New Methods In Vibration Analysis

accelerometer data and ”sunics”

presented by

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compiled by

Diego Tognola, Sunics

VANZ 2006

sunics

Part I

Sunics in General

What is a sunic ?

- a new way of looking at time series / signals
- re–arranges but preserves time waveform data
- visualizes data via a coloured bitmap
- produces representation as compact as spectrum

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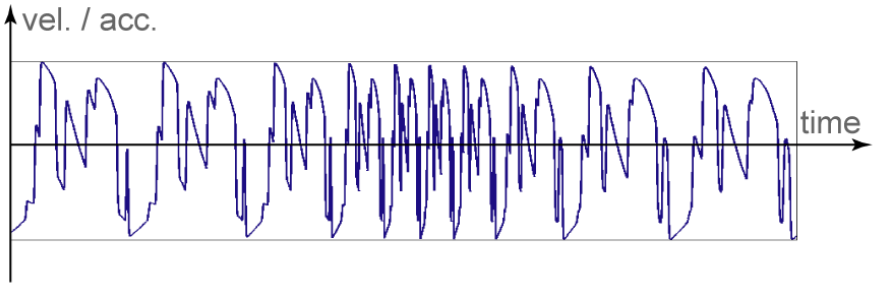

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cycles are stretched to equal length → *wave shapes*

wave shapes are arranged to ”waterfall diagram”

waterfall is connected and colour coded

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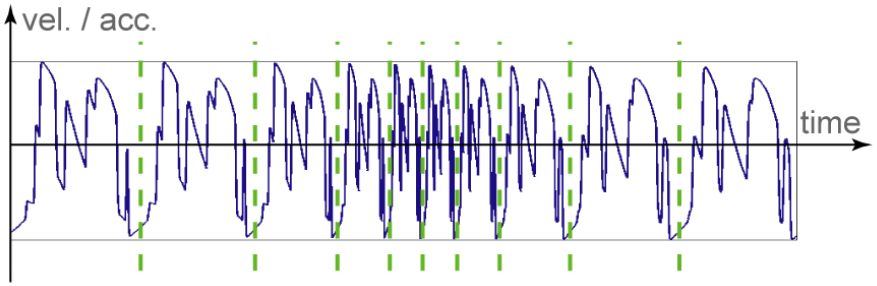

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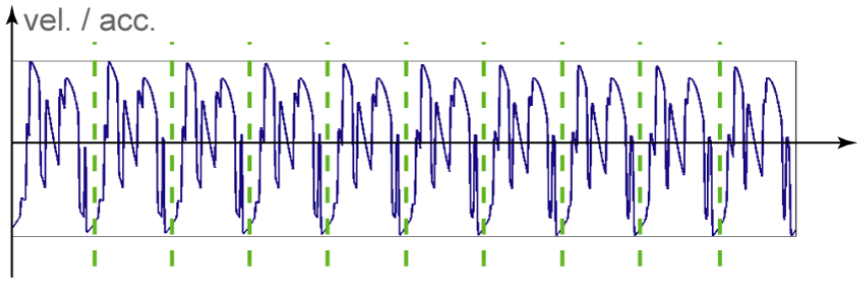

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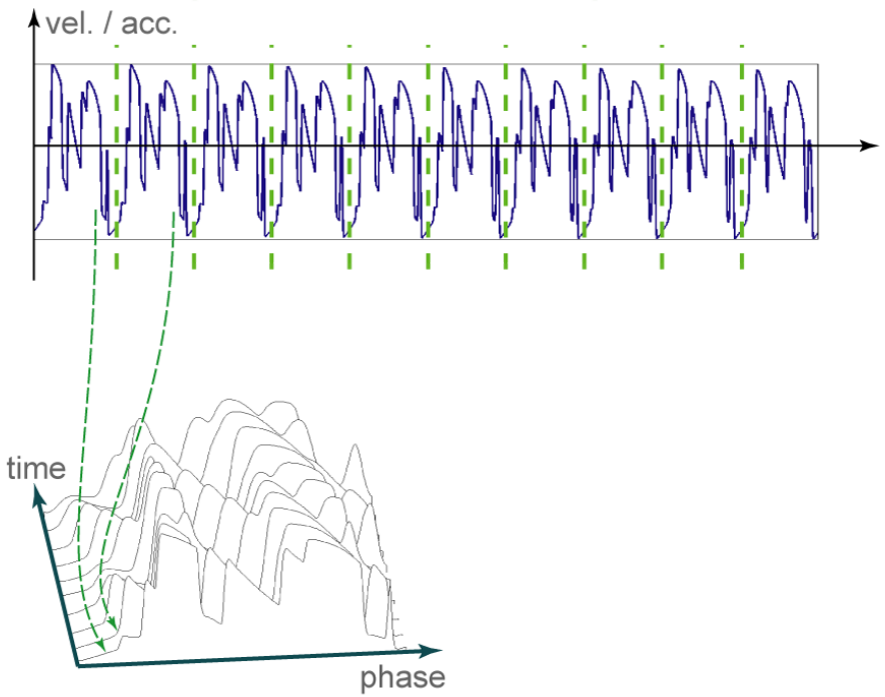

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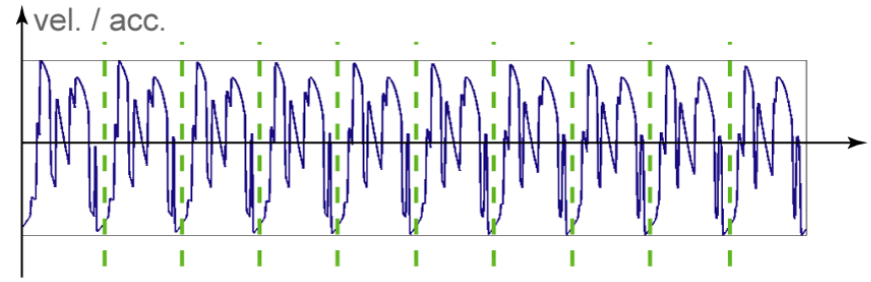

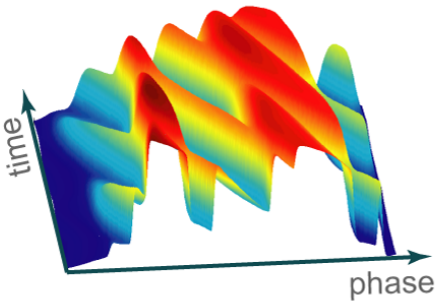

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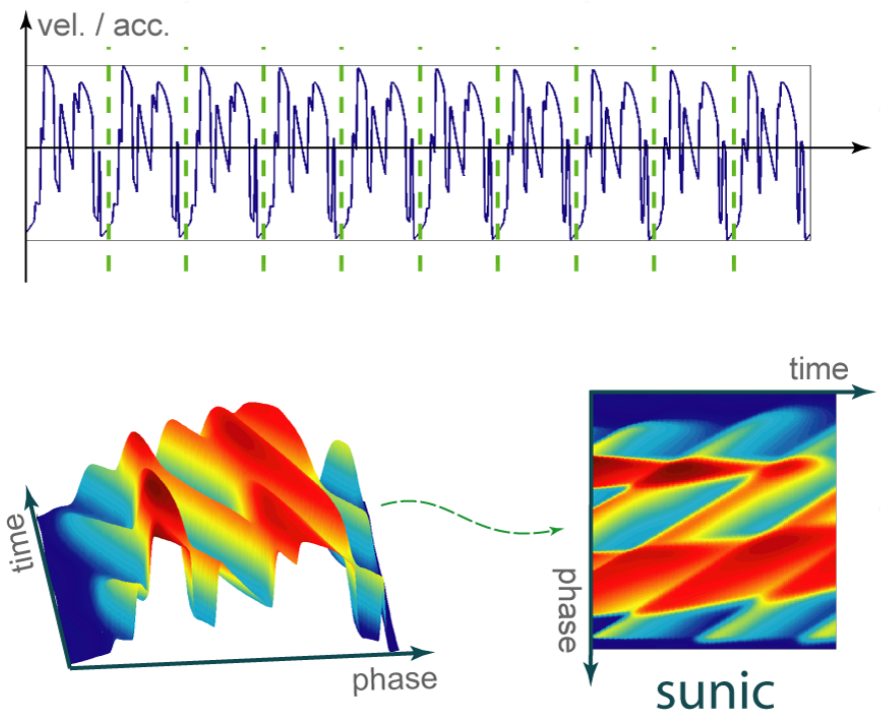

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- in time direction: evolution of wave shape, amplitude envelope
- colour values: amplitude, e.g. acceleration or velocity
- combined: location of phenomena in time and phase

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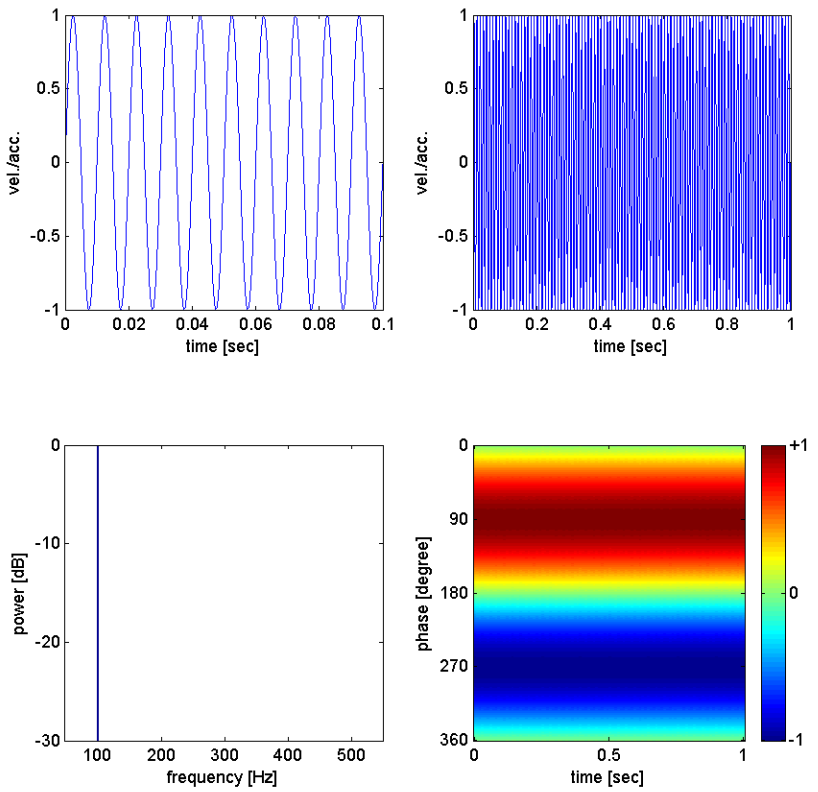
So let's look at some examples...

Sine Wave



Each ”image column” of the sunic has the same colouring.

