LSProbe 1.2 Application Note, Measuring Radio Jammers

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1 Introduction and Experimental Setup

The LSProbe 1.2 E-field probe offers superior sampling speed, accuracy and dynamic range. Its ability to record waveforms at full sampling speed is only limited by the amount of memory available to the host computer. The field probe incorporates two received signal strength (RSSI) detectors with characteristic frequency ranges that are accessible through the field probe's mode setting. In mode 0 and 4 the high frequency detector is used, covering frequencies between 30 MHz and 6 GHz. In mode 2, 3, 6 and 7 the low frequency detector is used, covering frequencies between 10 kHz and 400 MHz.

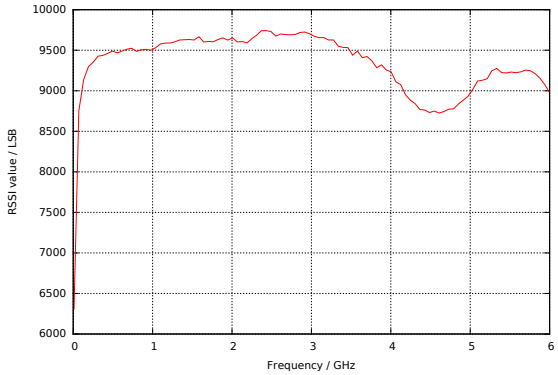
This document examines how the unique features of LSProbe 1.2 can be exploited for analyzing the frequency hopping behavior of a portable radio jammer. Radio jammers use relatively high power, broadband emissions for blocking specific frequency bands. They employ techniques such as rapid frequency hopping to block undesired radio services. Radio jammers are most commonly used in military environments.

Figure 1: GTEM wave guide and pulse generator

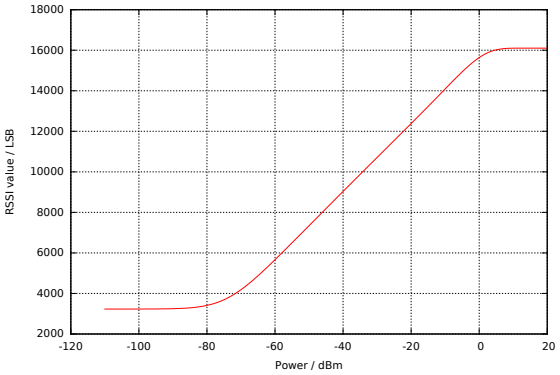
A radio jammer, whose manufacturer and model cannot be disclosed in this document, is connected to the 50 Ω feed of an approximately 5 m long GTEM wave guide. LSProbe 1.2, serial number 10 is placed centrally in a laterally open GTEM wave guide located in such a way that the septum height is approximately 75 cm. Fig. 1 depicts the setup. The field probe's x-axis is aligned in parallel with the E-field vector.

The E-field probe is operated in modes 0 (30 MHz bis 6 GHz, 330 ns analog rise time), 2

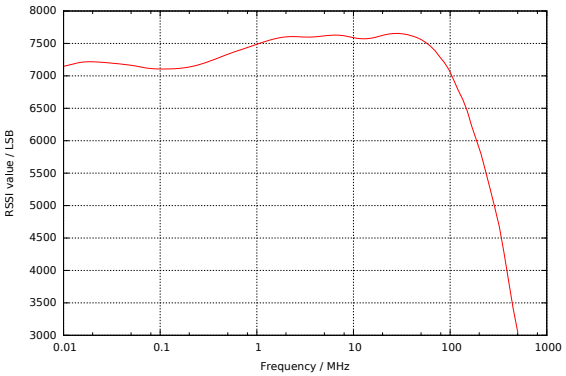
(10 MHz bis 500 MHz, 770 ns analog rise time) and 3 (10kHz MHz bis 500 MHz, 1.8 ms analog rise time). A sampling rate of 500,000 Samples/s is used for all measurements. 5,000,000 samples long waveforms are recorded for each axis, yielding records of 10 seconds length each.



