EX PARTE STATEMENT

On Tuesday, February 26, 2002, Jim Haynie, President of the ARRL, the National Association for Amateur Radio, and Christopher Imlay, General Counsel of the ARRL, met with Karen Rackley, Hugh Van Tuyl, Ira Keltz, and Geraldine Matise of the Federal Communications Commission's Office of Engineering and Technology to present two technical interference analyses, attached below, in Docket No. 01-278, relating to RFI identification tags.

ET DOCKET NO. 01-278
ARRL Ex Parte Presentation[1]
to the Office of Engineering and Technology
Federal Communications Commission
February 26, 2002

Executive Summary:

On February 7, 2002, Savi Technologies made several Ex Parte presentations to the FCC Office of Engineering and Technology related to ET Docket 01-278, "Review of Part 15 and Other Parts of the Commission's Rules." ARRL, the National Association for Amateur Radio has analyzed the summaries of these presentations. In these summaries, Savi covered two major points. The first responded to ARRL's Ex Parte presentation of January 14, 2002. Savi claims that ARRL's data and conclusions were incorrect by 30 dB. This conclusion is in error. ARRL is unable to determine how Savi arrived at some of the numbers it presented to the FCC to support this conclusion. ARRL notes that the calculations SAVI supplied are not self-consistent. The ARRL data for free-space propagation and signal levels are correct.

Throughout the course of this proceeding, Savi has made a number of technical claims, all suggesting that the signal levels from a near-continuous transmission of 110,000 microvolts/meter (peak) will not cause harmful interference to the Amateur Radio Service. If these claims are based on the calculation that SAVI used in its Ex Parte presentation, those claims are also in error. If SAVI's assumptions about the amount of power that will be received by nearby receivers (including their tag receivers) are inaccurate by 30 dB, their analysis is incorrect.

Savi's Analysis of ARRL Ex Parte Presentation:

Interference Analysis:

Quotes from the SAVI Ex Parte presentation are in italics. In its presentation analyzing ARRL's Ex Parte presentation and data, SAVI makes the following claim:

"The study is not an interference analysis in that it does not analyze the effect of an undesired received signal level on the desired signal level."

The ARRL presentation included detailed reference-circuit information about the operating parameters of various types of operation in the Amateur Radio Service and plots that showed the levels in these reference circuits against the spectral mask that SAVI offered as being representative of typical operation. It is clear that the effect of undesired signals that are several tens of dB greater than the desired amateur signal will have a harmful effect.

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[1] Presentation by ARRL President Jim Haynie and General Counsel Christopher Imlay. The calculations in this study were prepared by Laboratory Supervisor Ed Hare and Senior Engineer Zack Lau.

Peak-vs-Non-Peak Representation:

SAVI states:

- *"The signal levels from the undesired sources are incorrectly identified. The corrected field intensity levels at the distance of 3 meters are as follows:*
  Interrogator 110,000 microvolts/meter peak
  Tag 43,989 microvolts/meter peak

In its presentation, ARRL chose to simply compare the effect of a 110,000 microvolt/meter field against the reference-circuit data. Although an analysis of peak vs quasi-peak vs average power, vs the PEP ratings of most amateur communication could be done, the end results would, in almost all cases, be within a few dB of the results ARRL has presented. The proposed rules would allow near-continuous transmissions, so the results as presented by ARRL provide the easiest starting point from which corrections to actual signals could be made, should the Commission choose to incorporate those corrections and conditions into the rules. In any event, with undesired signals 100 dB or more above the desired signals in some cases, differences of a few dB do not change the conclusions drawn by ARRL.

It is appropriate to use the peak level of 110,000 microvolts/meter at 3 meters in analyzing the effect of such strong signals on weaker amateur communication. Most receivers in use in the Amateur Radio Service utilize automatic gain control (AGC). The levels of signals in the proposed rules are more than enough to cause the AGC circuits to function. Many, if not most, AGC circuits respond to peak signal levels, and thus the effect on amateur radio would, in most cases, be more related to the peak than the average signals. Other types of amateur communication, such as television or digital communications, would be impacted by the peak levels of the transmitter employed. The transmission times involved are long enough to interfere with video transmissions or with large numbers of bits in a data stream.