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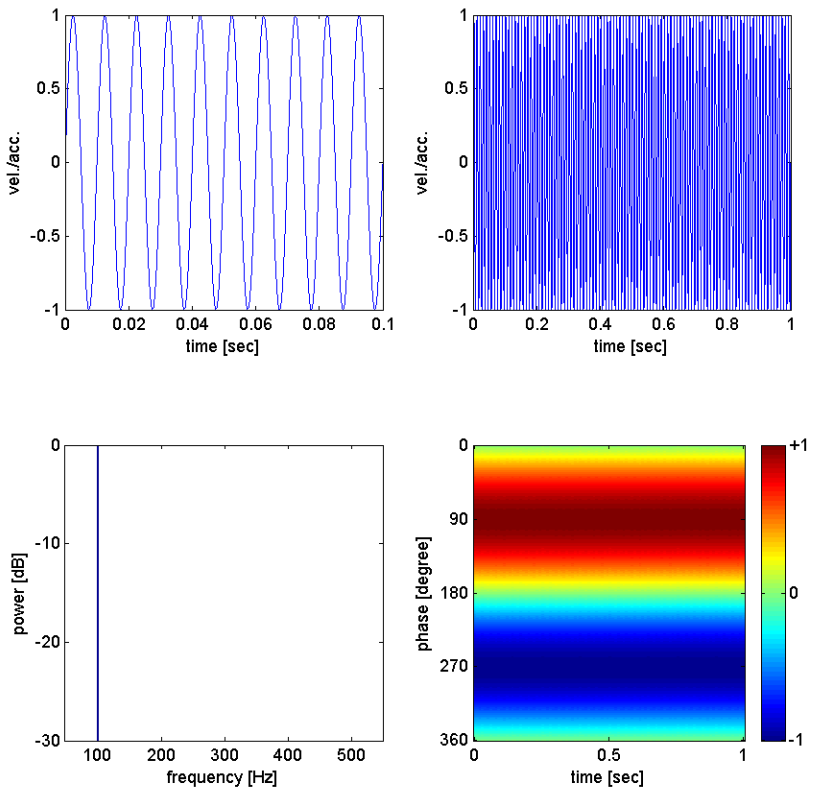

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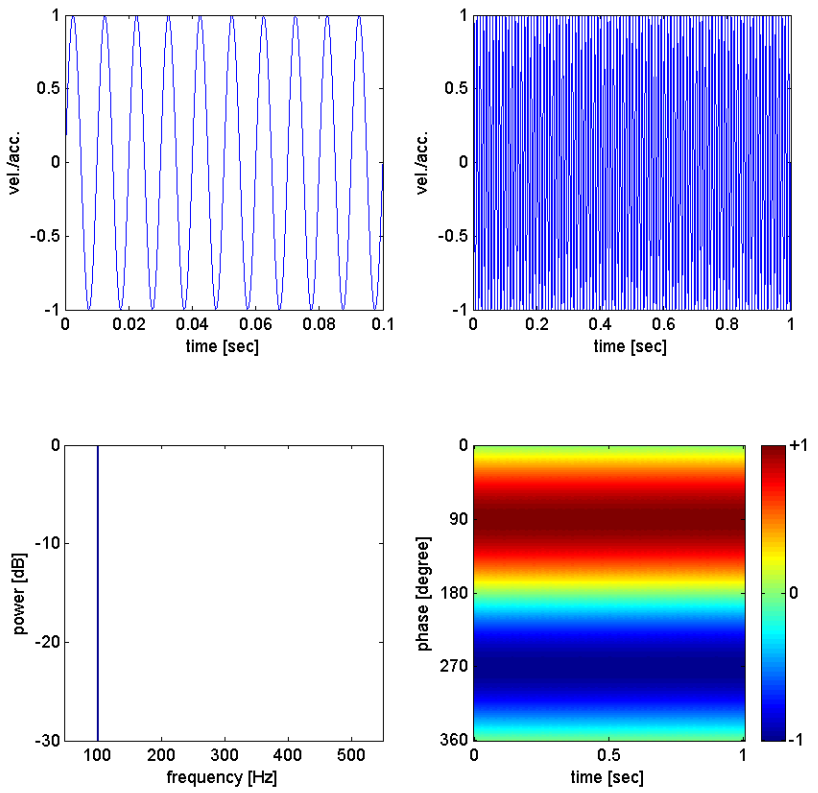

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This wave shape is constant for all times.

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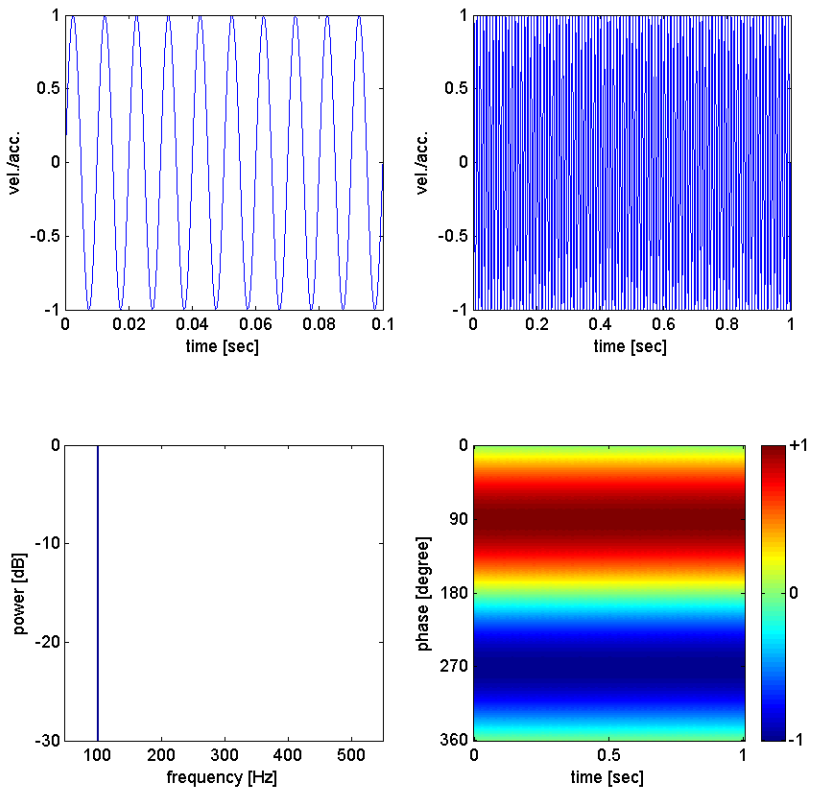

Each ”image column” of the sunic has the same colouring.

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The next example features a different wave shape...

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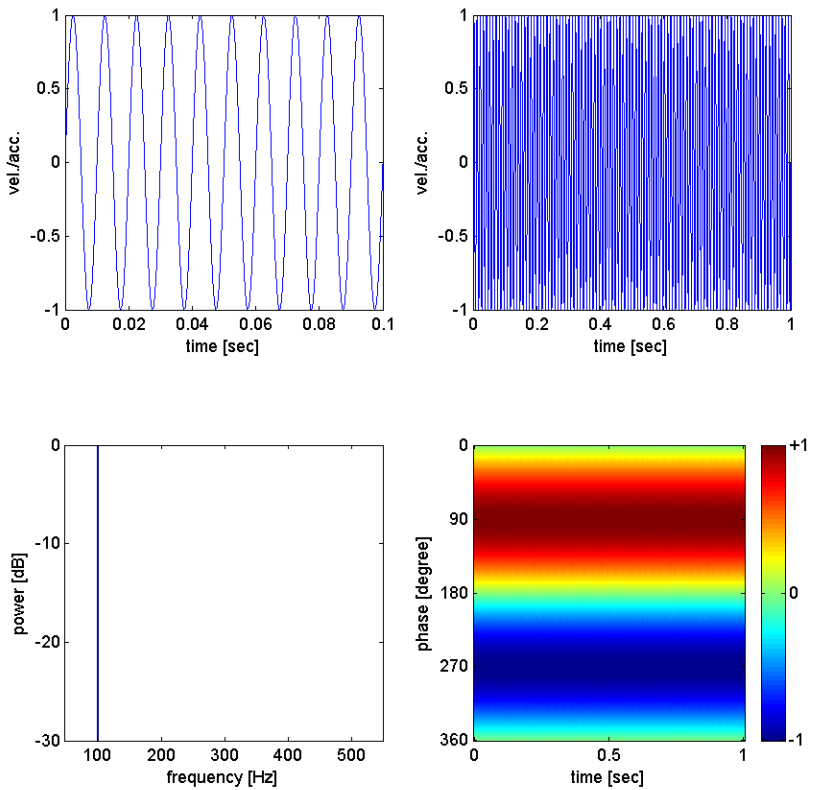
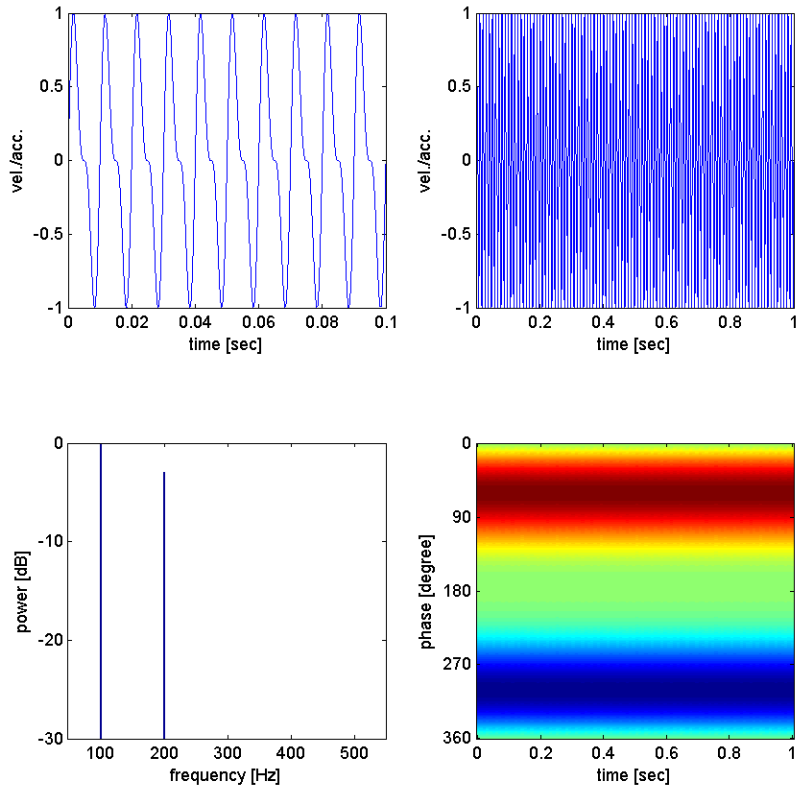