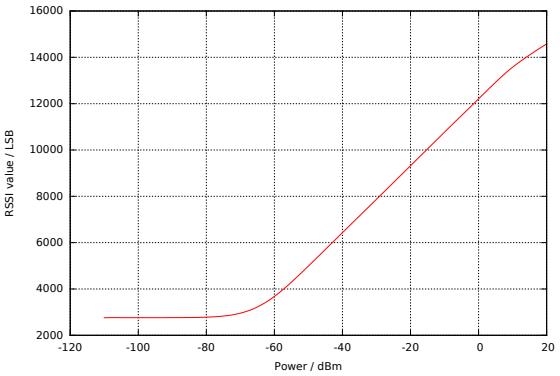
(a) Frequency response @ 10 V/m, mode 0



(b) Amplitude response @ 1 GHz, mode 0



(c) Frequency response @ bei 10 V/m, mode 2/3



(d) Amplitude response @ 100 MHz, mode 2/3

Figure 2: Typical RSSI characteristics

Fig. 2 gives the typical RSSI characteristics as a function of frequency and RF power for mode 0, 2 and 3. These plots can be used for extrapolation of the frequency hopping behavior of the radio jammer. Modes 2 and 3 differ only in their video bandwidth. Consequently, their characteristics for CW signals are virtually identical.

2 Experimental Results

An approximately constant power is assumed for all following discussions. This assumption is reasonable since the jammer must maximize its RF power output to have a maximum effect. If RF power were a frequency dependent or influenced significantly by the modulation

scheme this would be indistinguishable from frequency hopping by means of the LSProbe 1.2 E-field probe. This fact needs to be kept in mind for the following discussion.

2.1 Short Term Behavior

As depicted in Fig. 3 the jammer alternates between jamming modes with a period of 18 ms. Jamming mode A has a duration of 15 ms, jamming mode B has a duration of 3 ms.