To be complete, ARRL included the curves for 11,000 microvolts/meter (SAVI's proposed average emission level) to demonstrate that even if some amateur receiving equipment and operation responds only to the average levels, the effect of these strong signals would be strong enough to cause harmful interference.

Although ARRL appreciates the information that SAVI provided about the peak levels expected from their tag devices, ARRL analyzed the signal levels, conditions and frequencies being proposed in the rules, not the single example offered by the system that SAVI seeks to deploy at this time. ARRL did not tailor its presentation nor its Comments to the SAVI systems, which are not relevant to the notice proposal. Rather, it is only relevant to assume levels permitted by the proposed rules.

ARRL Data are Not in Error by 30 dB:

SAVI states:

- *"The ARRL curves for signal strength at various distances also appear to be in error by 30 dB. The vertical axes of the figures are labeled as dBW. Either the label is wrong or the data is incorrect. DBm vs dBW?*

- *" The correct signal levels at 3 meters when converted to dBm is as follows where, P (dBM) = -77 + 20 log E (in microvolts) – 20 log F (MHz).*

Interrogator -28.17 dBm or –58.17 dBW
Tag -36.13 dBm or –66.13 dBW

- *" The undesired received signal levels (Interrogator or tag soured) at 1 Km and 0.1Km is as follows*
  Interrogator -142.57 dBW and –122.57 dBW
  Tag -150.53 dBW and –130.53 dBW

The data in the ARRL curves are not in error by 30 dB. ARRL cannot determine what assumptions SAVI applied in order to reach its conclusion, but the curves shown by ARRL are very clearly identified as being free space curves. The mathematics ARRL used to generate these curves is correct and the results follow theory correctly. SAVI reasonably correctly determined that the received signal level (isotropic receiver) at 3 meters would be –28.17 dBm (minor differences notwithstanding).

But the figure SAVI provided for 0.1 km is not correct. The correct value for isotropic antennas is determined by the approximate formula SAVI used in their presentation, adjusted to give results in dBW and with the addition of a 20log(distance ratio) function (the –107 dB is rounded off in this formula):

$$P_{dBW} = -107 + 20\log(E_{microvolts/meter}) - 20\log(F_{MHz}) - 20\log(D_{meters_{actual}} / D_{meters_{reference}})$$

Equation 1.0

For 3 meters, where the field is presumed to be 110,000 microvolts/meter, this is approximately what SAVI calculated :

$$P_{dBW} = -107 + 20\log(110{,}000) - 20\log(433.92) - 20\log(3/3) = -58.92 dBW$$

Equation 1.1

Interestingly, SAVI calculated –58.17 dBW using the same formula. For a field of 110,000 microvolts/meter, the result is –58.17 dBm if the frequency is 398.1 MHz – a frequency much preferred by ARRL over the proposed 425-435 MHz.

Savi Data are Not Self Consistent:

SAVI's analysis is not self-consistent. Although SAVI and ARRL reach the same approximate conclusion about the amount of power that will be received by an isotropic antenna located at a point where the peak field strength is 110,000 microvolts/meter, SAVI has miscalculated the free-space field that will be present 100 meters from a source that is producing a field strength of 110,000 microvolts/meter 3 meters from that source.

Using Equation 1.0 on 433.92 MHz, ARRL calculates that –89.38 dBW will be produced in an isotropic antenna located 100 meters away from a source that is producing 110,000 microvolts/meter 3 meters distant from that source.

$$P_{dBW} = -107 + 20\log(110{,}000) - 20\log(433.92) - 20\log(100/3) = -89.38 dBW$$

Equation 1.2

At 1000 meters, the same formula calculates that –109.38 dBW will be produced.

Table 1 ARRL and Savi Calculations Compared

Distance from source	ARRL calculation for power	Savi calculation for power (interrogator)	Notes
3 meters	-58.92 dBW	-58.17 dBW	ARRL and Savi in agreement
100 meters	-89.38 dBW	-122.57 dBW	-20*log(100/3) = -30.46 dB from the field present at 3 meters. Savi data would require that the field vary as -43*log(100/3)
1000 meters	-109.38 dBW	-142.57 dBW	

ARRL's curves show data plotted at points from 1 meter to 1000 meters from a source that is radiating an RF signal that would result in a field of 110,000 microvolts/meter 3 meters distance from that radiating source (plane-wave fields assumed). Although it may not be visually evident from the graph, the curve for a 0 dBi gain receive antenna shows the field at 3 meters distance as –58 dBW . This is in reasonable agreement with the figure that SAVI cited for the interrogator, which generates a field of 110,000 microvolts/meter at 3 meters.

