Application Note
Pulsed EM field with high frequency carrier: how to measure weak r.m.s. signals using a Spectrum Analyser in time domain

Forewords

This application note explains how to perform measurements of pulsed electric fields using an Automatic Spectrum Analyzer (ASA). This technique applies in two particular cases:

- When the oscilloscope does not cover the useful frequency bandwidth,
- When the signal delivered by eoSense is too low to be acquired with an oscilloscope due to noise integration over the whole bandwidth.

This technique is presented here in the case of extracting the signal from a MRI machine but may be used in any other application presenting the same need of measuring a low magnitude electric field using a spectrum analyzer in time domain.

The other applications may be repetitive EMPs, radars.

Experimental setup and ASA parameters

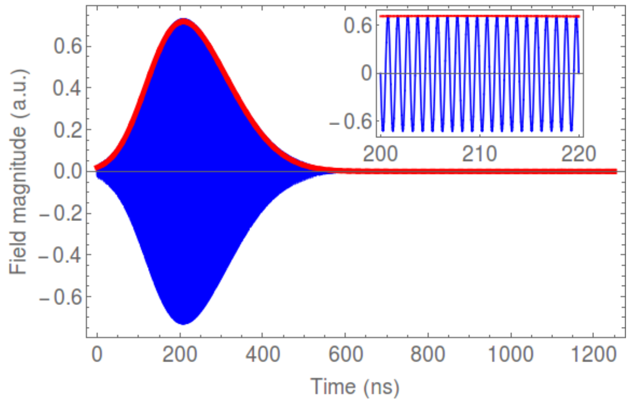
The above picture shows the following elements from left to right:

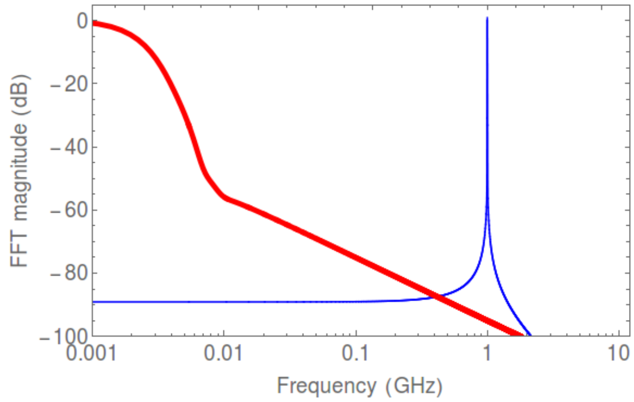
- The signal to be measured
- The electro-optic probe connected to the channel 1 input of eoSense opto-electronic converter
- The eoSense converter (with its laptop) output channel 1 connected via a coaxial cable to an ASA
- An ASA (not sold by Kapteos)

The eoSense delivers an analogue signal which is an image of the field vector component to be measured. This analogue signal is given in real time and include magnitude and phase information over the whole bandwidth of eoSense opto-electronic converter. Thus, the key point is the way to extract and record the useful information using an ASA with the following parameters:

- The **central frequency f_0 [Hz]**: it has to be fixed the carrier frequency f_c
- The **span SP [Hz]**: it should be tuned to zero ("zero span" mode also called "time mode")
- The **resolution bandwidth RBW [Hz]**: its value is crucial; it should be as low as possible to keep a low noise floor while being large enough to contain the spectral (Δf) useful information of the signal
- The **sweep time ST [s]**: it should be in line with the pulse duration (Δt) and repetition rate of the pulses (f_{REP})
- The **trigger level [dBm]** or **[V]**: it has to be adjusted to a fixed value allowing the visualization of the whole pulse (video trigger). Non applicable in case of an external trigger

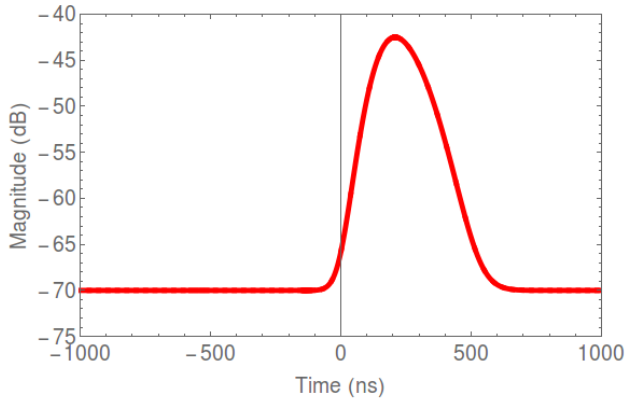
Examples



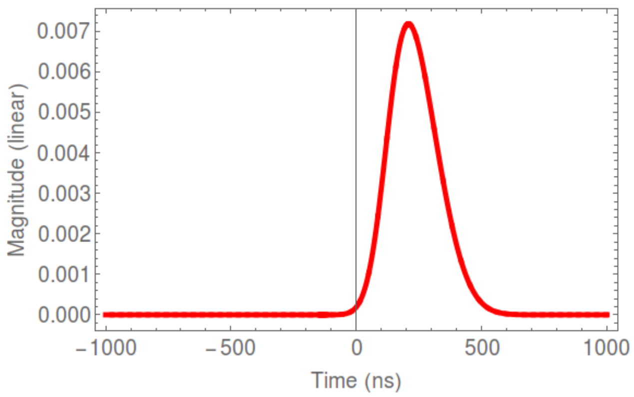


The pulse (red curve) is here asymmetric with a duration of 600 ns. The carrier frequency (blue curve) is f_0 = 1 GHz (period of 1 ns). The temporal evolution of the signal is given above with the associated spectra. A typical measurement using an ASA in frequency domain would lead to the blue curve of the Spectrum. The **zero span mode** could be used to extract shape and magnitude of the pulse envelope using the following parameters:

- Span SP = 0Hz (time domain)
- Carrier frequency f_0 = 1 GHz
- RBW = 10 MHz. RBW >~ Δf ~ 2 MHz (maximum to cover the spectrum bandwidth of the envelop down to -60 dB)
- Sweep time ST = 2 µs >~ 0.6 µs (to get the whole pulse)



Signal visualized on the Spectrum (log. scale)



Pulse extracted from the Spectrum (lin. scale)

The extracted pulse is usually expressed in **Volt** and has to be multiplied by the antenna factor to retrieve the temporal evolution of the rms electric field.

To keep in mind:

- $f_0 = f_c$
- SP = 0
- RBW >~ Δf
- Δt ~< ST < $1/F_{REP}$