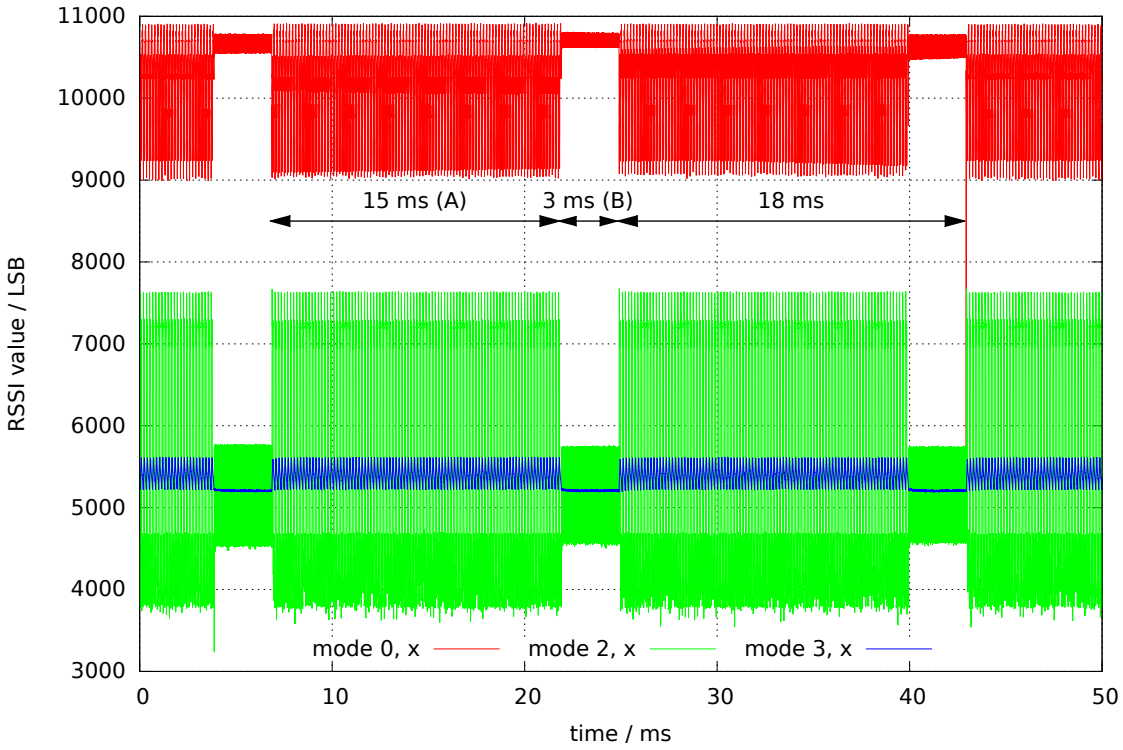


Figure 3: Timing and periodicity of jamming mode A and B

Fig. 4 demonstrates that the field strength detected by mode 0 is relatively constant and dips briefly when switching between jamming mode A and B. The field strength is approximately 20 V/m in this case. In jamming mode A the jamming signal exhibits a periodicity of 160 µs. Each period contains a 100 µs long section and a 60 µs long section. Due to the different frequency response of mode 0 and 2 it is possible to draw conclusions regarding the frequencies employed by the radio jammer.

The 100 µs long section is a unidirectional frequency sweep near 500 MHz. Since the waveform's shape is approximately identical in mode 0 and 2, see Fig. 4. One can conclude that the frequency is swept continuously. This fact is further supported by Fig. 5 which shows that the perpendicular y- and z-axis show large, sudden fluctuations which are characteris-

tic for TEM wave guides at high frequencies. The frequency range swept withing the 100 µs long section is thus relatively large.

The 60 µs long section is a unidirectional frequency sweep near 100 MHz, this can be concluded from observing the RSSI values' ratio in mode 0 and 2. Similar to the 100 µs long section large fluctuations of y- and z-axis point to relatively large frequency sweeps.

In jamming mode B the radio jammer alternates between two relatively narrow frequency bands near 300 and 400 MHz, each band is active for 10 µs at a time. Again, frequencies can be derived from the RSSI values in mode 0 and 2, see Fig. 4. Since there are neither significant RSSI variations in Fig. 4, nor in Fig. 5 the swept frequency range is relatively narrow.