The levels SAVI provided for 1000 meters distance, although incorrect because of this initial error, are 20 dB less than the numbers at a distance of 100 meters distance, indicating that they believe that the field follows a 20log(distance ratio) function. Of note, the test data included with their application for Certification of a series 400 RFID device has a section that discusses how the field varies as 20 log(D/reference distance). SAVI cannot allege (1) that the field varies as –43 log(100/3) between 3 and 100 meters, and (2) that the field varies as –20 log(1000/100) between 100 and 1000 meters.

For reference, here are the graphical data from the 0 dBi (isotropic) antenna from Figure 1 of ARRL's Ex Parte presentation of January 14, 2002.

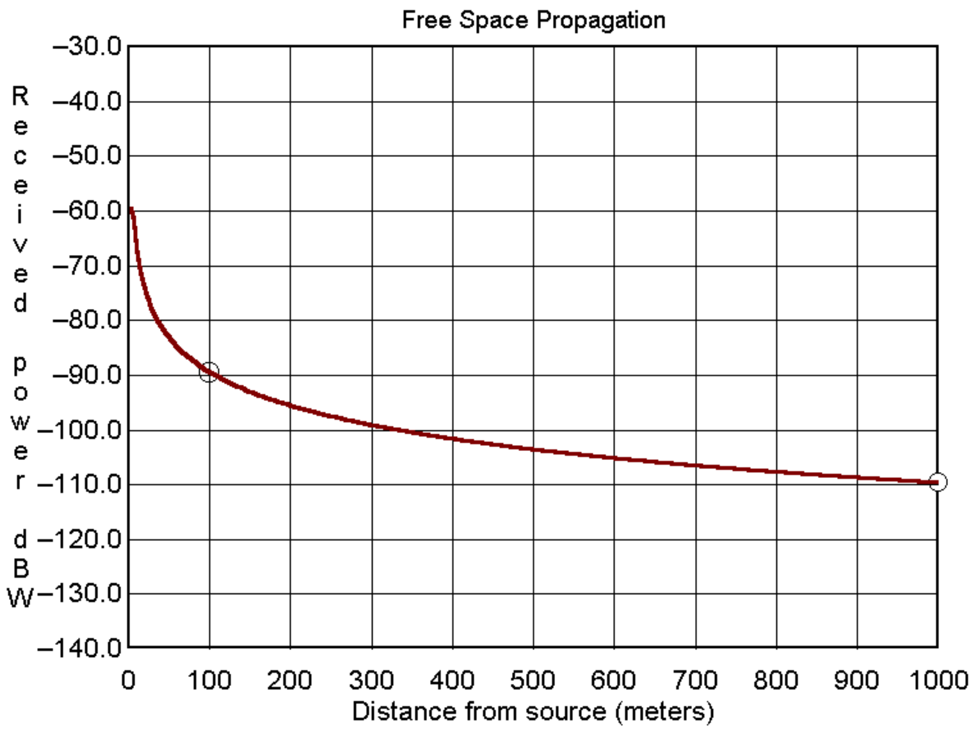

Figure 1. This is the 0 dBi data from Figure 1 in ARRL's Ex Parte presentation. It shows the amount of power that will be received by an isotropic antenna located the specified distances from 3 to 1000 meters from a source that is producing 110,000 microvolts/meter peak at a point 3 meters from that source. The circles represent ARRL calculations for 100 and 1000 meters from the radiating source. This follows a 20 log(distance ratio) function.

