4.º Congresso do Comité Português da URSI

"Comunicações rádio pessoais: redes de curto alcance e RFID"

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Figuras de Mérito para Sistemas de Radiocomunicações variantes no tempo

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creating and sharing knowledge for telecommunications

Contents

Introduction and motivation

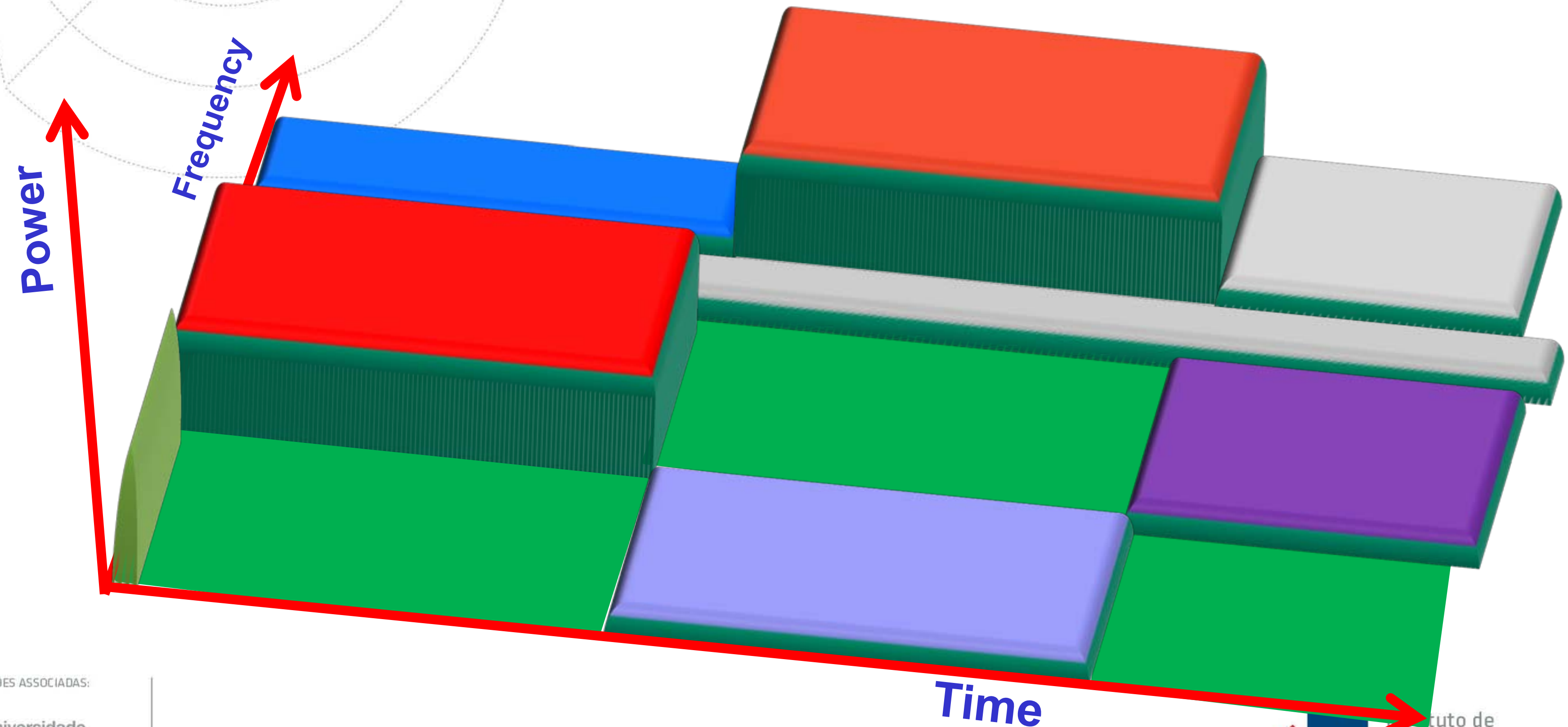
1. Wireless communications systems commonly transmit/receive RF signals **which are time varying**.
2. Most of them are **pulsed or switched**, not only due to power consumption restrictions, but also due to new emerging opportunistic paradigms such as cognitive radio.
3. For instance, the GSM technology is inherently time varying, either for being **TDD (Time Division Duplex)** based, or for using circumstantially **FH (Frequency Hopping)** schemes.
4. In the past, spectrum assignment was technology based, i.e. a predetermined band was allocated to a specific radio service, and all technical parameters, **such as modulation, bandwidth, transmitted power, etc. were very well known in advance**.

Introduction and motivation

- Recent trends on the spectrum policies tend to achieve a more **flexible spectrum usage**, adopting, from the very beginning, the eminent principle of "Technological Neutrality".
- Some radio bands, in the future will allow that the telecommunications **operator can choose, at any time**, the most suitable technology or modulation scheme to assure the provisioning of its service in accordance with the required degree of quality.
- **In the limit, a wide range of transient RF signals easily share the same or adjacent channels**, with a strong potential of interference, arising, for instance, from nonlinear distortion phenomena.

Introduction and motivation

- Future RF systems will strongly depend on cognitive radio, and thus on time varying signals.