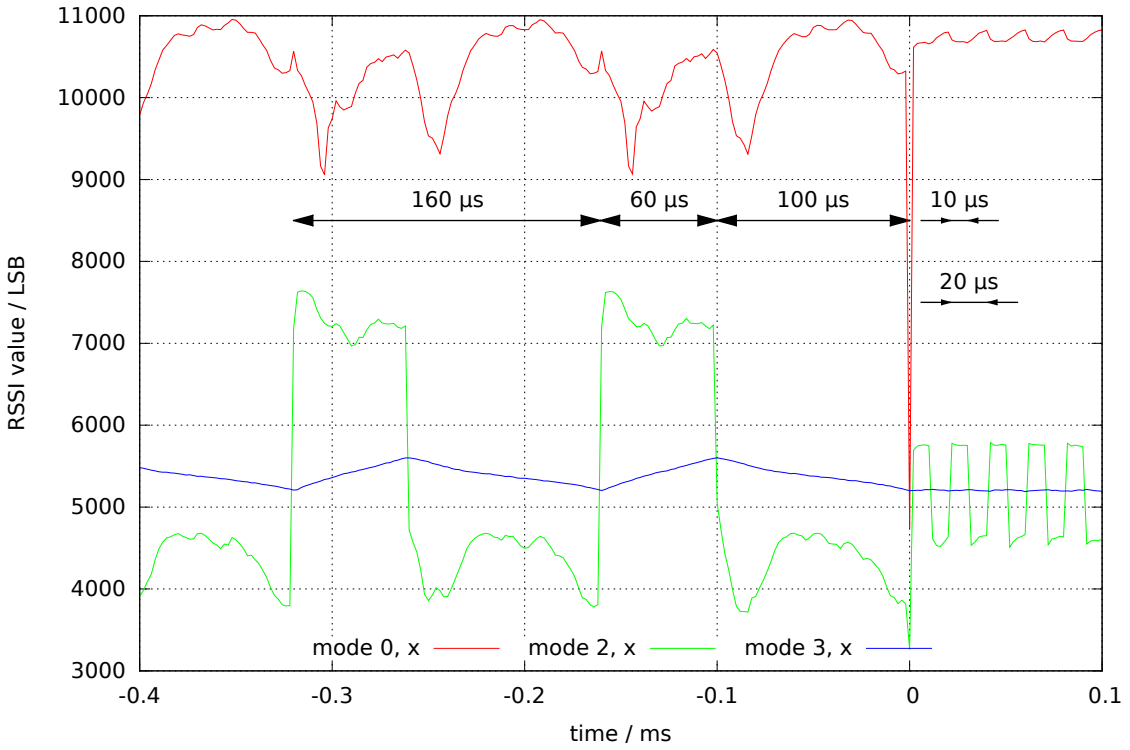


Figure 4: Detailed view of transition from jamming mode A to jamming mode B, comparing mode 0, 2 and 3

2.1.1 Long time behavior

Fig. 6 shows the RSSI values' trend over a duration of 10 s. Peaks at a distance of very nearly 5 s stand out.

In Fig. 7 and 8 these peaks are shown close up. The radio jammer turns off the RF signal for 22 µs, remains at a constant frequency for 640 µs and resumes the previous jamming

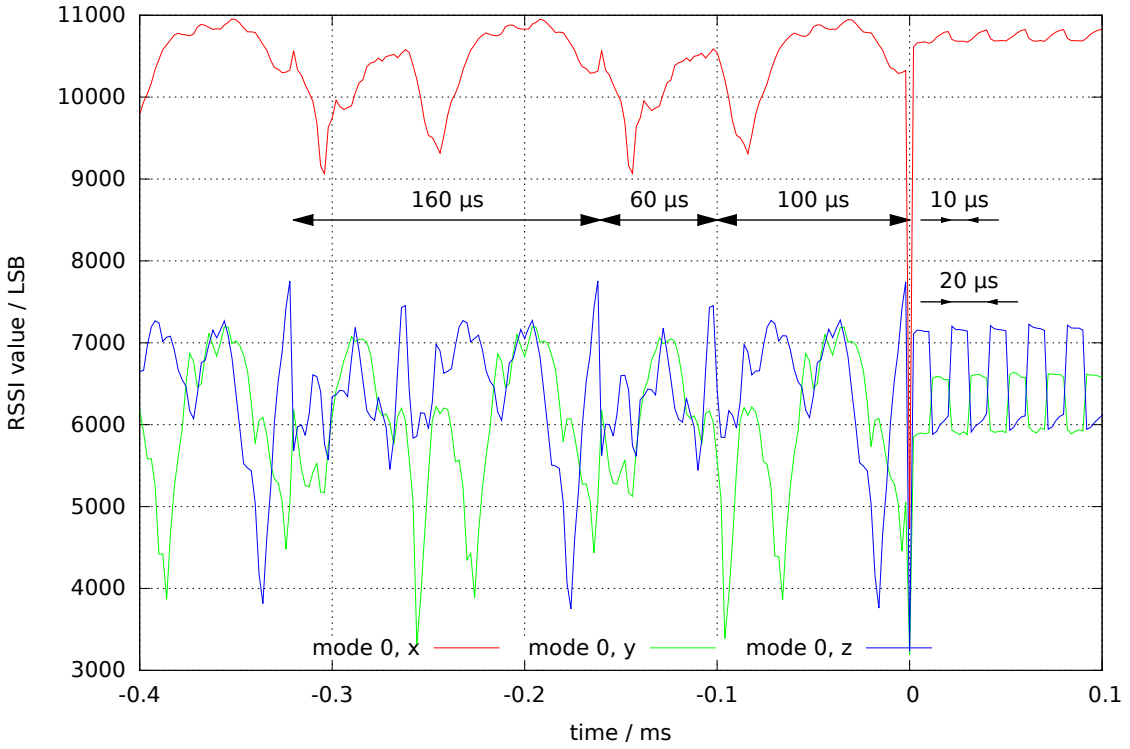
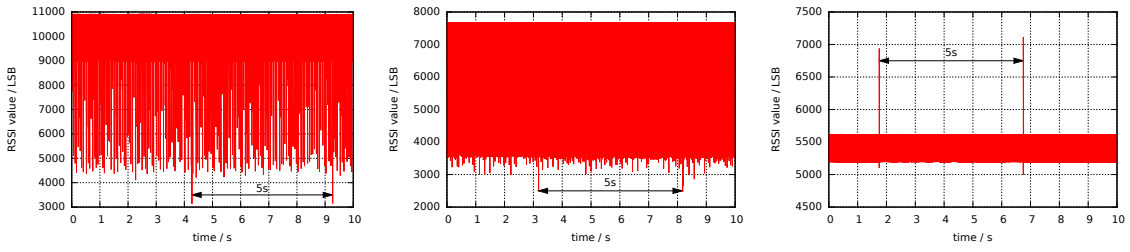