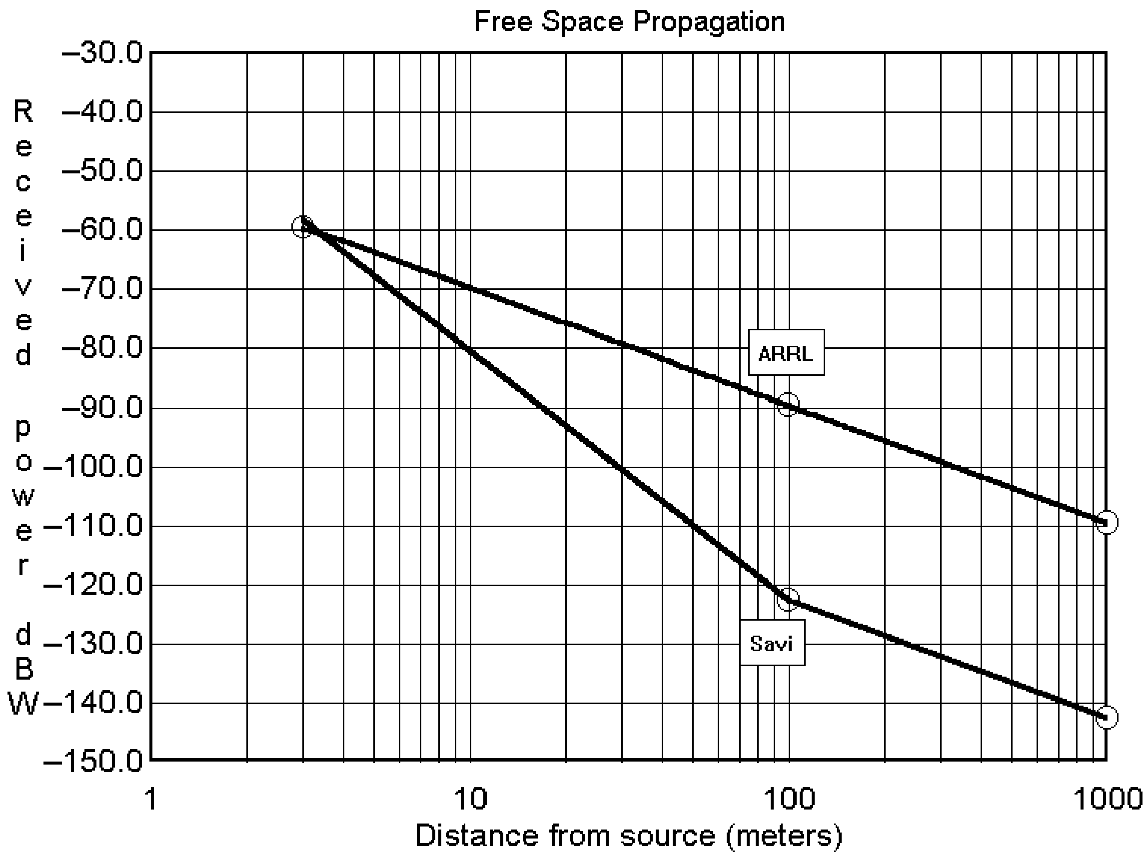

Figure 2. The ARRL data from Figure 1, redrawn onto a logarithmic graph to better show the function of how power density varies in free space. SAVI's calculations for 3 meters, 100 meters and 1000 meters are shown for comparison. The graph shows the amount of power received by an isotropic antenna located at distances from 3 to 1000 meters from a source that is radiating at SAVI's proposed peak power levels. The ARRL data follow a 20 log(distance ratio) function.

Conclusion:

Throughout the course of this proceeding, SAVI has claimed that the signal levels from a near-continuous transmission of 110,000 microvolts/meter (peak) will not cause harmful interference to Amateur Radio communications. However, SAVI's technical analysis is flawed, thus invalidating their conclusion regarding interference potential.

ARRL Spectral Mask Graphs:

In carefully reviewing ARRL's Ex Parte presentation, ARRL noted that some of the graphs did contain an error smaller than the 30 dB SAVI had claimed for the Figure 1 and Figure 2 graphs showing expected received power versus distance. The received-power-versus-distance graphs were correct, but ARRL has supplied separately a corrected version of the Ex Parte summary, with the corrections.

ET DOCKET No. 01-278
ARRL Ex Parte Presentation[2]
to the Office of Engineering and Technology
Federal Communications Commission
February 26, 2002

Executive Summary:

In its February 7, 2002, Ex Parte presentation to the Office of Engineering and Technology related to ET Docket 01-278, "Review of Part 15 and Other Parts of the Commission's Rules", Savi Technologies presented summary information of two incomplete and inconclusive field studies. From the results that Savi described, SAVI cannot have used transmissions that simulate the *proposed* new regulations. They may have used interrogators and tags that meet the current FCC regulations for periodic radiators, certainly not a fair comparison. SAVI used non-standard test methods, lacking substantive measurements. The signal levels SAVI suggests are strong enough to cause harmful interference to amateur operation.