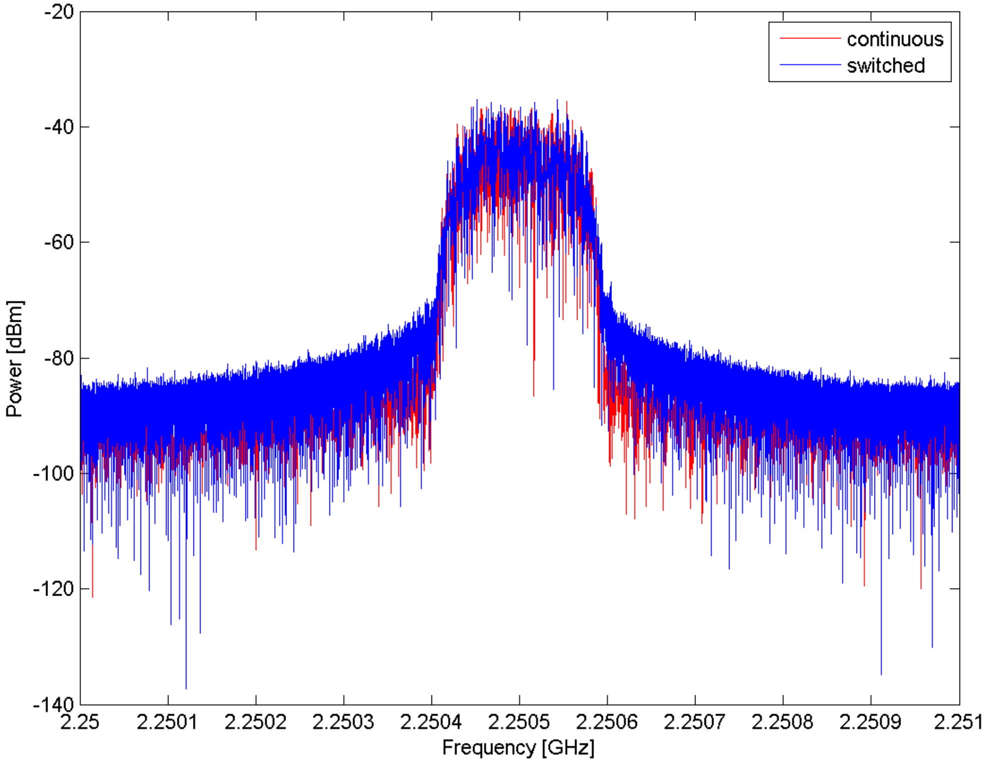


Contents

- Introduction and motivation
- **Analysis of Transient Signal Spectrum**
- Multi-sine Analysis
- Modulated Signals Analysis
- Conclusions

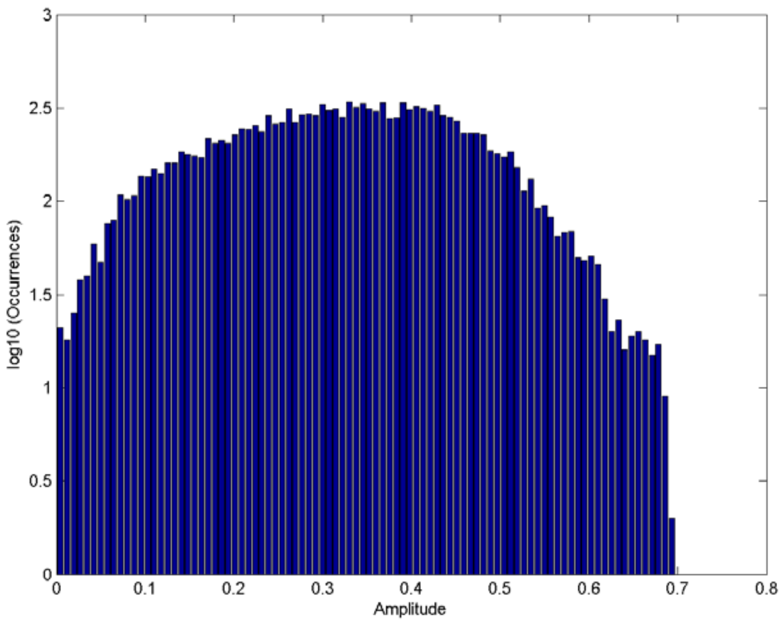
Analysis of Transient Signal Spectra

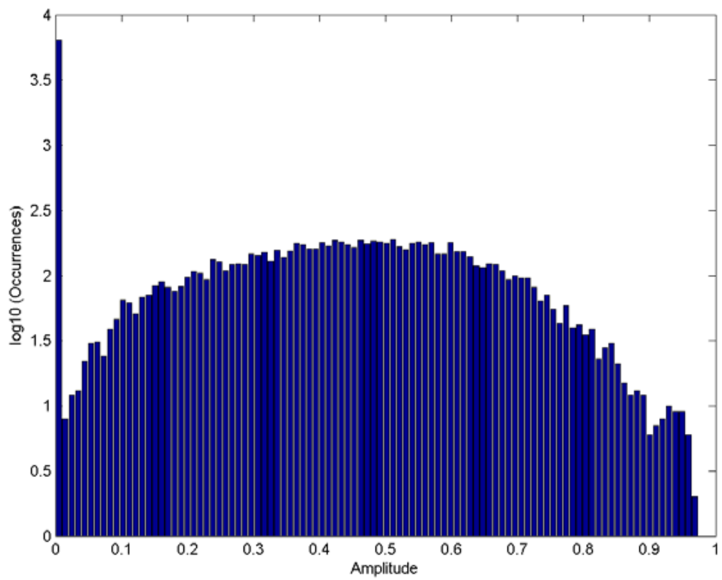
The use of traditional FFT spectra evaluations can lead to misleading results when transient signals are considered, for instance a 256-QAM signal can be:



Analysis of Transient Signal Spectra

The switched signal will impose a statistical pattern that move closely to the low values of amplitude.





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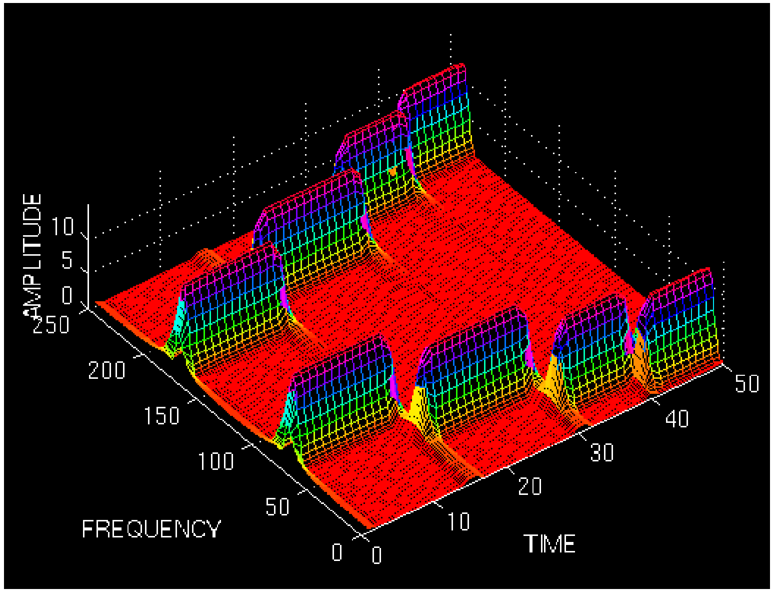
Analysis of Transient Signal Spectra

Transient signal Spectra can be studied not using traditional FFT tools but using more advanced tools as the short time Fourier Transform or Wavelet Transforms:

$$STFT \equiv X(\tau,\omega) = \int_{-\infty}^{\infty} x(t)w(t-\tau)e^{-j\omega t}\,dt$$