Two Synchronous Components I



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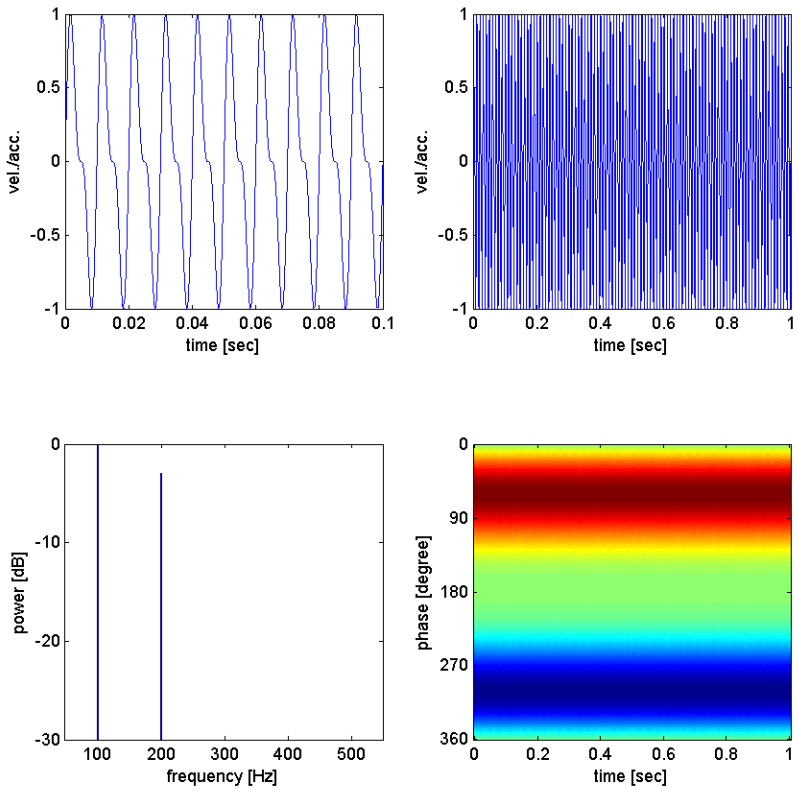

zero phase difference

Again, the wave shape is constant over time.

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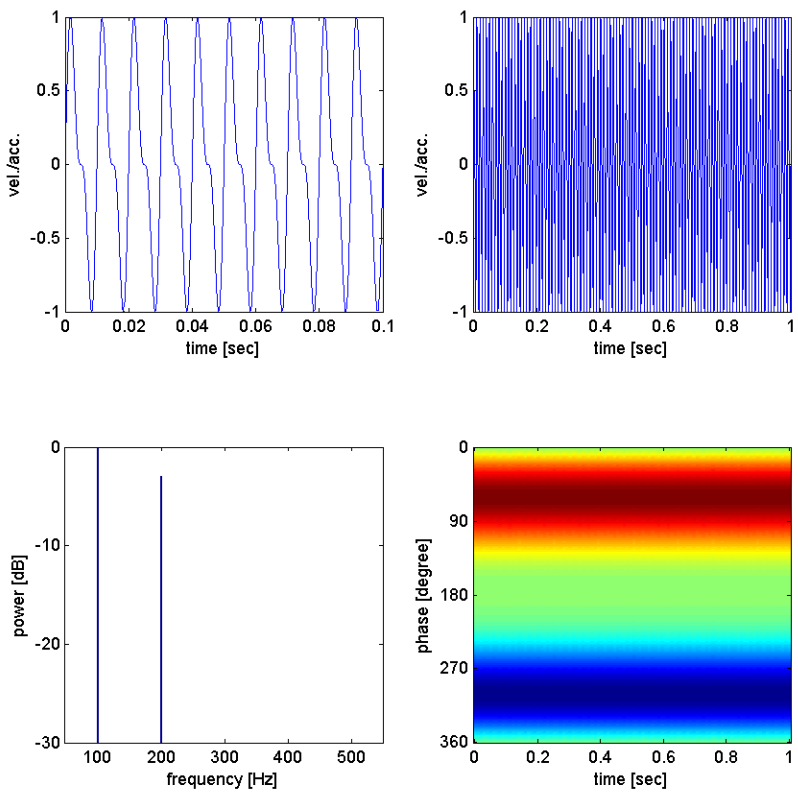

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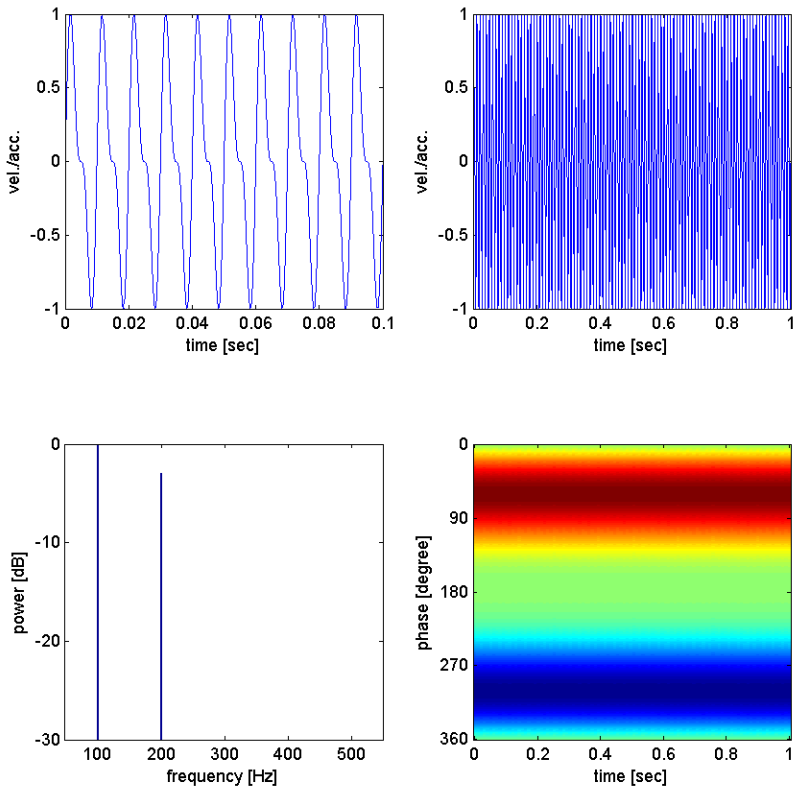

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What happens if the
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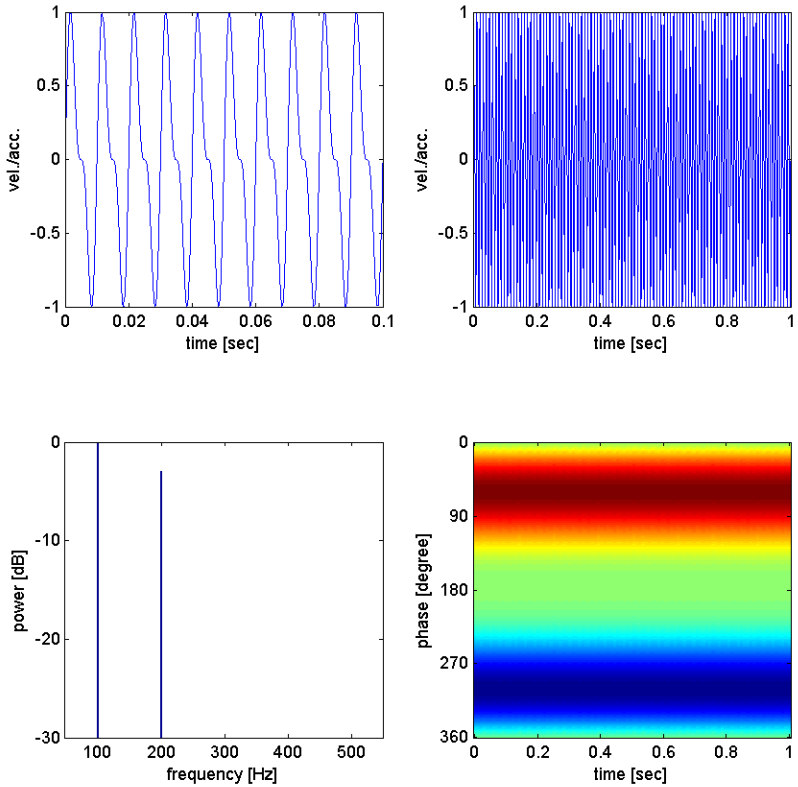
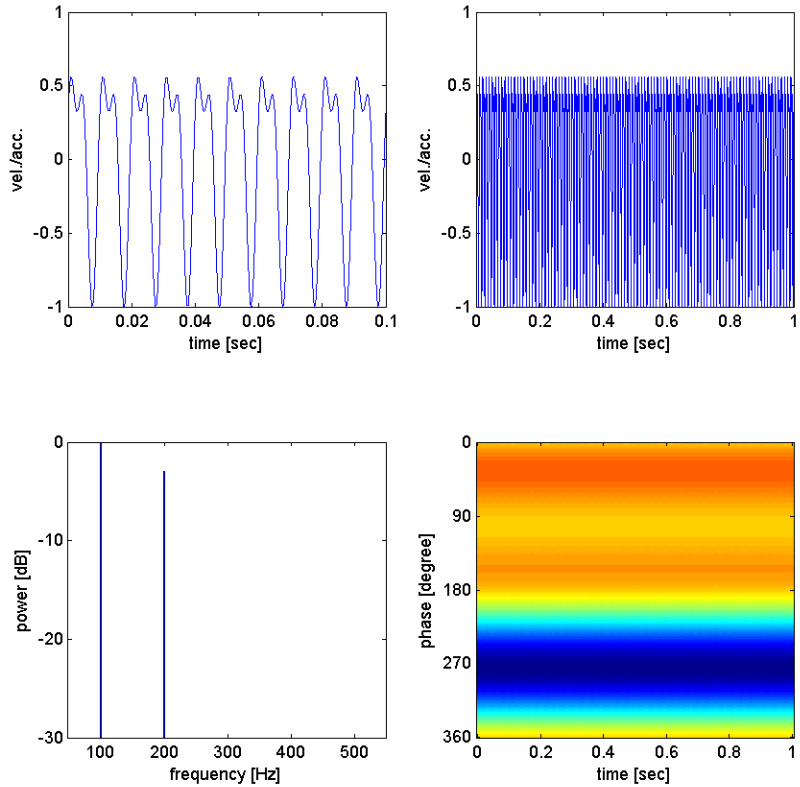