SAVI's threshold criteria for interference is a breaking squelch. It concludes that signals in excess of –103 dBW at the input terminals of amateur receivers will not break the squelch of amateur receivers tested. The premise that –103 dBW signals will not be heard by nearby receivers is simply not true.

The proposed rules encompass 425-435 MHz, a frequency range that includes amateur uses significantly more varied than FM and repeater link operation. SAVI's contention that its signals on 433.92 MHz will not cause interference elsewhere in the band is inaccurate and irrelevant; under the proposed rules changes, RFID signals can *appear* "elsewhere in the band," so the on-channel levels are what are important.

Received Signal Level (RSL):

In appendix E of its Ex Parte presentation, SAVI stated:

"The desired RSL is in the range of –89 dBW to –99.4 dBW for antenna heights of 20 to 200 feet."

These received signal levels (RSL) are what SAVI is claiming represent typical amateur operation. The source of these levels is undetermined. As shown in the reference data included in ARRL's January 14, 2002 Ex Parte presentation, the minimum RSLs for various types of amateur operation, including FM voice, are *significantly* below the –89 dBW to –99.4 dBW cited by SAVI. As just one example, on page 5 of its earlier Ex Parte summary, ARRL demonstrated that FM voice desired signals can be as low as –150 dBW for a 12-dB SINAD signal. Corrected for the stipulated 5-dBi antenna gain, this is an RSL of –145 dBW to an isotropic receiving antenna.

A desired signal level of –89 dBW would have a noise margin of approximately 50 dB more than the signals that Amateur operators often use. Although certainly some signals in the Amateur Service could be at this exceptionally strong level, due to close proximity of an amateur receiver to another amateur station, this is the exception, rather than the rule. To the contrary, at VHF and above, an

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[2] Presentation by ARRL President Jim Haynie and General Counsel Christopher Imlay. The calculations in this study were prepared by Laboratory Supervisor Ed Hare and Senior Engineer Zack Lau.

"S9" (extremely strong) signal is often taken to be 50 microvolts into 50 ohms, a level of –103 dBW. In some standards or recommendations, the IARU Region 1 recommendation for S units, for example, S9 on VHF and above is assumed to be –123 dBW. With this standard, the levels SAVI claim as "typical" are 34 dB higher than the levels the IARU cites for an S9 meter reading. The IARU Recommendation specifies as follows:

IARU Region 1 Technical Recommendation R.1
BRIGHTON 1981, TORREMOLINOS 1990
STANDARDISATION OF S-METER READINGS

1. *One S-unit corresponds to a signal level difference of 6 dB,*
2. *On the bands below 30 MHz a meter deviation of S-9 corresponds to an available power of -73 dBm from a continuous wave signal generator connected to the receiver input terminals,*
3. *On the bands above 144 MHz this available power shall be -93 dBm,*
4. *The metering system shall be based on quasi-peak detection with an attack time of 10 msec ± 2 msec and a decay time constant of at least 500 msec.*

Note added by ARRL: -73 dBm = -103 dBW and –93 dBm = -123 dBW.

ARRL also questions how the cited RSLs can vary with antenna height. First, it is unclear why the necessary power to the receiver is dependent on antenna height. Certainly SAVI cannot mean that an antenna at 20 feet elevation will receive a signal level of –89 dBW while an antenna at 200 feet elevation will reduce the signal level at the receiver to –99.4 dBW. In general, raising an antenna will result in a stronger signal being received from a distant source, so, levels notwithstanding, this statement is inaccurate.

Carrier/Noise+Interference [C/(N+I)]:

In Appendix E, SAVI cited some figures for carrier/(noise+interference) [C/(N+I)]. ARRL cannot determine how SAVI arrived at these figures. They are not derived from the minimum signal levels provided by ARRL. SAVI claims that at 100 meter separation, (the desired operating range), the [C/(N+I)] level would be 23.5 dB from a SAVI interrogator. The RFID signals do not stop at 100 meters. Although this may be the range that SAVI expects from a 3.6 milliwatt device, a signal at that power level can be used to communicate over a much greater range.

