

# Using Spectrograms to Find Signal Anomalies

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Spectrograms are a useful tool for the display of wireless waveforms. Recently, their utility has been greatly enhanced through improvements in the resolution of the images that they produce. Post-processing of spectrograms has also been introduced which creates a powerful new tool for investigating the characteristics of signals.

Rather than talk about the power of spectrograms, let's use an example to demonstrate their usefulness. This example will use plots from Spectro VSA. Spectro VSA is a software package with two significant enhancements over previous implementations of spectrograms.

- 1) The image quality of the spectrograms produced by Spectro VSA is significantly higher than other implementations. This is made possible by modifications to the underlying digital signal processing algorithms.
- 2) While other implementations of spectrograms stop with the image, Spectro VSA goes beyond to include post processing of the image. This is a powerful new extension to the use of spectrograms. Spectrograms are not merely an interesting display, but are actually a workspace which allows any part of the time-frequency space to be investigated.

For our example, let's consider a case where an EDGE waveform has a strange EVM problem. Figure 1 shows a plot of power vs time for an EDGE frame with its eight timeslots. The first timeslot has an EVM of 5.1%, the remaining timeslots each have an EVM around 0.5%. Traditional displays make it difficult to discover why the first timeslot has such poor EVM. As will be seen, a spectrogram will make it quite clear what is causing the EVM problem.

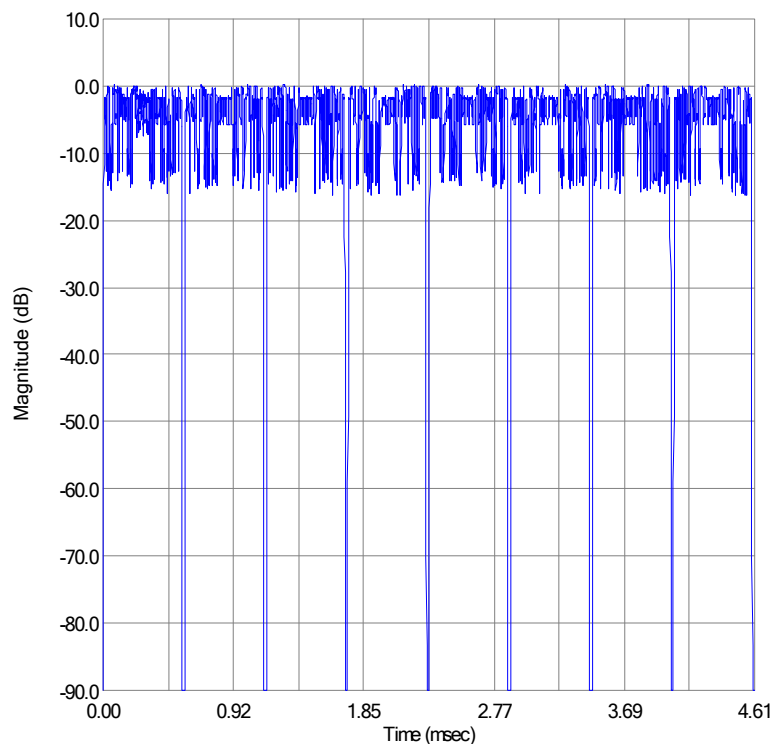


Fig. 1: Power vs time for an EDGE frame.

Figure 2 shows an IQ constellation plot for the entire frame.