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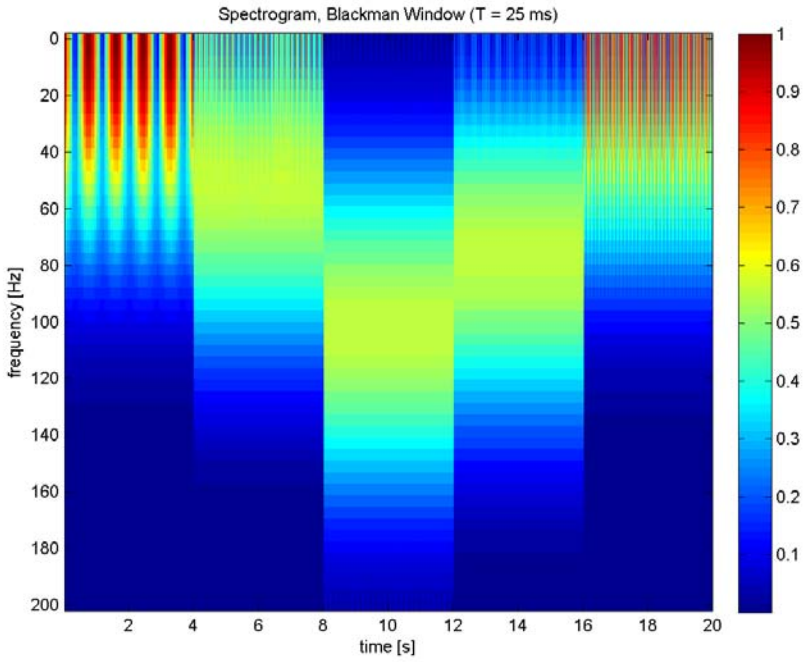
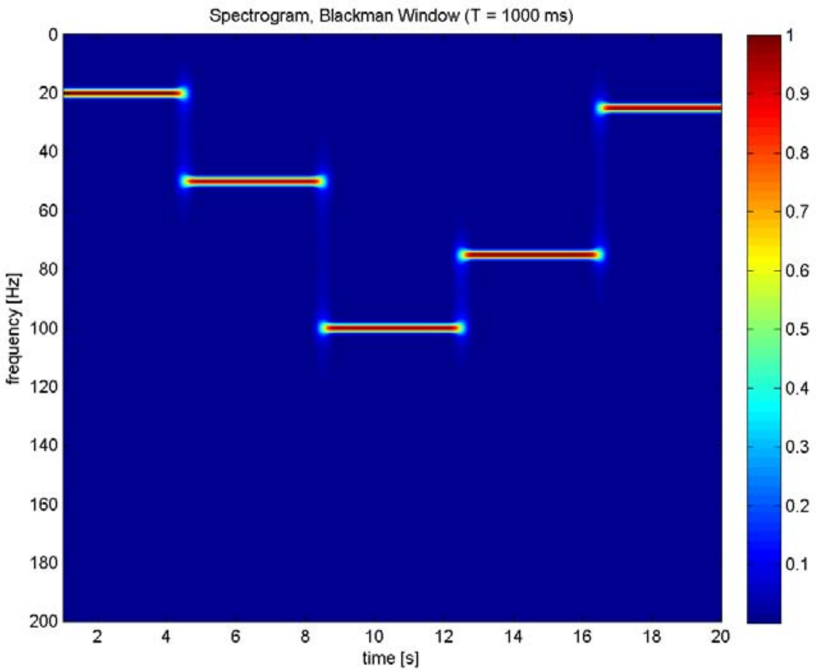
Analysis of Transient Signal Spectra

The selection of the time window is very important:

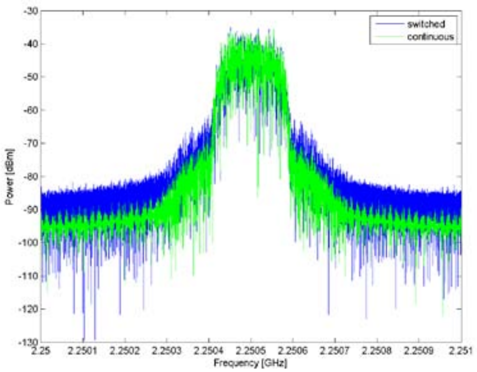




Analysis of Transient Signal Spectra

The proposed figure of merit should now be defined for a certain time window:

$$ACPR = \frac{\int_{\omega_{L_2}}^{\omega_{U_1}} S_{out}(\omega)\, d\omega}{\int_{\omega_{L_1}}^{\omega_{L_2}} S_{out}(\omega)\, d\omega + \int_{\omega_{U_1}}^{\omega_{U_2}} S_{out}(\omega)\, d\omega}$$



$$\Rightarrow ACPR(\tau) = \frac{\int_{T_1}^{T_2} \int_{\omega_{L_2}}^{\omega_{U_1}} S_{out}(\tau,\omega)\, d\omega\, d\tau}{\int_{T_1}^{T_2} \int_{\omega_{L_1}}^{\omega_{L_2}} S_{out}(\tau,\omega)\, d\omega\, d\tau + \int_{T_1}^{T_2} \int_{\omega_{U_1}}^{\omega_{U_2}} S_{out}(\tau,\omega)\, d\omega\, d\tau}$$

