Reply Comments
FCC 98-208 Notice of Inquiry
in the Matter of Revision of Part 15 of the Commission's Rules
Regarding Ultra-Wideband Transmission Systems

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TEM Innovations is a technology generation firm headed by the inventor of Micropower Impulse Radar (MIR). MIR is a low-cost UWB impulse technology that has attracted over 5000 inquiries and has been licensed to dozens of companies by Lawrence Livermore National Laboratory. Wideband (WB) pulsed-RF sensors currently in development at TEM Innovations are also generating the same high level of interest.

IN REPLY:

1. Objections to UWB operation are avoided with carrier-based *WIDEBAND* operation.

The FAA, the GPS Industry Council, and CEMA raised objections to intentional radiation in the restricted bands. These objections are overcome with carrier-based wideband operation, such as in the 6-7GHz and 25-31GHz bands. *Operation in the restricted bands is* ***not*** *required by wideband (WB) devices.*

Objections raised by WINForum to UWB radiation in the ISM, PCS and U-NII bands can be overcome with carrier-based wideband operation. Since WB and UWB devices are very susceptible to interference (see section **4** below), they will mainly operate in bands where there is little activity. Accordingly, the ISM bands at 0.91, 2.4 and 5.8GHz, the PCS bands, and the U-NII bands will not see much WB activity (assuming the FCC removes pulse desensitization (PD) correction to allow WB operation in the 15.209 bands). At higher frequencies such as 24GHz, directional antennas and environmental absorption will effectively eliminate interference.

2. ARRL objections are based on erroneous calculations.

Calculations presented by the ARRL erroneously assume that bandwidth correction factor BWCF = **10**$\log(B_{UWB}/B_{victim})$ rather than BWCF = **20**$\log(B_{UWB}/B_{victim})$, as stated in HP Application Note 150-2. Consequently, the relevant ARRL calculations are approximately 50dB in error. Furthermore, the ARRL inexplicably assumes the UWB transmitter antenna has 33dBi gain at 432MHz. That would be a very large antenna, and one that is not suggested by any known or proposed UWB system, with the possible exception of a hypothetical long-range military UWB air-surveillance radar.

After applying the correct BWCF and assuming a more realistic dipole antenna, interference is below the amateur radio noise floor at 30-meters. The ARRL needs to recalculate it's figures, including its wildly erroneous calculations regarding the Zircon UWB device.

The principal of TEM Innovations (and amateur extra-class licensee NR9N) ran tests with an all-mode communications receiver (Icom R7100) capable of tuning 25-2000MHz and operating in AM, AM-wide, FM, FM-wide, NBFM, and SSB modes. A UWB motion sensor with emissions of 660μV/m at 3-meters spanning 1-2GHz was undetectable at any frequency and in any mode beyond a 1-meter range.

3. No objections were raised to the removal of Pulse Desensitization correction.

Virtually all Comments objected to PD correction and found it technically inappropriate. ***No*** *objections were raised against its removal.*

4. UWB systems are very susceptible to interference. Higher frequency carrier-based systems are needed.

By definition, UWB receivers have virtually no front-end filtering—they are responsive to every emitter across a *very* wide spectrum. Their primary means of selectivity is sample averaging, which is a slow process that varies with the square root of the number of samples correlated/averaged. The following example illustrates UWB interference susceptibility:

> Virtually any ~1-watt narrowband emitter operating between 300 and 3000MHz (e.g., a cell or PCS phone) will produce ~100μV antenna voltage at 2km range (assuming omni antennas). Accordingly, a UWB sampling receiver will produce a sequence of samples with +/-100μV variation. Random or coded sample-timing will not reduce this variation—the interference is inherently random. A 100μV variation (-70dBm or 6dB over S-9 on a signal strength meter) is a very high level by receiver standards—for a signal, not to mention interference. Obviously, *UWB receiver susceptibility to ubiquitous interference sources, even at >2km range, is a* ***severe*** *problem.*
>
> If the UWB receiver averages 100 samples, this variation will be reduced to 10μV (-90dBm or S-7)—still a very high level. When the samples are taken at a 1MHz rate (a typical UWB PRF), the UWB data rate after this marginal amount of averaging is a paltry 10kb/s.
>
> In comparison, a FHSS receiver with the same 10kb/s data rate would have a noise floor of –134dBm, or 44dB better than a UWB system having a PCS phone within 2km. The FHSS system can avoid narrowband interference by hopping, whereas the UWB system cannot. Furthermore, the 44dB advantage held by the FHSS system can be translated into a 1Mb/s data rate with 24dB to spare.