Figure 5 from ARRL's earlier Ex Parte showed a comparison between the desired minimal FM voice signal in the Amateur Service of –150 dBW and the calculated RFID signal level. Here is the corrected data from Figure 5, designated as Figure 1 in this document.

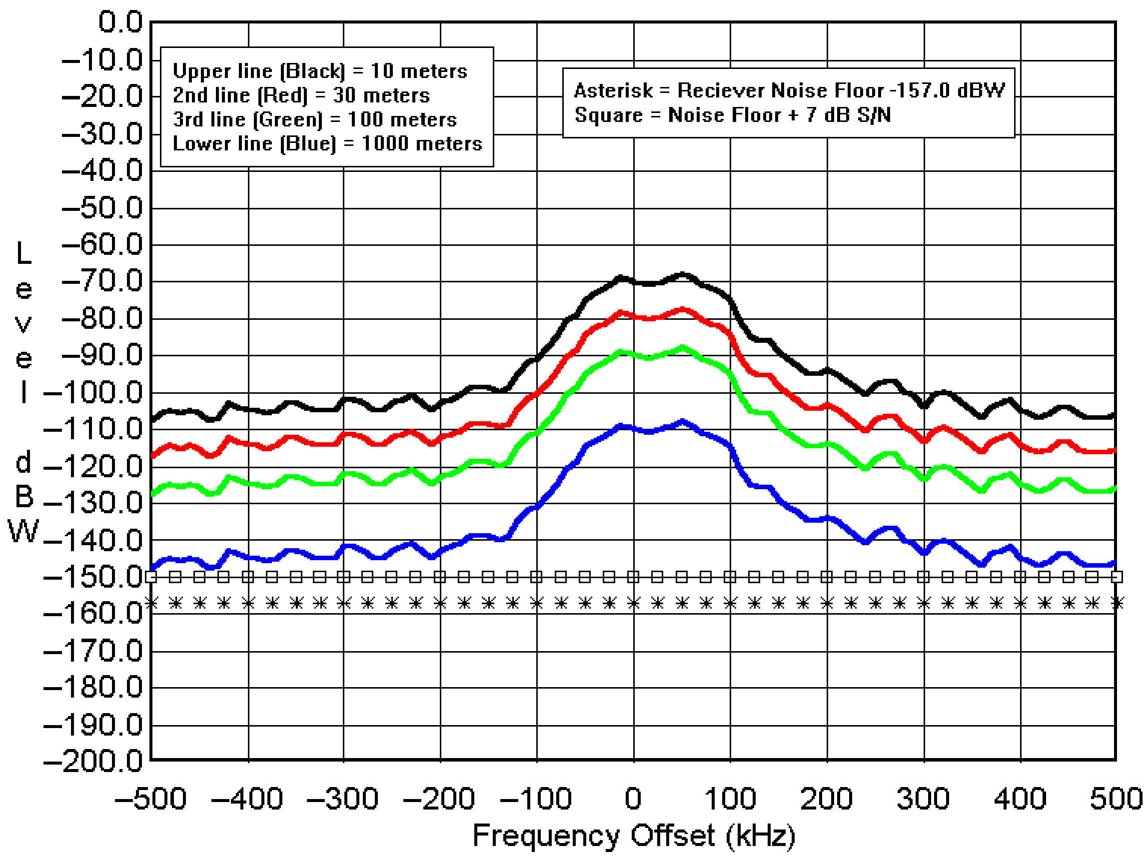

Figure 1. These data show the expected RFID system levels from the typical RFID transmitter generating 110,000 µV/m at 3 meters. The amateur station is an FM receiving station using a 5-dBi gain antenna. The antenna is located at a distance of 10 meters, 30 meters, 100 meters and 1000 meters from the point at which the field is 110,000 µV/m. The predicted levels from the RFID transmitter have been adjusted downward by 3 dB to account for the receiving system bandwidth of 15 kHz. This amateur station typically has –157 dBW of receiver sensitivity and a signal margin of approximately 7 dB for minimal communication. Figure 2 represents measurements made in the ARRL Lab. The receiver tested was an Alinco model DR-605.