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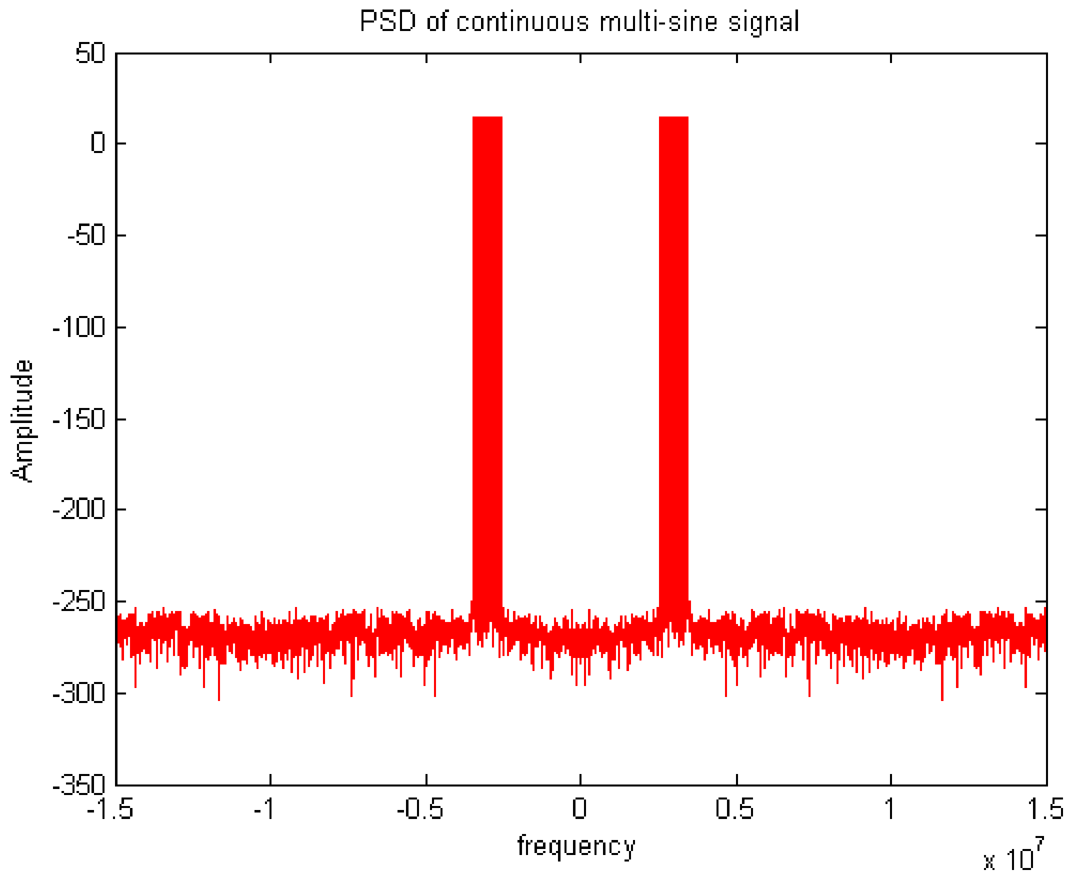
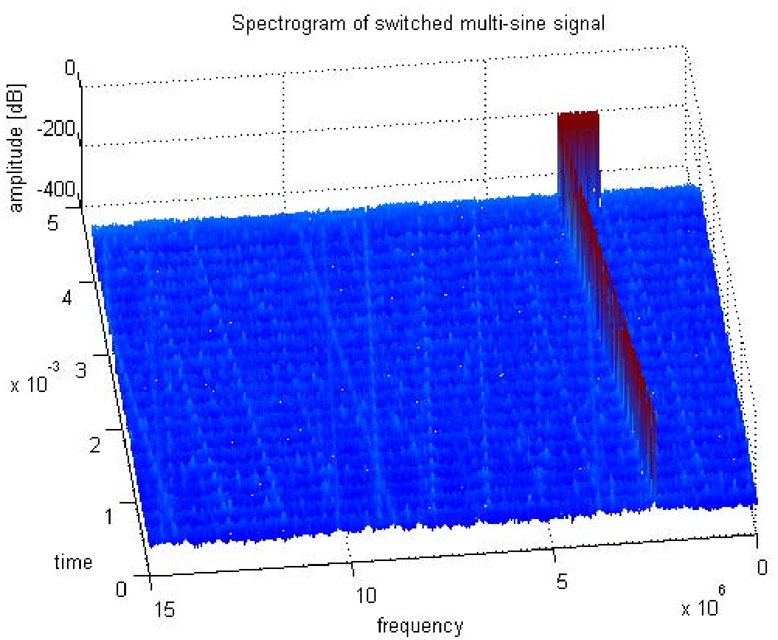
Multi-sine signals

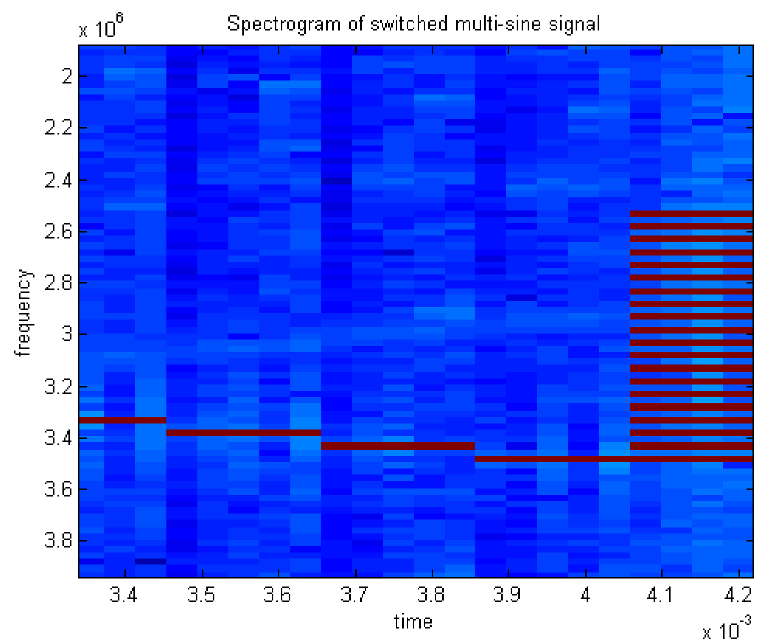
Multi-sine signals will be used in order to understand this analysis.



Multi-sine signals (Input Signal)

The last figure of the multi-sine was actually constructed using a switched one tone signal over the time, that is, the signals is actually a single tone at each time frame:

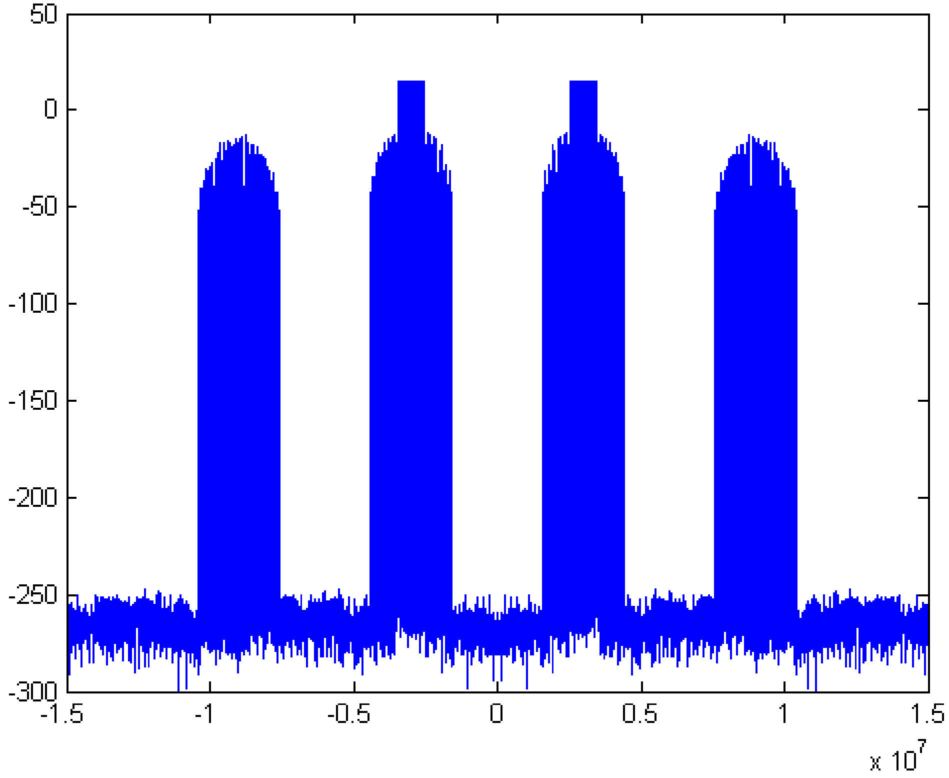




Multi-sine signals (Output Signal after N.L.)