zero phase difference

Two Synchronous Components II



non–zero phase difference

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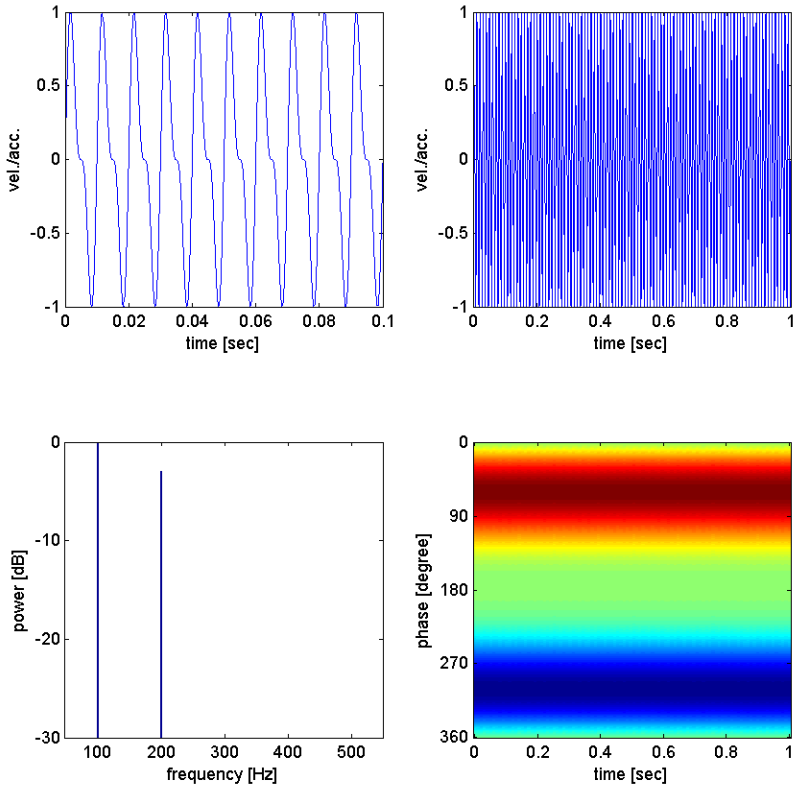

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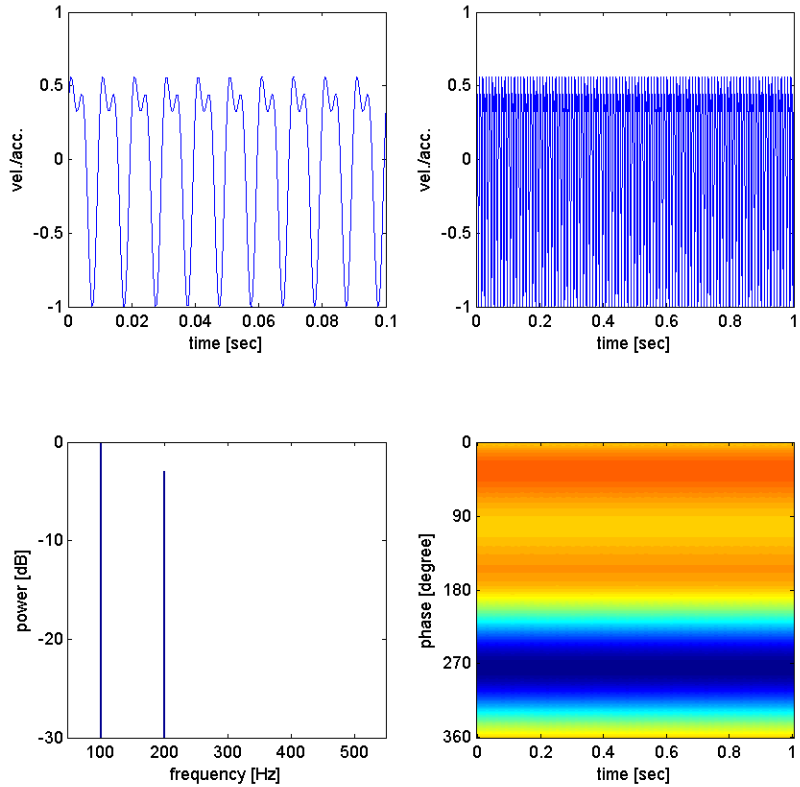

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Time waveform and sunic show a difference.

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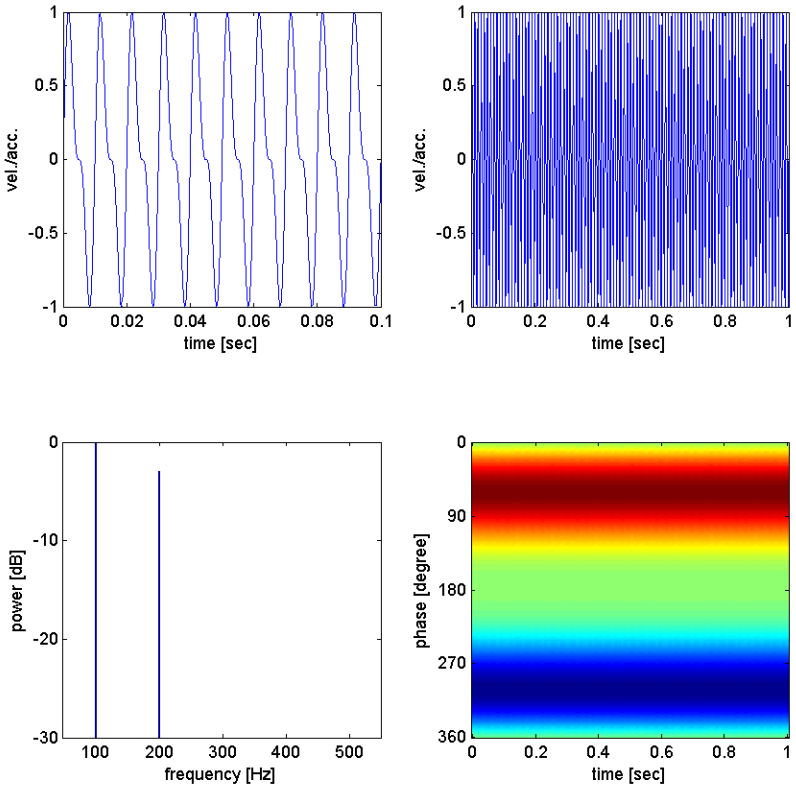

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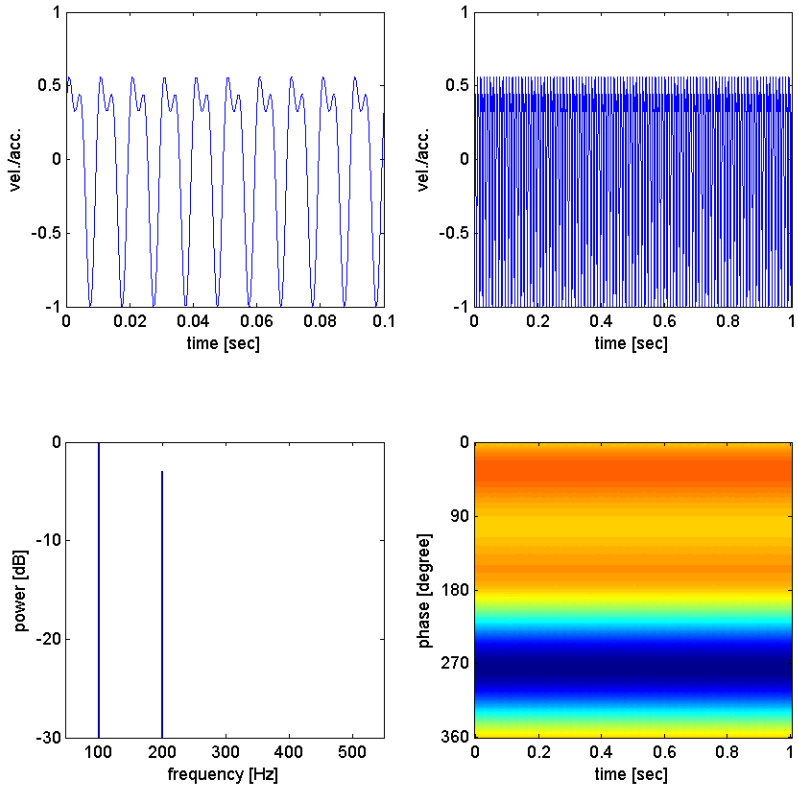

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The spectrum shows no difference.

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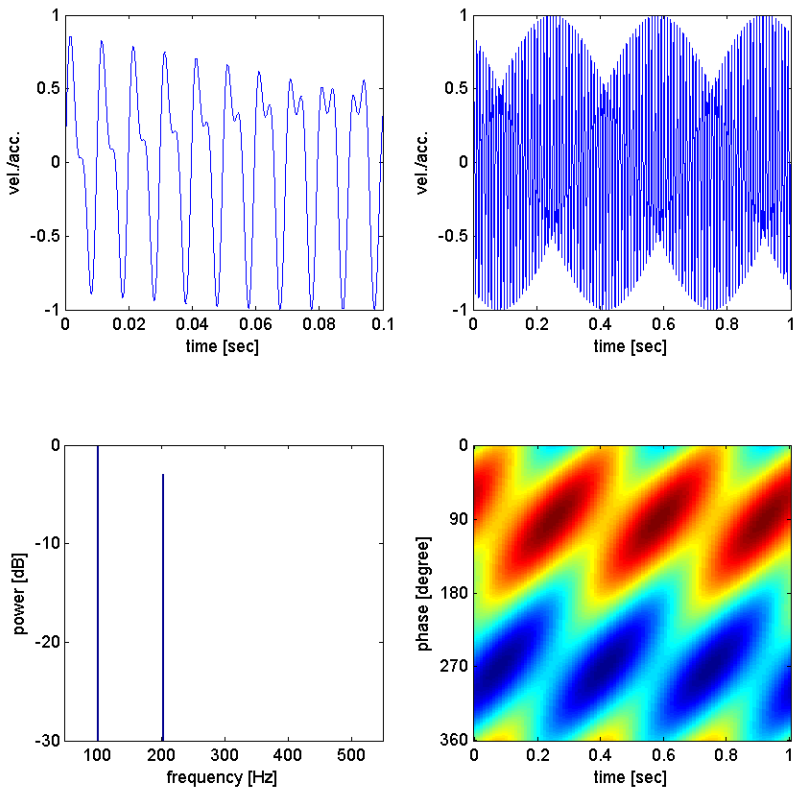