The above example does not consider more powerful sources of interference to UWB receivers: (1) a 100-watt amateur transmitter at 1296MHz, (2) a 500-watt cellular phone base station (densely networked in urban and suburban regions), (3) 1 to 5-megawatt FAA radar radars (common at airports), or (4) 5-megawatt UHF TV transmitters (common in major cities). A 1-megawatt emitter has the same interference level at 2000km as a 1-watt emitter does at 2km. Furthermore, the above example does not consider the UWB receiver's own extremely high noise level (input thermal noise is -76dBm or S-9, assuming BW = 3GHz and NF = 3dB). UWB's extreme susceptibility to interference and its inherently low sensitivity have no doubt kept the major radio houses (e.g., Motorola or Rockwell Collins) away from UWB technology.

This NOI has generated concern that UWB devices will proliferate. They will not—their tremendous susceptibility to interference will limit UWB deployment to portable, short-range systems such as subsurface imagers (e.g., GPR) and to remotely located systems. It is too late for the widespread deployment of UWB sensors and voice/data links—cell and PCS phones, microwave ovens, WLAN's, VHF/UHF TV, and FAA radar got there first.

In contrast, carrier-based wideband sensors with front-end RF filters will operate where:

(1) the mutual interference potential is low, e.g., the 15.209 bands
(2) there are no interference sources, e.g., inside storage tanks
(3) environmental absorption is high, e.g., at 24GHz and higher
(4) large amounts of sample averaging (N=10,000) can be applied, e.g., most sensors
(5) directional antennas and short ranges limit interference, e.g., door openers.

Wideband technology can employ very simple front end filtering to eliminate interference from the common sources cited in the previous example. TEM Innovations takes advantage of the sharp filtering offered by a waveguide beyond cutoff to eliminate cell and PCS phone interference to its 5.8GHz sensors. Yet, the cost of this "filter" is only a few cents worth of sheet metal, which also serves to provide antenna gain and directionality. An example is given in Figure 1 for a TEM Innovations 5.8GHz Differential Pulse Doppler motion sensor.

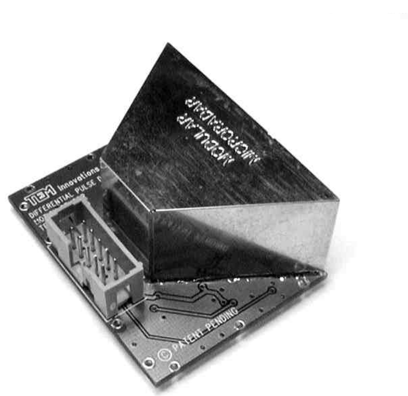

Figure 1. A 5.8GHz horn/waveguide antenna forms a natural sharp-cutting highpass filter to eliminate interference from common sources below 3GHz.

Wideband sensor technology has been publicly available from Lawrence Livermore National Laboratory since 1994 and from a number of US and foreign companies.

SUMMARY

Arthur D. Little, Endress & Hauser, MA/COM, MSSI, Rosemount, Saab, and TEM Innovations all Commented in favor of wideband (WB) technology. The Commission is urged to consider the following *Options*:

1. Do not apply pulse desensitization correction (PD) to wideband emitters in the 15.209 bands. ***This Option will enable 90% of all low power WB sensor applications.*** *Operation in the restricted bands is* **not** *required.*

2. Combine Option 1 with the removal of the distinction between intentional and unintentional radiation, *only* for operation in the restricted bands adjacent to the ISM bands at 2.4, 5.8, 10.5 and 24GHz. ***This Option will enable 100% of all WB and sensor applications, including moderate power emitters, particularly in the 10.5 and 24GHz ISM bands.***

The Commission is further urged to not couple difficult UWB issues (such as the objections that have been raised to intentional radiation into certain restricted bands, and the questionable viability of UWB systems in the presence of ubiquitous interference) with low spectral density carrier-based wideband technology. Failure to take ***prompt***, positive action on wideband technology will encourage the next decade's hottest sensor technology to flourish outside the United States.

Sincerely,

Thomas E. McEwan