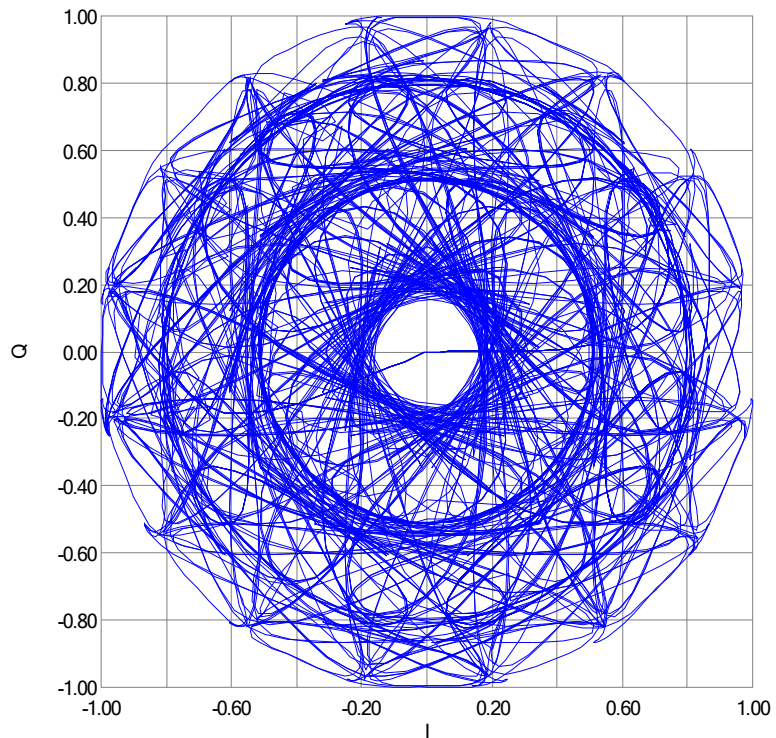


Fig. 2: IQ constellation plot for the EDGE frame.

Figure 3 shows a spectrum of the frame using an RBW of 10 kHz. None of these plots reveal why the first timeslot has a poor EVM.

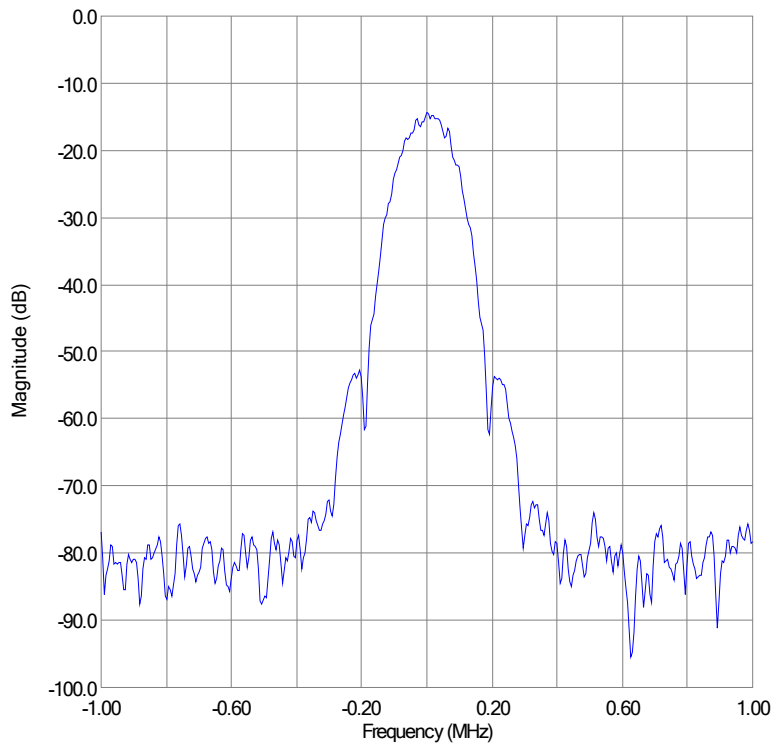


Fig. 3: Spectrum of the EDGE frame.

In an attempt to discover the problem with timeslot 1, isolating that timeslot may help. Figure 4 shows power vs time for just timeslot 1. If we knew just what to look for, perhaps we could recognize the problem from this plot. However, the source of the higher EVM is not extremely obvious.

