sum_{i=2}^{N} \frac{nf_i - 1}{\prod_{j=1}^{i-1} g_j} \qquad (1)$$

1.2 *"In the calculation of the overall system noise figure we have some concerns regarding the input to the computer model. In particular, the measurement system is modeled as a seven-stage cascaded network; however, the TRB measurement system utilized only three active stages.*[4]*"*

Both active and passive stages must be included in the cascaded gain and noise figure equations[5]. Individual sub-components such as the integrated attenuator of a spectrum analyzer may be represented as a separated stage in the model or lumped together according to equation 1.

1.3 *"Additionally, noise figure values of 1 dB and 10 dB are shown as inputs to represent the band-pass filter and the in-line attenuator, respectively. These are passive components in the TRB measurement system and thus have no associated noise figure.*[6]*"*

Passive components including filters, transmission lines, and attenuators add noise that is proportional to their amount of insertion loss[7] As a result, these components each have a noise figure that is equal to their loss[8,9]. The 10 dB attenuator has a noise figure of 10 dB and the other passive components have noise figures that correspond to their loss values accordingly. These are correctly entered in the calculation. Note that we chose *not* to include cable and connector losses in the calculation (they are set to zero for both gain and noise figure) since there was not enough information given to estimate these parameters. The

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[2] Federal Communications Commission, *Memorandum Opinion And Order And Further Notice Of Proposed Rule Making*, ET Docket No. 98-153, March 12, 2003, p. 87.

[3] Merril I. Skolnik: *Radar Handbook*, McGraw-Hill Book Company, New York, p. 2-30, 1970.

[4] Federal Communications Commission, *Memorandum Opinion And Order And Further Notice Of Proposed Rule Making*, ET Docket No. 98-153, March 12, 2003, p. 87

[5] Merril I. Skolnik: *Radar Handbook*, McGraw-Hill Book Company, New York, p. 2-30.

[6] Federal Communications Commission, *Memorandum Opinion And Order And Further Notice Of Proposed Rule Making*, ET Docket No. 98-153, March 12, 2003, p. 87.

[7] A. E. Siegman, *Microwave Solid-State Masers*, McGraw-Hill, New York, 1964, pp. 373-375

[8] Misha Schwartz: *Information Transmission, Modulation, And Noise, A Unified Approach to Communication Systems*, McGraw-Hill Book Company, New York, p. 450, 1980.

[9] Merril I. Skolnik: *Radar Handbook*, McGraw-Hill Book Company, New York, p. 2-32.

inclusion of these components would have widened the discrepancy between the calculated noise figure and the reported TRB system noise floor.

1.4 *"Finally, a noise figure of 60 dB is input for the spectrum analyzer. No explanation is provided to support this value and in fact, the spectrum analyzer would be a significantly limited piece of test equipment with a noise figure of this magnitude.*[10]*"*

As the cascaded noise figure equation (eq. 1) shows, the value of the first component's noise figure adds directly to the overall cascaded noise figure. Since an attenuator's noise figure is simply the attenuation value, this means that integrated front-end attenuators add directly to the noise figure of a component. The noise figure of the E4440A spectrum analyzer is reported by the manufacturer to be approximately 20 dB. When 40 dB of attenuation is invoked using the integrated attenuator, the noise figure of the analyzer becomes 60 dB. We believe that the responder is correct in questioning the usefulness of the analyzer in such a configuration. Despite this limitation the measurements reported by the TRB using this setup may indeed be faithful to the ambient environments at the measurement locations. Additional information regarding the system's noise performance is required to make this determination.

1.5 *"The fact that many of the components used in the measurement system exhibit frequency dependence is precisely why measured calibration curves were provided in the TRB report for each frequency band for which field measurements were performed. It is not surprising that a calculation of the overall system gain based on minimum specifications differs from an actual measurement of the system gain at a discrete frequency. Actual measurements are the only way to accurately determine the overall measurement system characteristics over various discrete frequency ranges.*[11]*"*

The measured calibration curves referred to by the responder are gain curves. Neither noise figure nor noise floor curves of the system are reported. The gains calculated by RF Metrics for system A and system B do match the TRBEMR values at the center frequencies. It is the reported noise floors that do not match the calculations. Knowledge of the system noise figure is crucial to the interpretation of the measurement results.

Both manufacturers of the LNA components specify a gain flatness across the measurement band that limits the frequency dependence of their contributions to the system noise figure. For the Miteq amplifiers this flatness is ±1 dB. For the HP LNA, the variation is similarly small. When these variations are included in the calculation the discrepancy between the estimate of the noise floor and the

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[10] Federal Communications Commission, *Memorandum Opinion And Order And Further Notice Of Proposed Rule Making*, ET Docket No. 98-153, March 12, 2003, p. 87.

[11] *Id.*

values reported in the TRBEMR remains. We agree with the responder that the best method of determining the system noise floor is to measure it. We encourage the TRB to report the quantitative results of such a measurement.

1.6 *"We note that there were no measurement locations identified where the ambient emission levels in the GPS LI or L2 frequency bands even remotely approached the maximum input levels calculated by RFM. High amplitude emissions (relatively speaking) were only encountered in those measurements performed within the 960-1 188 MHz band, and then only at a few limited locations, in particular the airport sites. Even at these sites, most of the emissions were well below the amplitude levels indicated above. In those few cases where emissions were observed at levels great enough to pose a potential for system overload, tests were performed to verify the measurement system linearity as noted previously. Where necessary, the measurement system was desensitized through the addition of in-line attenuation.*[12]*"*

The vulnerability of the LNA components is not limited to emissions within the passband of the filter. Since these are wideband amplifiers, they will exhibit non-linear output from input signals across their entire range. All three devices are sensitive to a much wider range of frequencies than the GPS bands surrounding L1 and L2. The calibration curves for the filters used in the system do not extend down to bands that include broadcast, pager, and other high-power services. At the airport locations the LNA may be vulnerable to local radar emissions which can exceed 1 megawatt peak EIRP. Even if the filter maintains 30 dB of rejection at these frequencies, high-power emissions may still affect the LNA performance depending on the geometry of the emitter and measurement system.

As the responder points out previously, the best way to resolve this issue is to measure the system response at the frequencies in which these high power services operate.

Conclusion

Our primary objection to the published TRBEMR is that critical measurement system noise data and non-linearity performance data are not reported in the form of quantitative measurements, nor are detailed component gain and noise performance parameters shown. This leaves us no choice but to use the manufacturer's nominal values for these parameters and estimate the system performance. The result of the system noise calculation using these values is not consistent with the reported noise floors in the TRBEMR. Additionally, the calculation shows that the system may suffer from compression under circumstances that could be encountered at field measurement sites. The FCC's claims regarding the effect of passive components on the system noise figure do not conform to standard measurement system design practices and lead to an incorrect estimate of the noise floor. The assertion that gain compression is not occurring due to

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[12] Federal Communications Commission, *Memorandum Opinion And Order And Further Notice Of Proposed Rule Making,* ET Docket No. 98-153, March 12, 2003, p. 88.

the lack of strong signals in the system passbands neglects the effects of strong out-of-band signals. Finally, no quantitative measurements are presented in the report or the response to address these issues specifically. The present inability to interpret the significance of the TRBEMR data would be remedied if the TRB would:

1. Repeat the measurement protocol with the system input terminated in a 50 ohm load. The resulting plots would represent the system noise floor as well as show any feed-through signals entering the system.
2. Repeat the measurements where we have indicated that non-linear system behavior is possible with a fixed attenuator inserted at a point between the antenna and the first LNA