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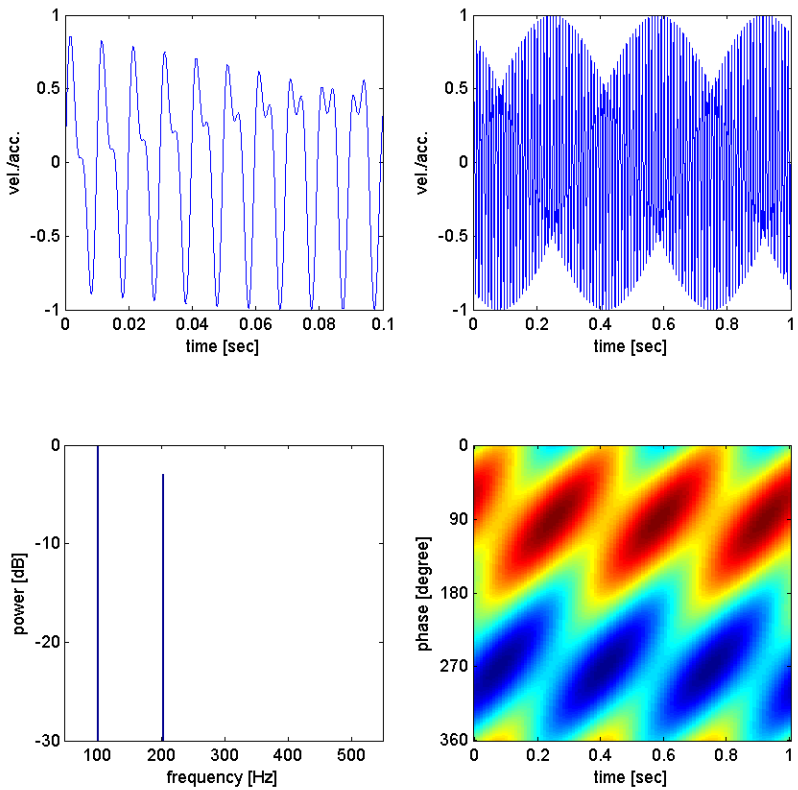

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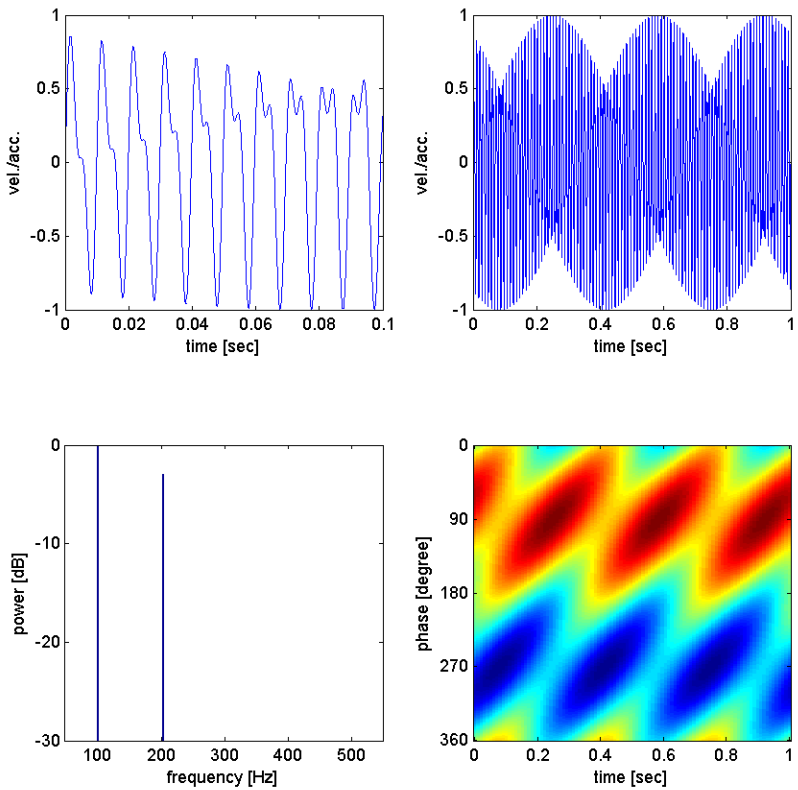

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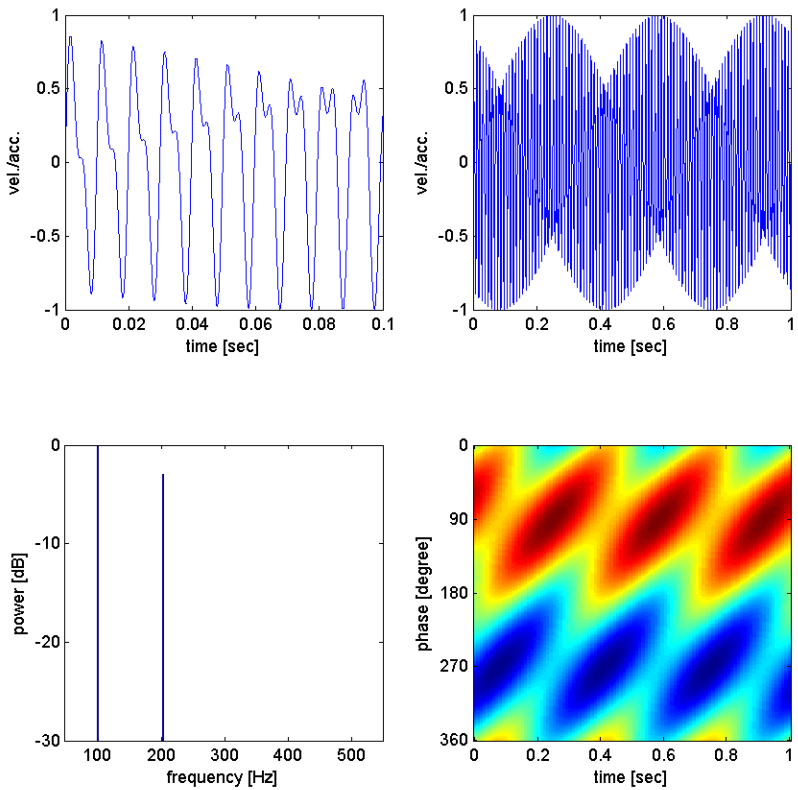

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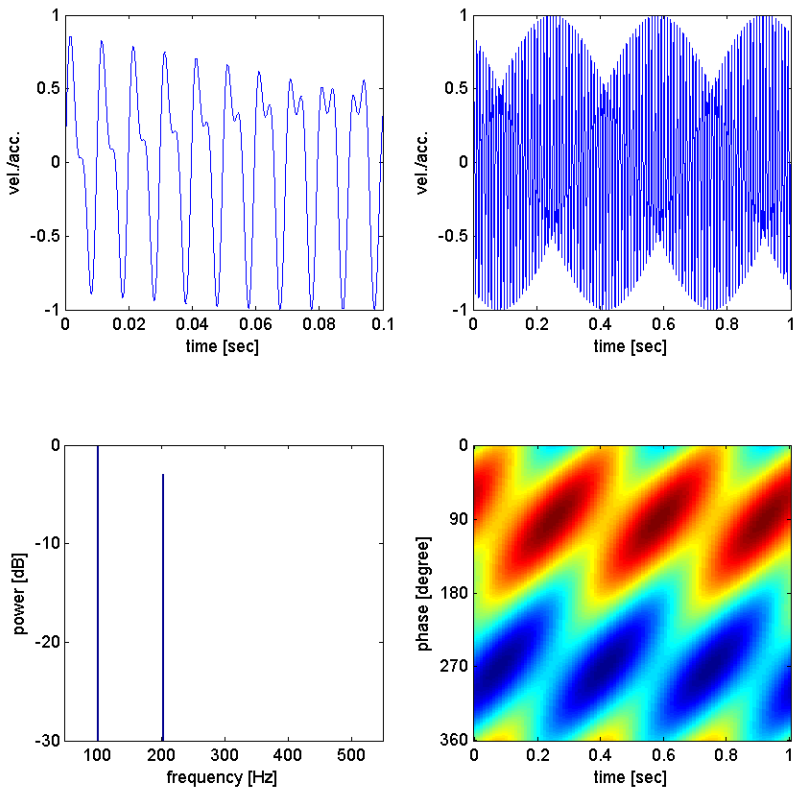

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But it is more difficult to see in the time waveform

and impossible to see in the spectrum.

So what can sunics reveal in vibration analysis ?

Part II

Sunics in Vibration Analysis

Applications in Vibration Analysis ?

- recognition of phase–related changes (e.g. rotating machinery)
- efficient time waveform analysis (no zooming or scrolling required)
- detection of slow changes (low frequency components)
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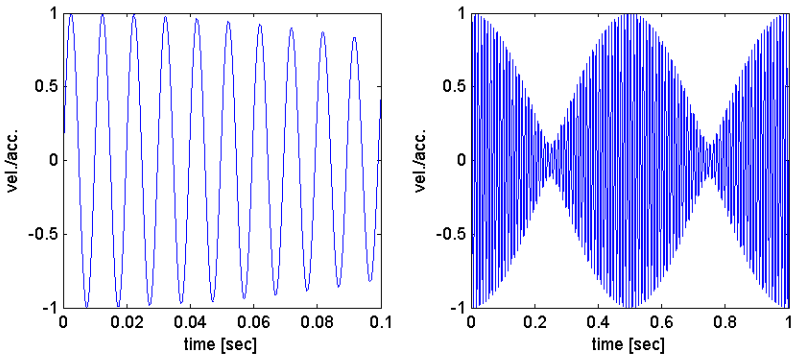
Let's go back to examples...

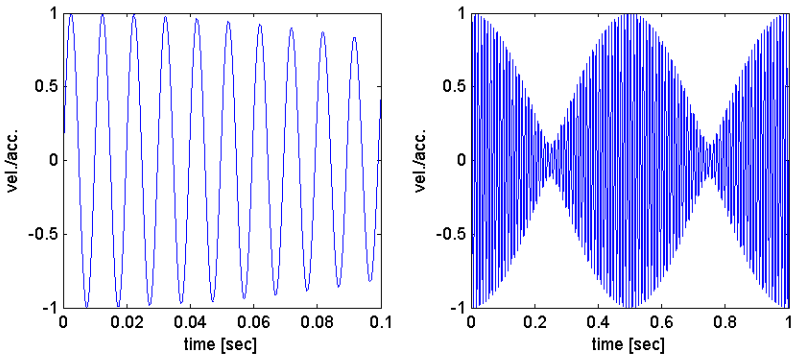
Beating



(2Hz beating frequency)

The sunic features:

Beating



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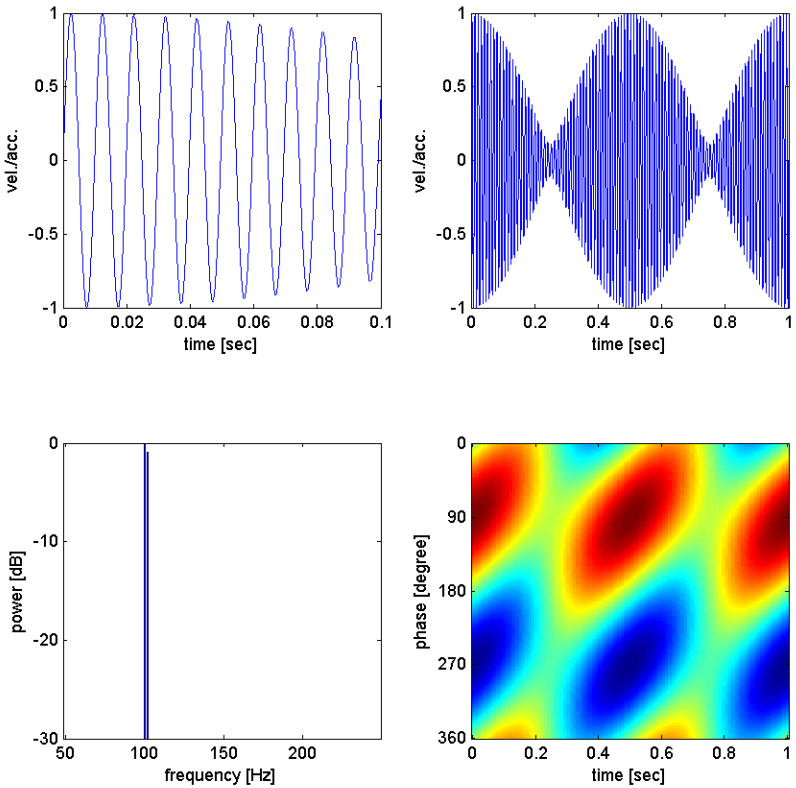

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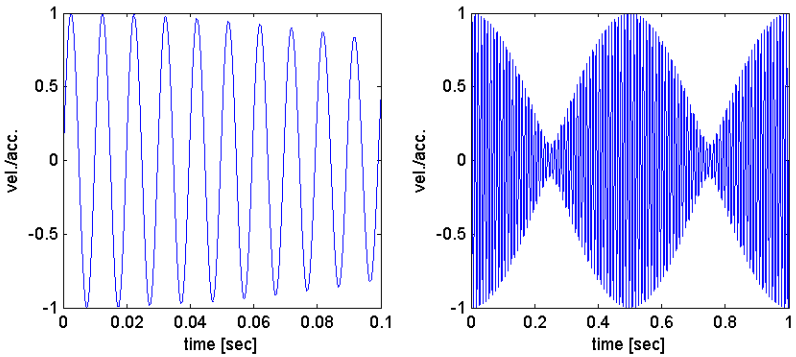

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The sunic features:

- variation in colour range showing amplitude envelope
- diagonal pattern implying asynchronous components
- two repetitions corresponding to 2Hz beating frequency.

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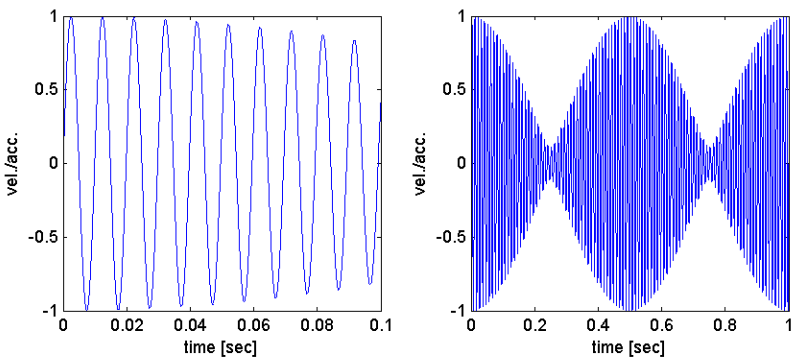

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Compare this to the following amplitude modulation:

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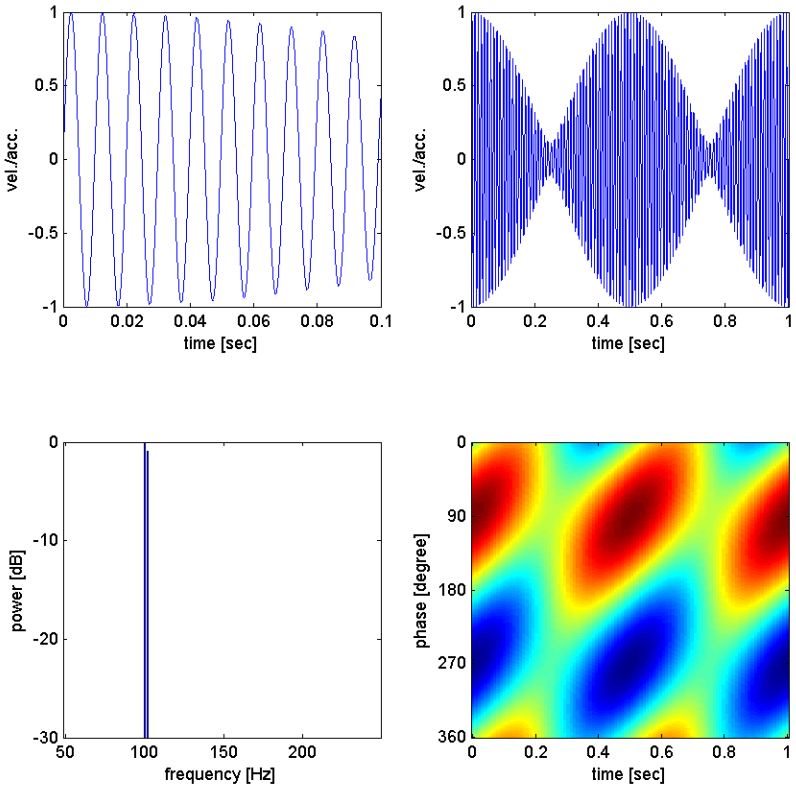
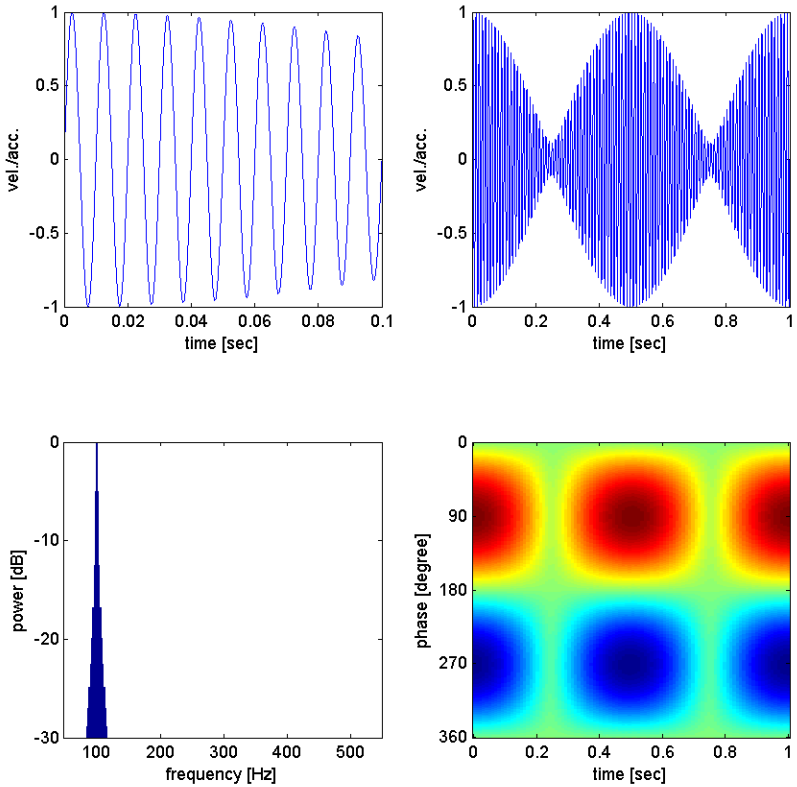


Amplitude Modulation



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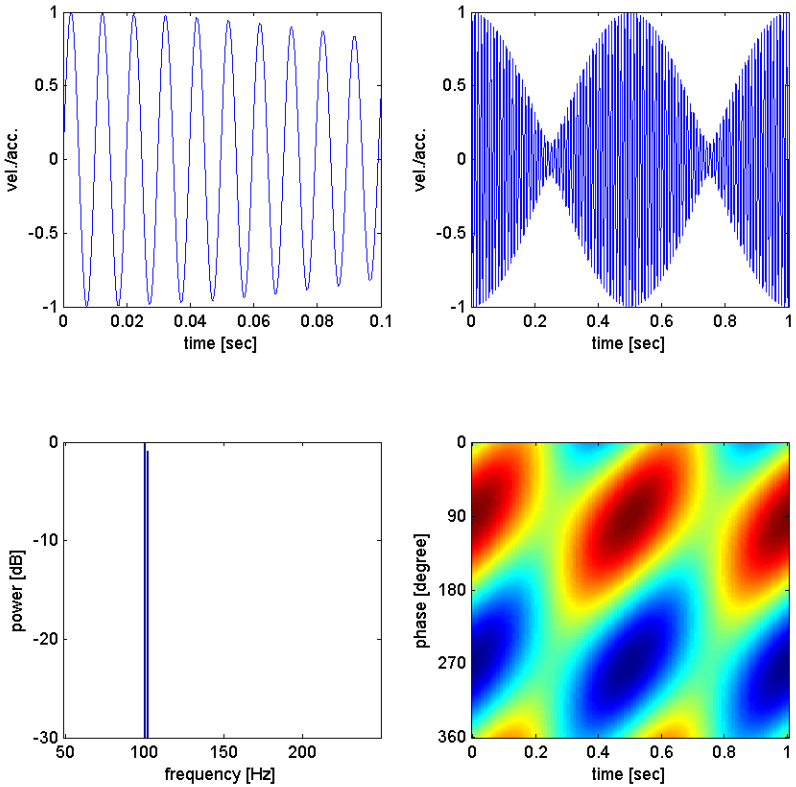