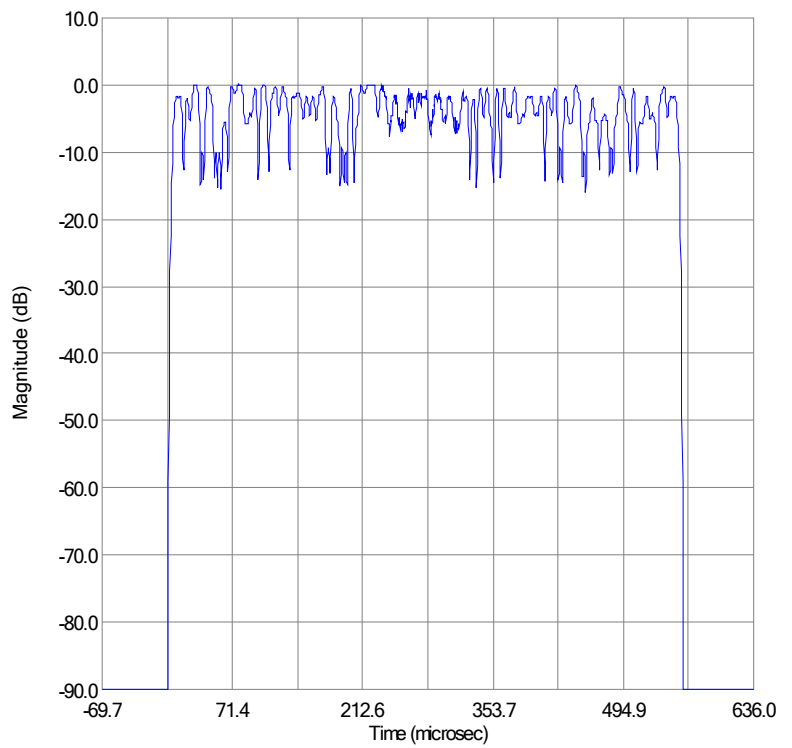


Fig. 4: Power vs Time for the first timeslot of the EDGE frame.

Figure 5 shows an IQ constellation plot of timeslot 1. Some of the data on the left side of the plot looks strange, but other than a vague sense that something is wrong, this plot hasn't revealed the problem.

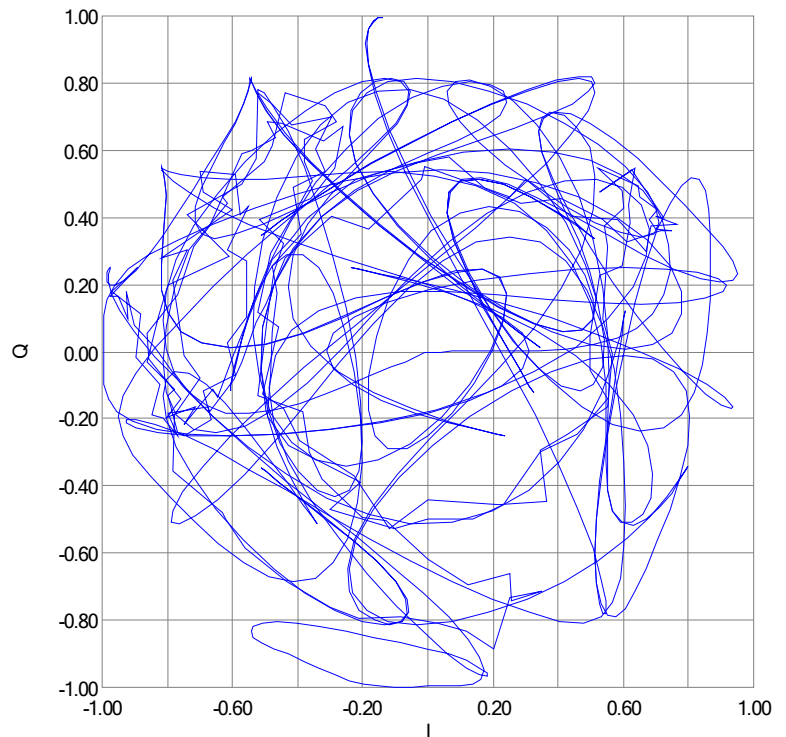


Fig. 5: IQ constellation plot for the first timeslot of the EDGE frame.

Figure 6 shows the spectrum of timeslot 1 using an RBW of 10 kHz. This plot shows some difference from figure 3. The noise floor is somewhat higher for timeslot 1 as compared to the noise floor of the entire frame.