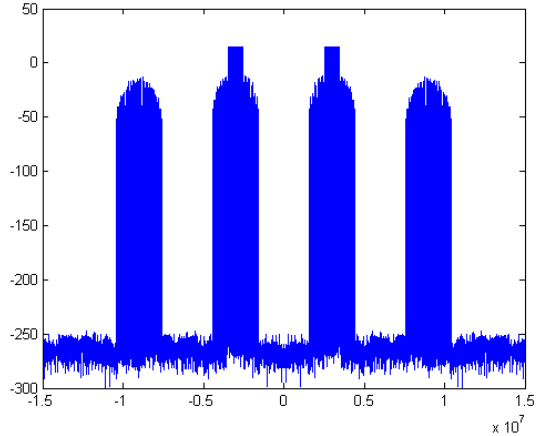
What will happen if we pass this signal through a nonlinearity:

$$y(t) = a_1 x(t) + a_2 x(t)^2 + a_3 x(t)^3$$



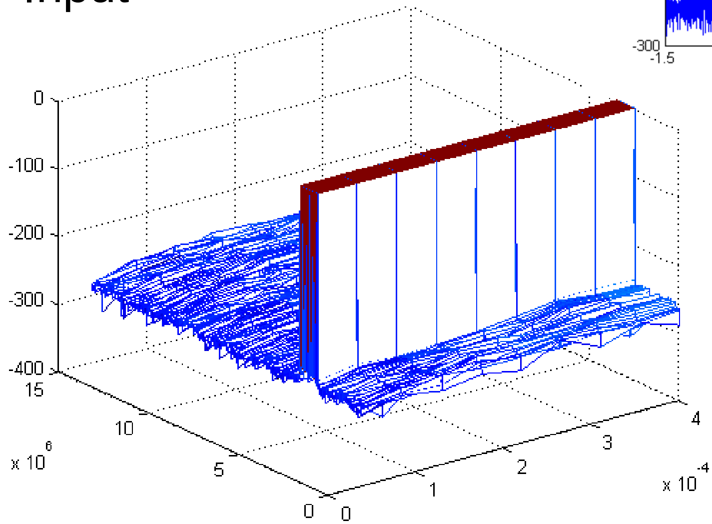
Multi-sine signals (20 tones simultaneously)

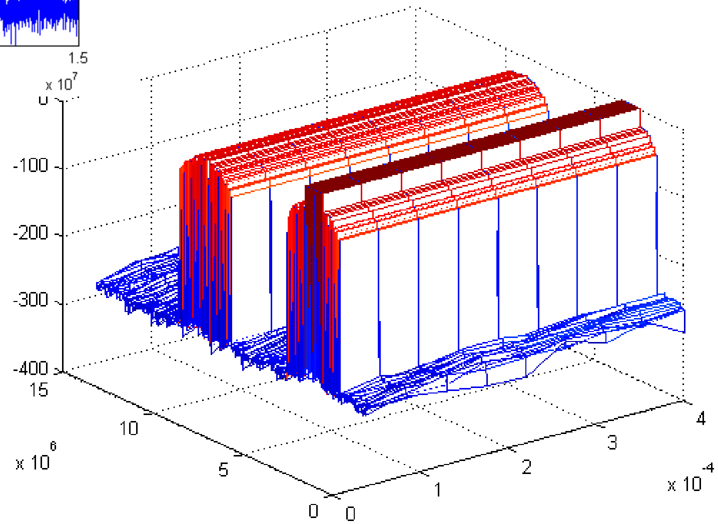
The output spectrogram of a continuous multisine will be:



Output

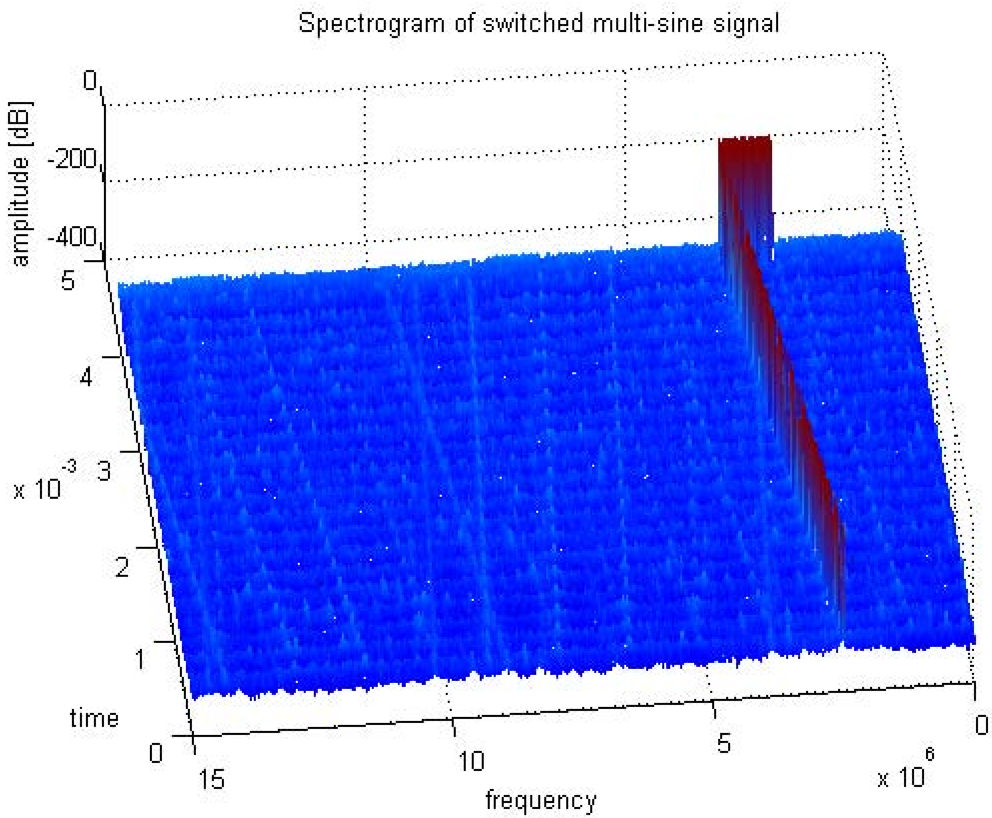
Input





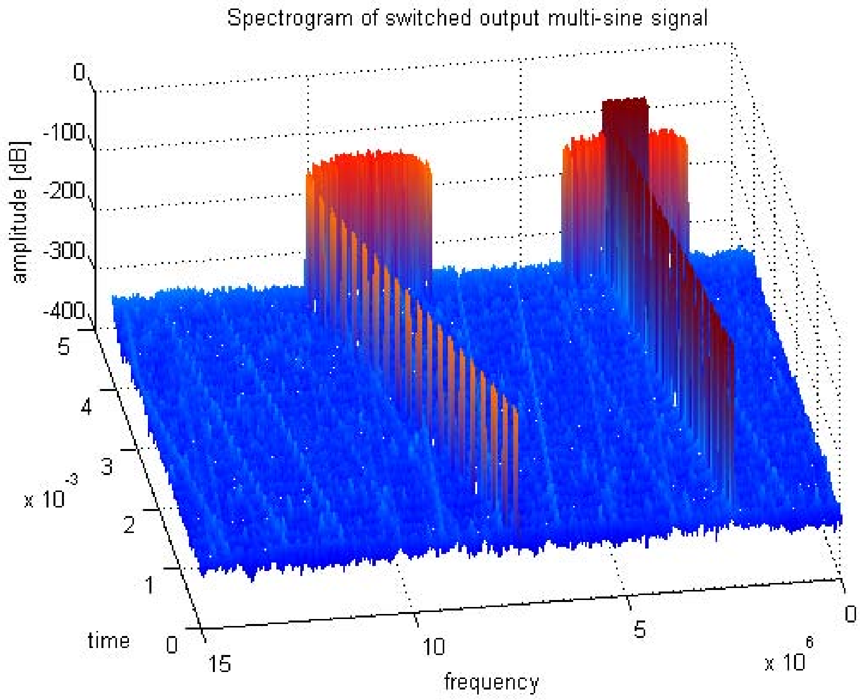
Multi-sine signals (Input Signal)

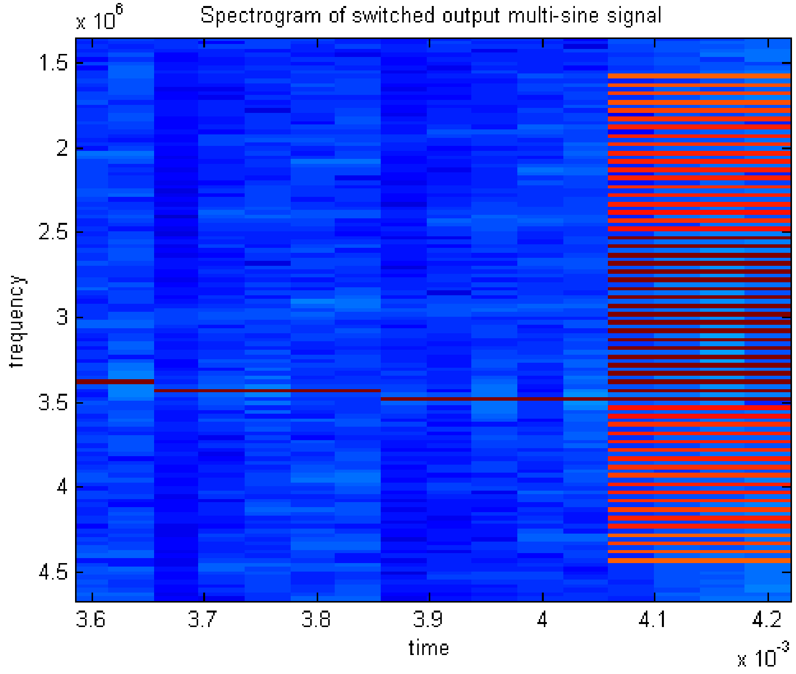
The input signal measured with a traditional SA, when we have a switched multi-sine:



Multi-sine signals (Output Signal)

The output spectrogram will be:





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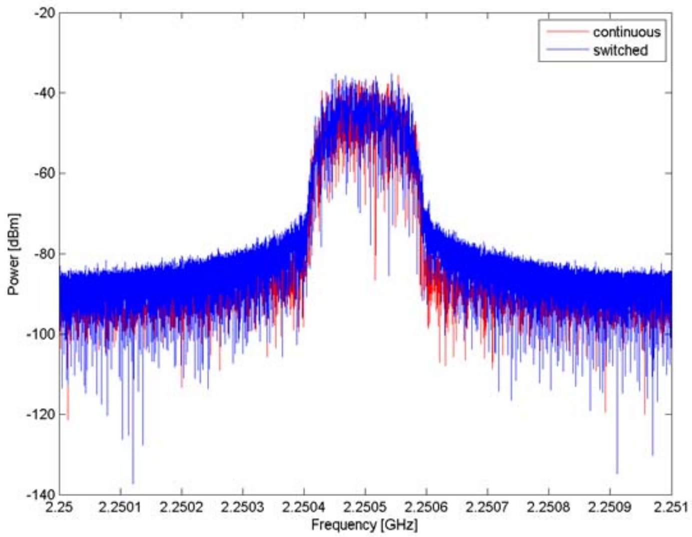
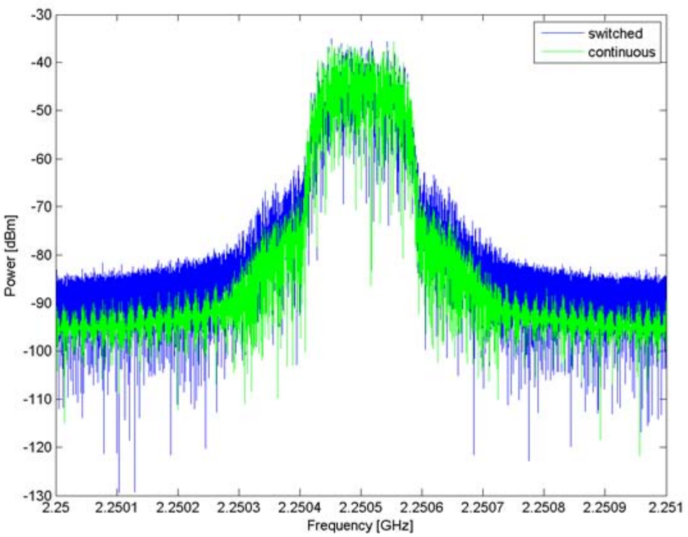
Modulated switched signals

In the QAM (baseband) continuous signal we will have:

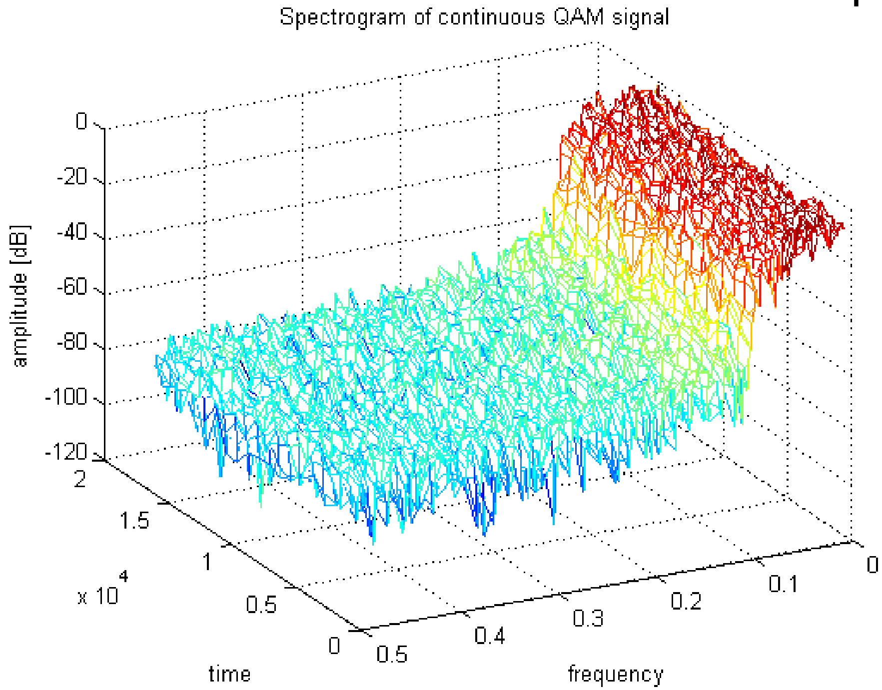


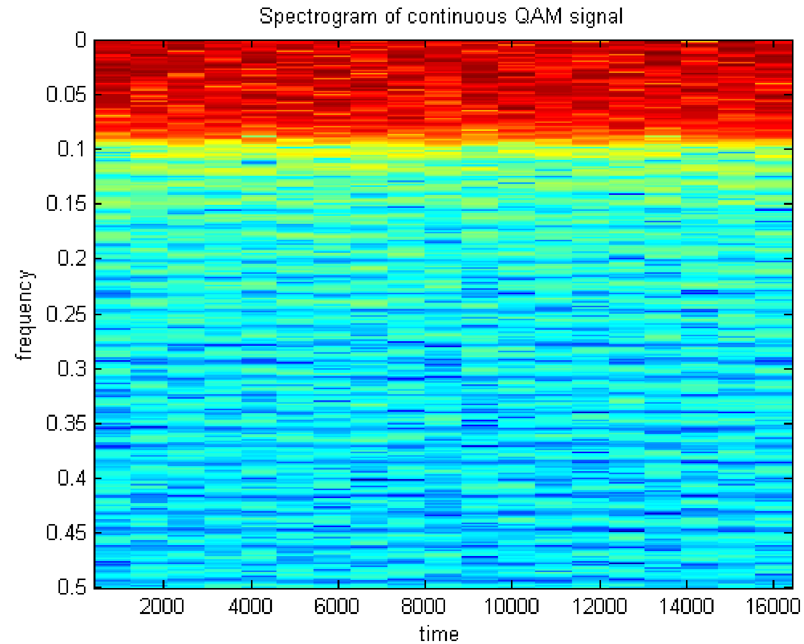


Modulated switched signals (input cont. signal)

In the QAM (baseband) input **continuous** signal we will have:

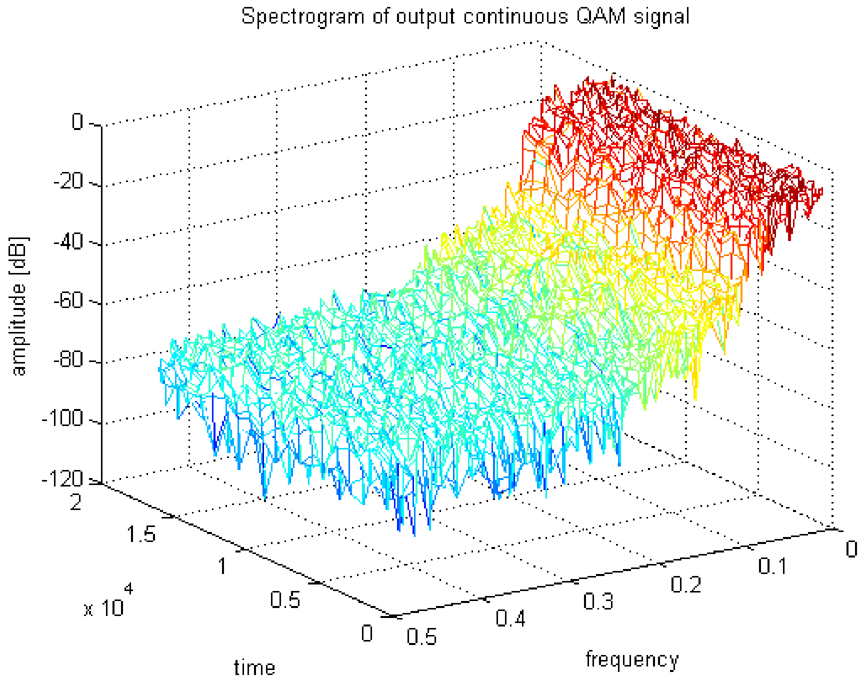
Input

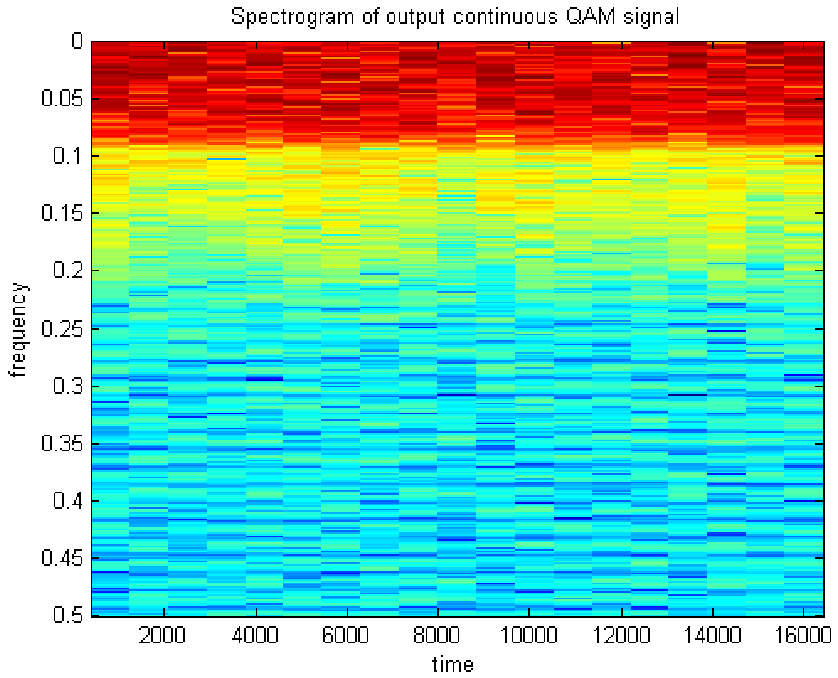




Modulated switched signals (output cont. signal)