FM Voice is an Inappropriate Standard for Determining Interference Potential:

The above analysis assumes that the victim receiver uses a 15K0F3E (FM Voice) emission. SAVI chose this because it represents the "best case" for their position. Other modulation modes are much worse cases than is FM voice. SAVI admits that FM is the mode with the most tolerance for noise and interference. However, the inherent limiting and noise reduction in most FM receiver circuits is not enough to overcome a noise level that is 61 dB greater than the desired signals.

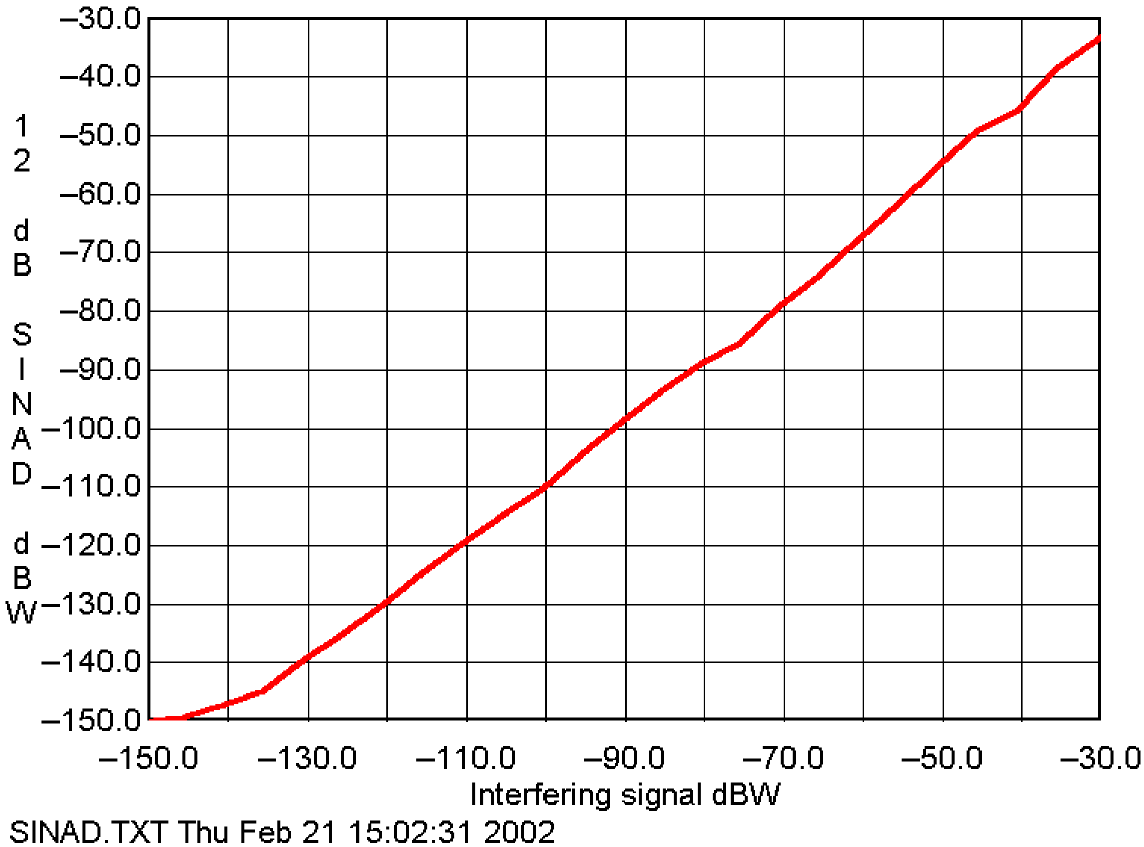

Figure 2: Plot of level of desired signal required to obtain a 12-dB SINAD on a current amateur FM transceiver in the presence of specific levels of 100-kHz-wide FM digital signals. The modulation was a pseudo-random digital stream at 9600 bits/s, with the deviation adjusted to give a –3 dB signal bandwidth of approximately 100 kHz. This is intended to simulate the spectral mask that SAVI presented as typical of its current products. The receiver employed for this test was tuned to the 70 cm amateur band. It has a receiver sensitivity of approximately –152 dBW for 12 dB SINAD and a bandwidth of approximately 15 kHz.