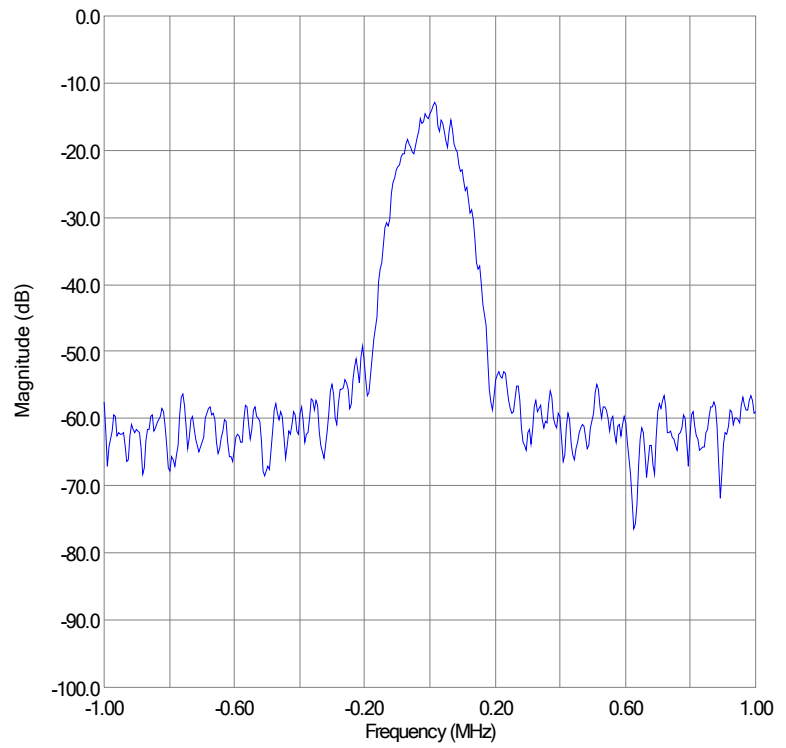


Fig. 6: Spectrum of the first timeslot of the EDGE frame.

Figure 7 is a spectrogram of the first timeslot. The horizontal axis is frequency. The vertical axis is time. The color indicates the power at a particular time and frequency. It is quite obvious from this figure what is causing the higher value of EVM. There is some other signal which is present from about 220 to 330  $\mu\text{sec}$ .

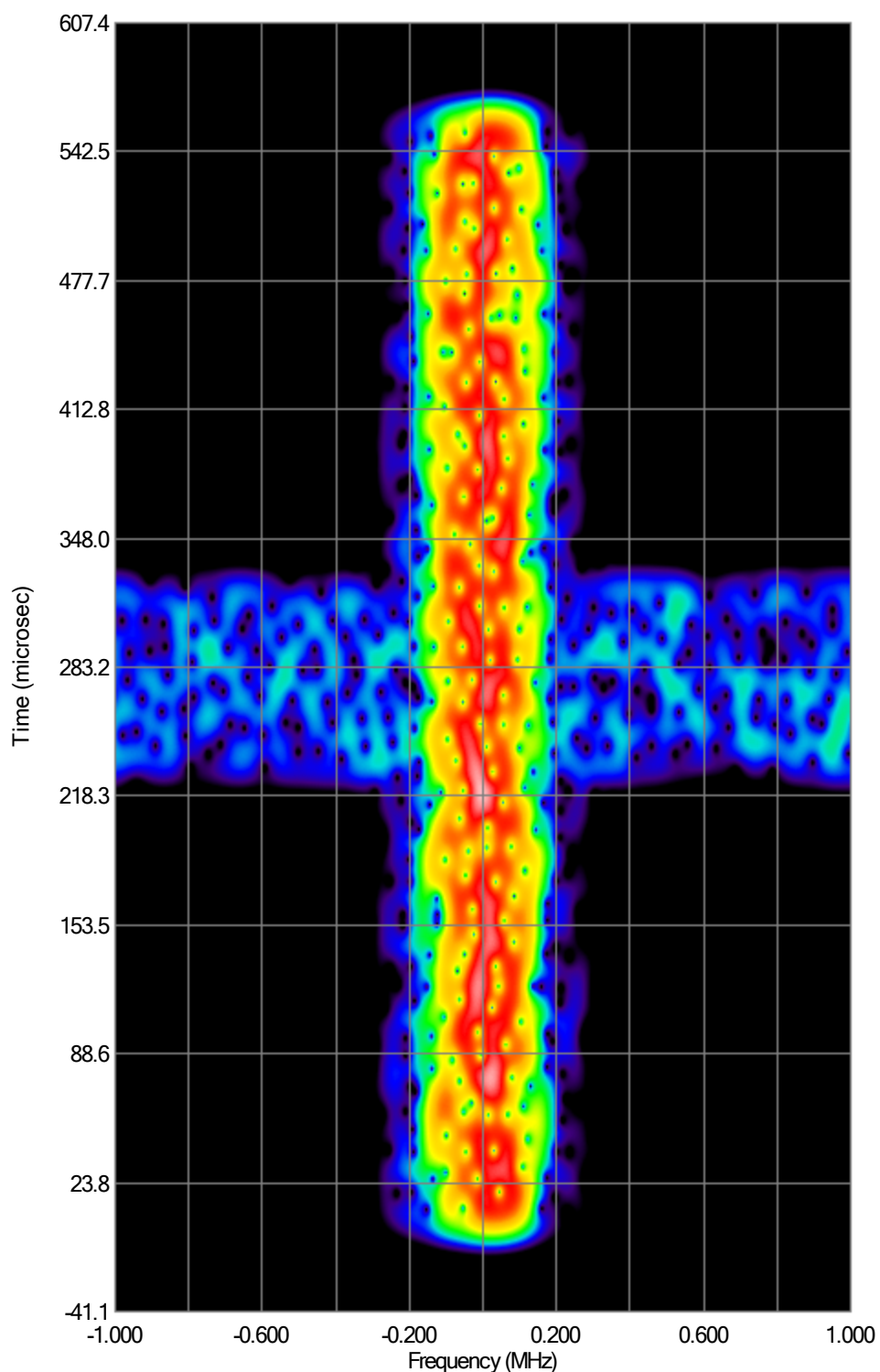
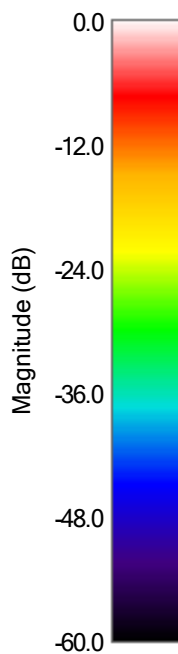