Figure 5: Detailed view of transition from jamming mode A to jamming mode B, comparing mode x, y and z in mode 0



(a) mode 0 (b) mode 2 (c) mode 3

Figure 6: RSSI peak values for a duration of 10 s

operation after another gap of 22 µs. It can be found that these gaps are not synchronized with the jamming operation. The ratio of mode 0 and 2 RSSI values points to a frequency near 100 MHz which is might be used for synchronization with other radio jammers.

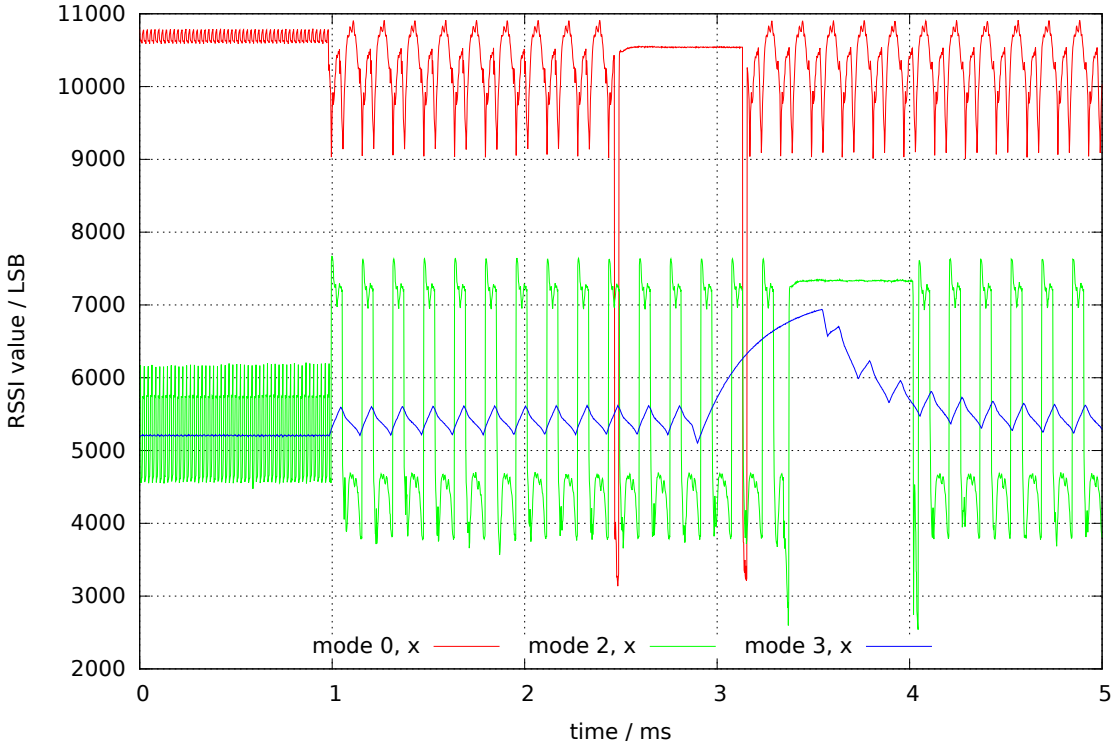


Figure 7: Close-up of periodic breaks of the jamming pattern, synchronized with the jamming pattern