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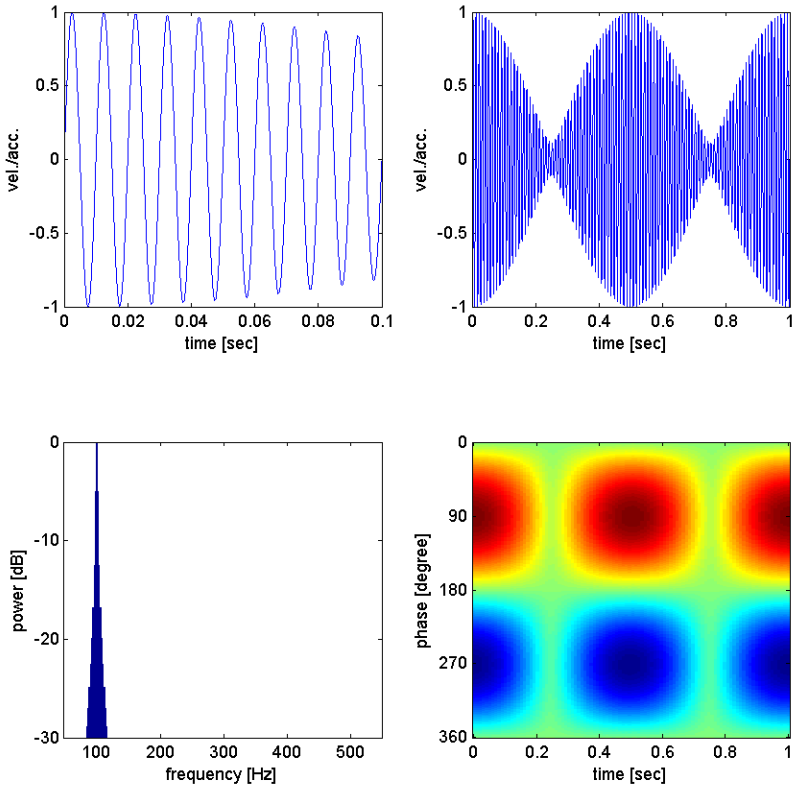
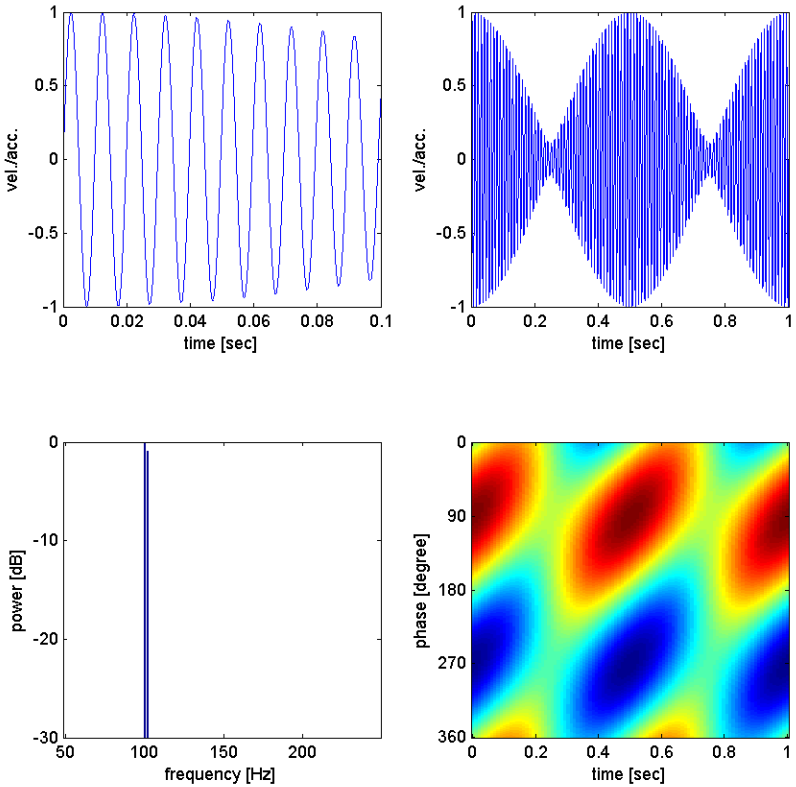


The time waveform shows little difference.

Beating



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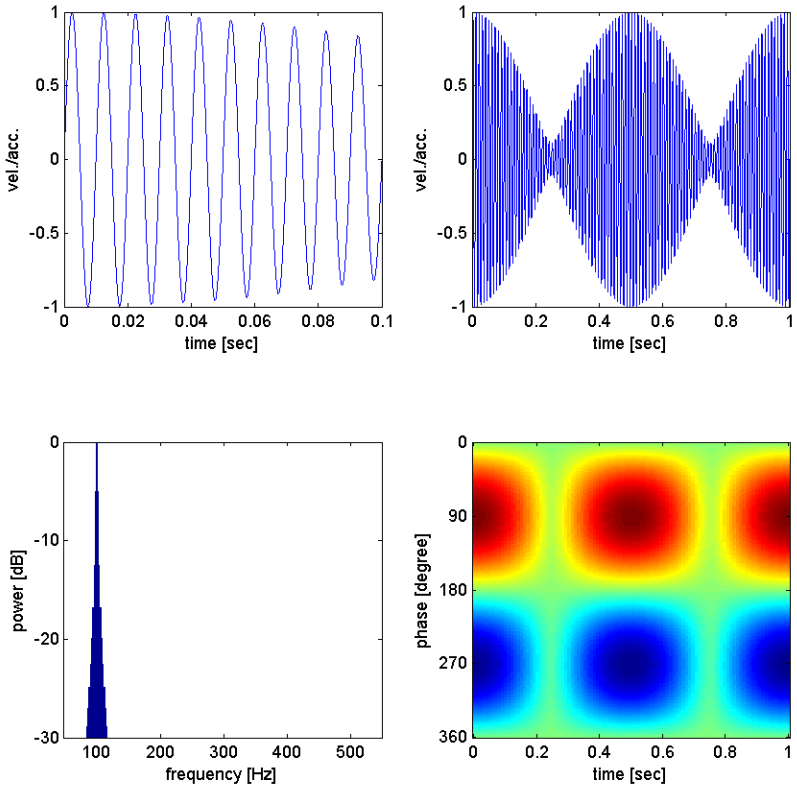
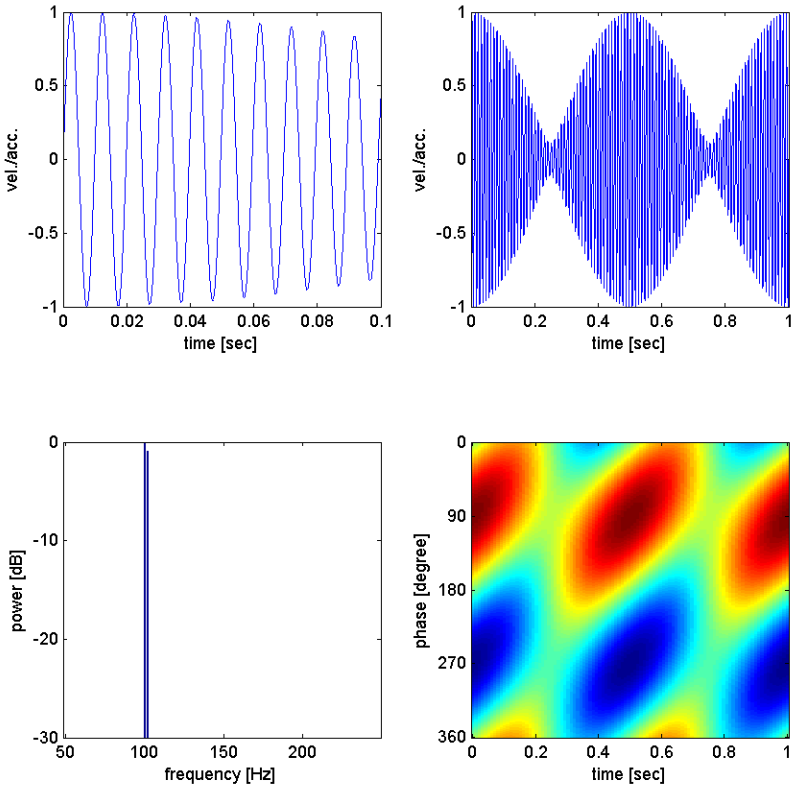


The spectrum shows little difference.

Beating



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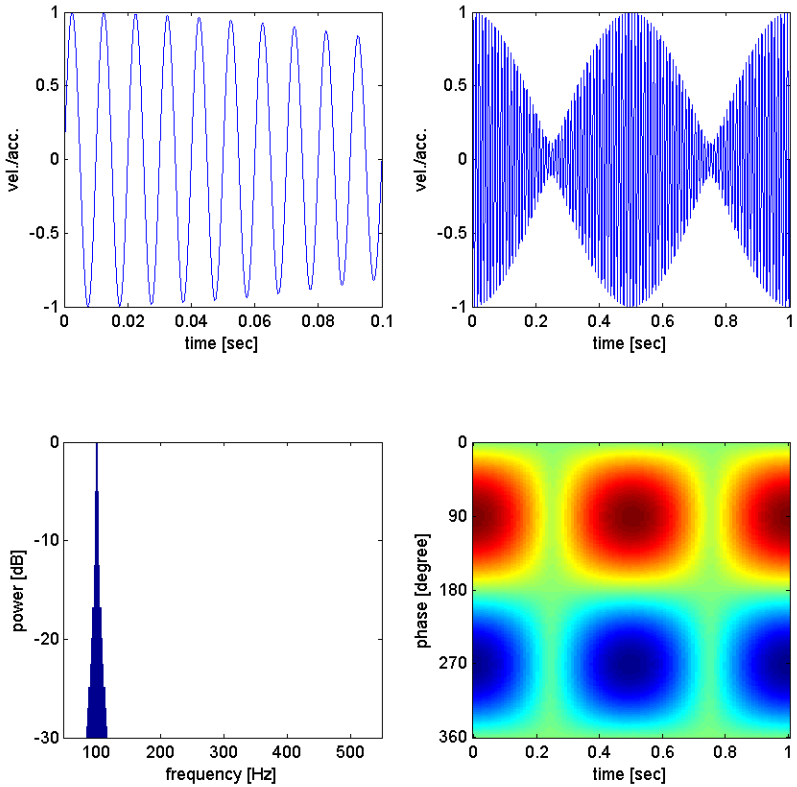
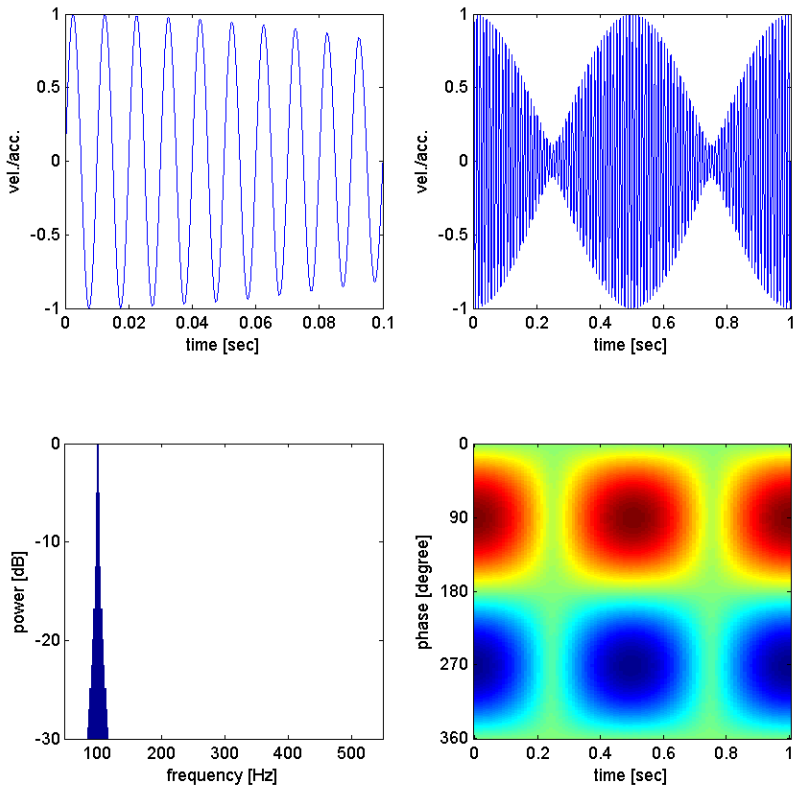


The sunic clearly shows a difference.