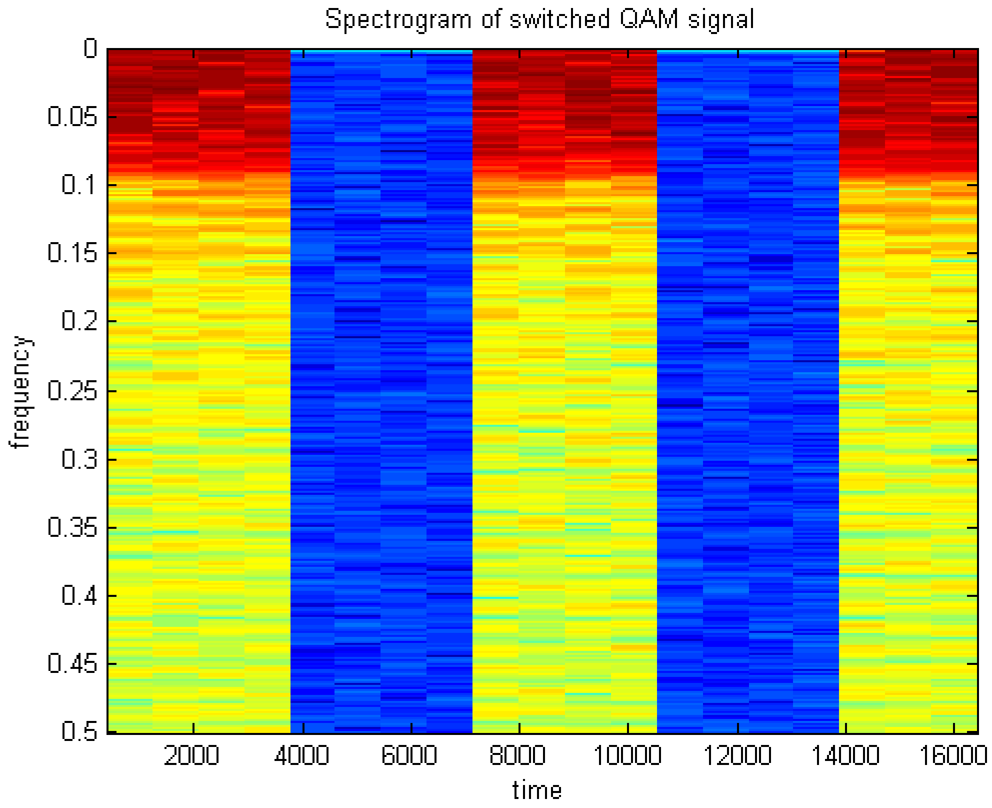
In the QAM (baseband) output continuous signal we will have:





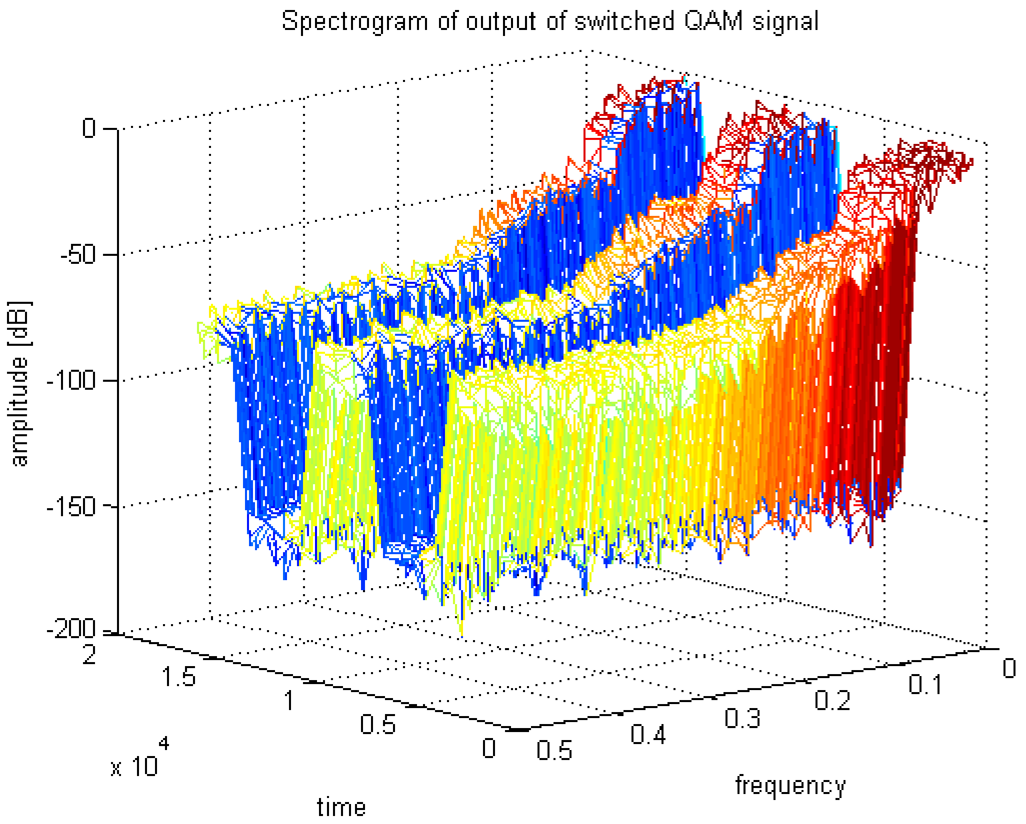
Modulated switched signals (output switched signal)

In the QAM (baseband) switched signal we will have:



Modulated switched signals (output switched signal)

In the QAM (baseband) switched signal we will have:



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Conclusions

1. Figures of merit measured with traditional approaches should be changed for new and time varying signals.
2. Variation in time can trigger other interesting nonlinear phenomena, mainly dynamic ones.
3. New and fast instrumentation are needed for gathering all the information we need from these systems.
4. Spectrum analyzers based on STFT are a demanding and important problem in future measurement instruments.