2.2 Conclusions

It has been shown that the LSProbe E-field probe can be applied to easily examine the temporal behavior of a radio jammer starting from microsecond timescales up to multiple seconds timescales. As mentioned above the measurement time is only limited by the amount of memory available on the host computer. The results presented above have been checked and confirmed by spectrum analysis.

By combining waveforms recorded in different modes LSProbe 1.2 offers a new measurement technique that is available in no other E-field probe. Please contact LUMILOOP GmbH for more detailed instructions and assistance with the described measuring technique.

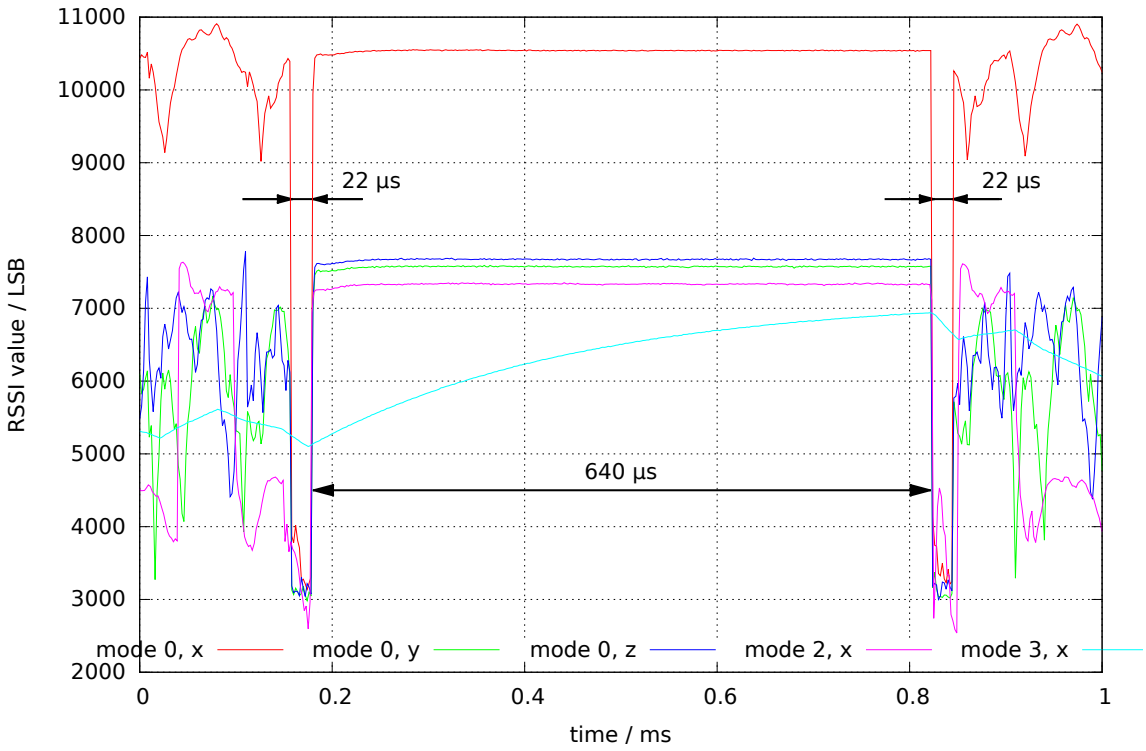


Figure 8: Close-up of periodic breaks of the jamming pattern, synchronized with the break

3 Acknowledgement

The results contained in this application note are presented with the permission of the Bundeswehr Research Institute for Protective Technologies and CBRN Protection (WIS) in Munster. We thank Mr. Kreitlow and his colleagues for their kind support and advice in the course of the experiments.