The graph shows about 10 dB of difference between the level of undesired signal and the desired signal. The bandwidth of the undesired signal is 100 kHz while the receiver bandwidth is 15 kHz, explaining 8.2 dB of the difference. The remainder is probably due to the some amount of FM limiting of the noiselike undesired signal. At 12 dB SINAD, there is not much scope for the limiter to work, but some limiting may occur.

SAVI claims that at 100 meters separation, amateur signals will be 23 dB higher than the proposed RFID signal. This is incorrect. To obtain this figure, SAVI significantly overestimated the desired amateur signal and made an error in significantly under-calculating that the RFID signal at 100 meters would be at a level of –122.5 dBW. Even in the FM case, had SAVI used the correct calculations to determine the proposed RFID signal level at 100 meters of –89 dBW and used the amateur FM signal level of –150 dBW the resultant [C(N+I)] would be negative. The undesired signal level is 61 dB higher than the desired signal. This is the level shown in Figure 1 of this document. When other operating modes are evaluated, the [C/(N+I)] becomes increasingly negative in some cases.

EME Weak Signal Report

SAVI presented information about field tests that it had done at Amateur Station K5GW, an Earth-Moon-Earth (EME) amateur operator whose station is at the upper end of performance. In this study, SAVI reports that that a 50 microvolt signal (50 ohms, S9, -103 dBW) was received when a SAVI interrogator and Tag were placed 30 meters from the EME antenna. This is somewhat below the level shown in Figure 13 of the revised ARRL Ex Parte presentation, but the emission levels of the test signals SAVI used, assuming they meet the present rules, are about 8 dB below the levels proposed in the NPRM. A test distance of 30 meters is *well* within the near-field region of that array, so the amount of gain realized to a point that close will be less than what the array achieves in the far field. ARRL does not have specific information about the Yagi spacing of the 64 10-element Yagis used at K5GW, but if they are spaced 1 wavelength apart, a reasonable estimate, the near-field region of this antenna extends to about 90 meters from the center of the array.

Even so, ARRL would expect to see a higher signal level than this, under the test conditions described. If the Savi transmitter were operating at the –24.4 dBW that the rules change would allow for a 0 dBi gain antenna, the path loss over 30 meters to the EME array would be 78.6 dB. The formula for path loss:

$$FSL_{db} = -27.55 + 20\log(D_{meters}) + 20\log(F_{MHz}) \qquad \text{Equation 1.0}$$

predicts that the path loss at 433.92 MHz over a distance of 30 meters should be 54.74 dB. This would mean that if the EME array were achieving full gain over that distance (not likely), the received signal is calculated to be at a level of –79.14 dBW. Of note, this is 20 dB lower than the calculated level of –59.14 dBW at 3 meters separation, again showing good self-consistency to the ARRL data in Figure 1 and Figure 2 of received levels vs distance.

It is unclear how SAVI can contend that a received signal level of –103 dBW will not cause interference to the Amateur Radio Service. For the EME station tested, the received signal level of –103 dBW is significant, considering that under the proposed rules, this signal *could* be present anywhere between 425-435 MHz. This aspect of SAVI's test clearly shows an interference potential from the proposed rules change.

FM Receive Tests at W5OLY:

SAVI also described field testing done at amateur station W5OLY. Like the tests done at K5GW, the results of these tests are lacking in technical data. Again, the test signal used was *not* at the level or duration of the signals being proposed under the NPRM. The peak power is at least 8 dB lower and the duration of transmission is much less. SAVI's own calculations indicate that at a point 3 meters from an RFID device creating a peak field of 110,000 microvolts/meter, the expected signal received on an antenna with 0 dBi gain will be approximately –59 dBW. It is inconceivable that a signal of –59 dBW would not cause harmful interference to amateur communication on the RFID operating frequency. SAVI is correct that if a desired amateur signal level is somewhat above the level of the interfering signal, the FM limiting and capture effect might allow the FM receiver to hear the desired signal with relatively little noise. However, this premise becomes involved if the desired signal is at a level lower than the interfering signal. In almost all cases, especially with handheld FM receivers, such as the one SAVI used for this test, desired signals will be considerably below –59 dBW. From ARRL's reference-circuit data, the desired signal level in an FM voice circuit can be as low as –150 dBW, approximately 90 dB lower than the level SAVI claims as an interference threshold.