Fig. 7: Spectrogram of the first timeslot of the EDGE frame.

A previously unexplored feature of spectrograms is post-processing of the display. Using Spectro VSA, let's investigate what type of signal is intruding onto the frequency space and causing the higher EVM value. This post-processing feature shows that spectrograms are not just an interesting display, they are a workspace for investigating any fragment of the time-frequency space.

We can select the portion of the spectrogram between 220 and 330  $\mu\text{sec}$  and ask for the spectrum of the signal. Figure 8 shows this spectrum. The signal density outside of the region of the carrier is relatively constant. This indicates that the intruding signal might be noise. Broadband noise has a relatively constant amplitude over frequency.

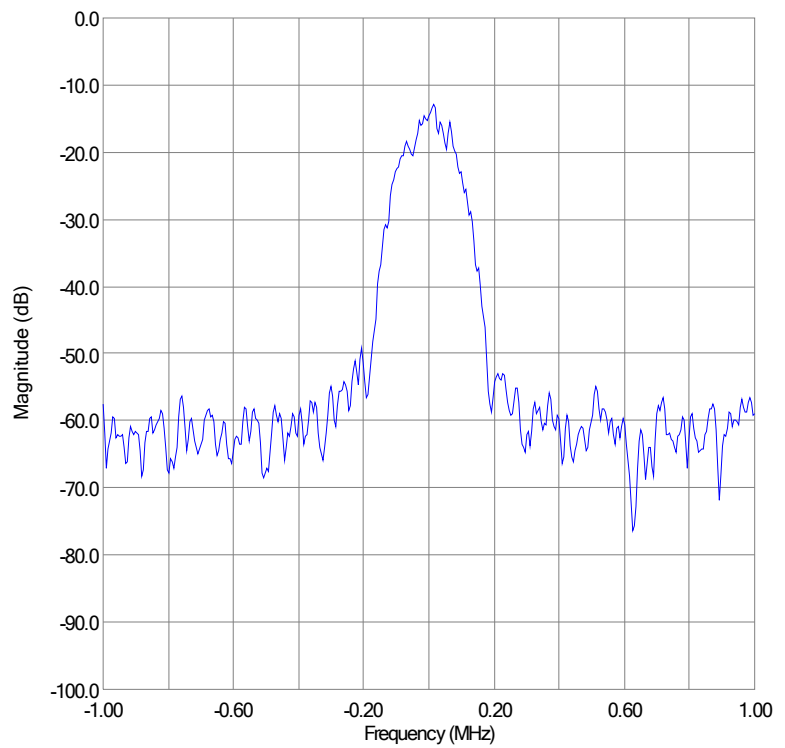


Fig. 8: Spectrum of the section between 220 and 330  $\mu\text{sec}$  of the first timeslot.

To investigate this region further, let's extract the signal between 220 and 300  $\mu\text{sec}$  and from 0.3 to 1.0 MHz. This time we will examine not the spectrum, but the signal as a function of time which is due to this fragment of the time-frequency space. Figure 9 shows the power vs time. Figure 10 is a constellation plot. Both of these plots show the character of the signal for this fragment of the time-frequency space to be quite random. We therefore conclude that the signal intruding onto timeslot 1 and causing the higher value of EVM, is most likely noise.

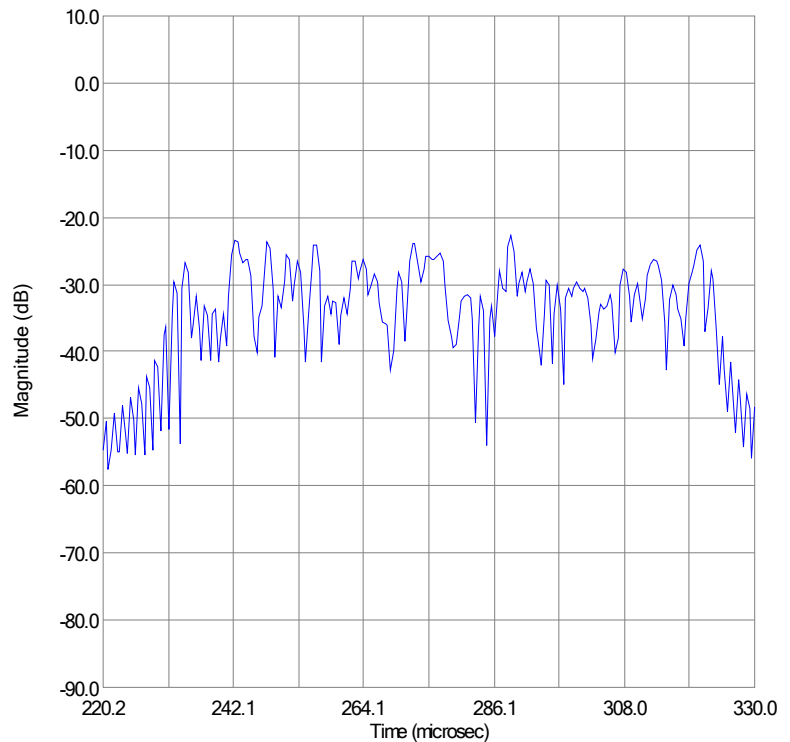


Fig. 9: Power vs Time for the section between 220 and 330  $\mu\text{sec}$  and from 0.3 to 1.0 MHz of the first timeslot.

At this point we have a fairly good working hypothesis of what is causing timeslot 1 to have a much higher EVM value than the other timeslots, namely the presence of noise. We would then proceed to look for the source of the noise. While the use of spectrograms has not solved the problem, it has shown us what to look for.

This example illustrates some of the power of spectrograms. As a display, a spectrogram makes it easy to visualize certain features of signals which are quite hard to observe using other display types. As a workspace, spectrograms make it possible to investigate the characteristics of any fragment of the time-frequency space in the time domain or the frequency domain.

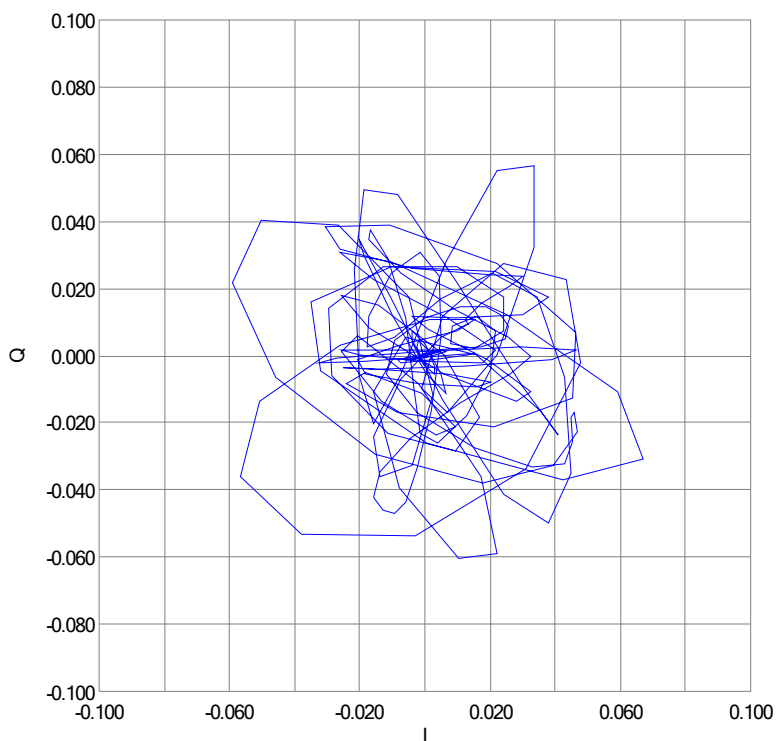


Fig. 10: IQ constellation plot for the section between 220 and 330  $\mu$ sec and from 0.3 to 1.0 MHz of the first timeslot.

For more examples on the use of spectrograms, visit [www.constantwave.com](http://www.constantwave.com).