Amplitude Modulation



In general, sunics show differences in a very distinct manner.

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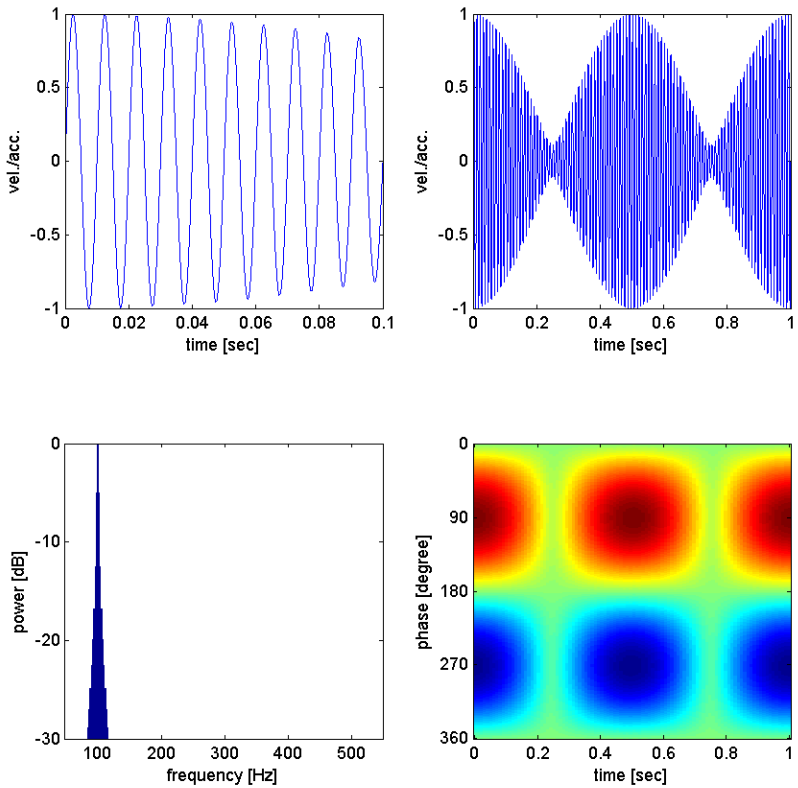

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This is not always the case for spectra:

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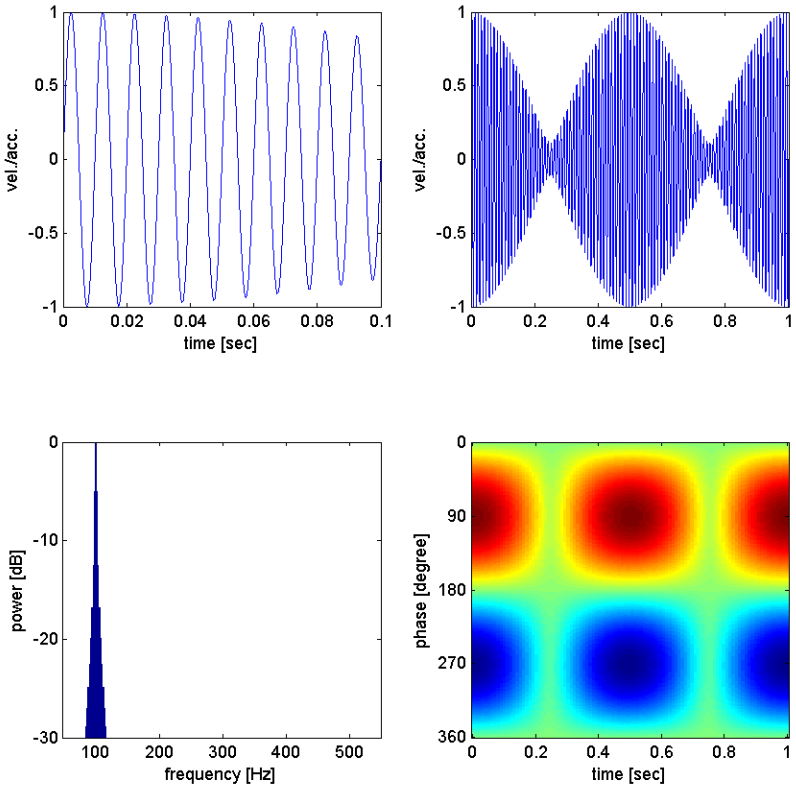
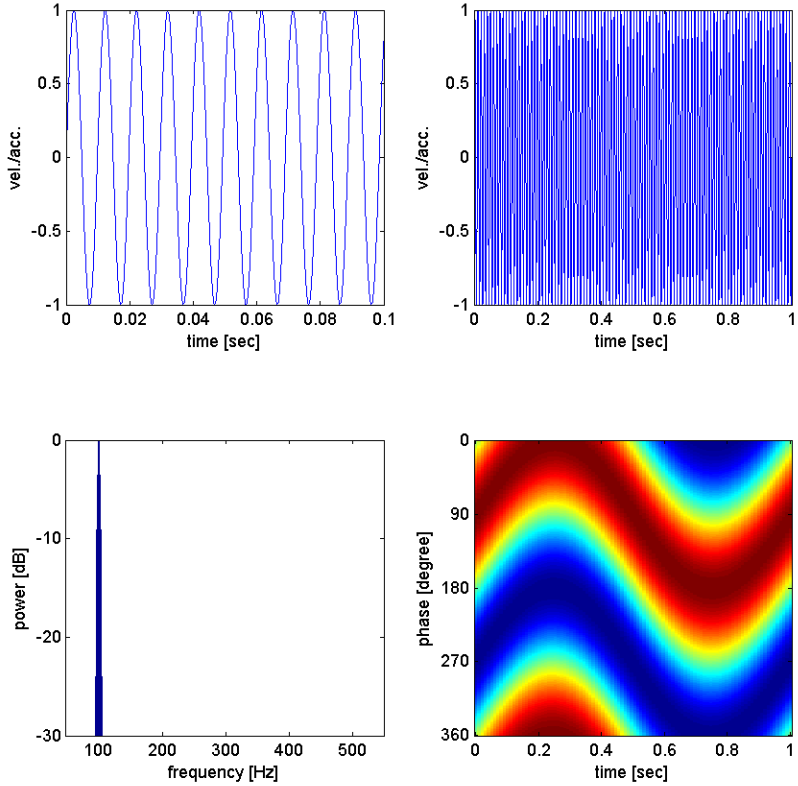
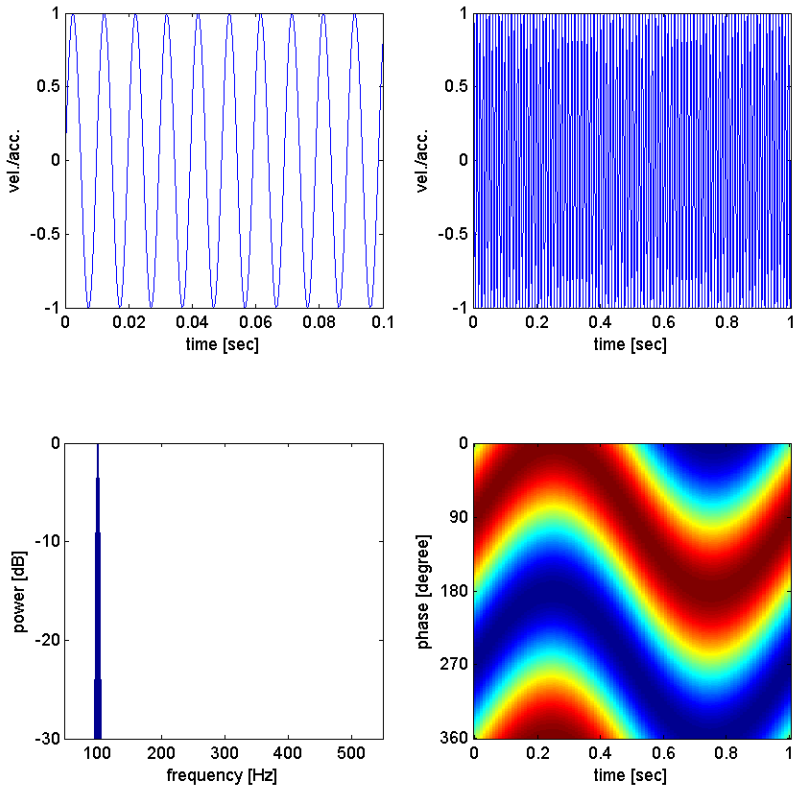


Phase Modulation

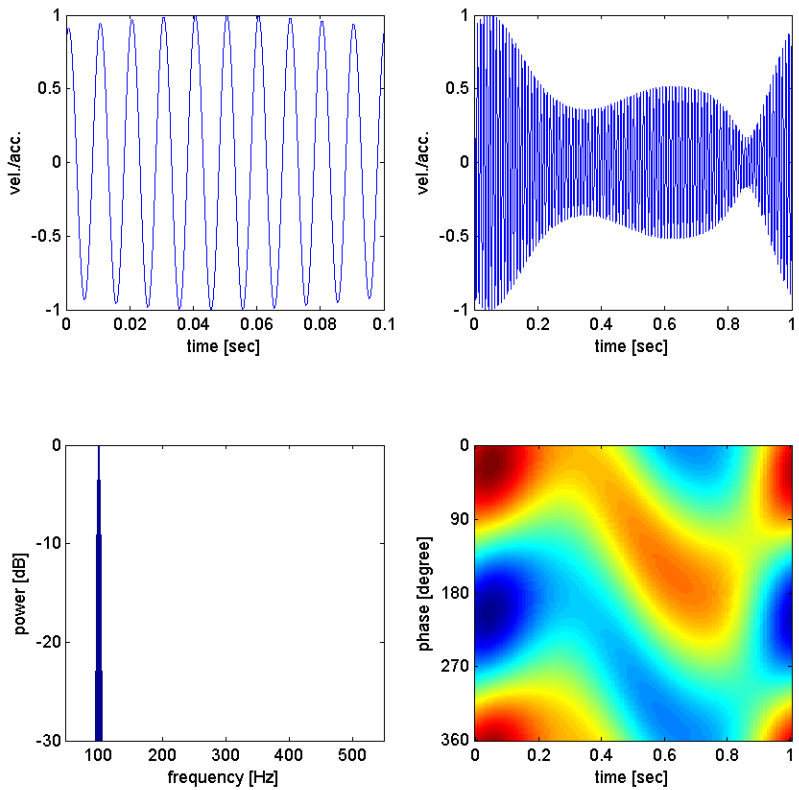


Note the similar spectra here...

Phase Modulation



Amplitude and Phase Modulation



..and here.

Impacts

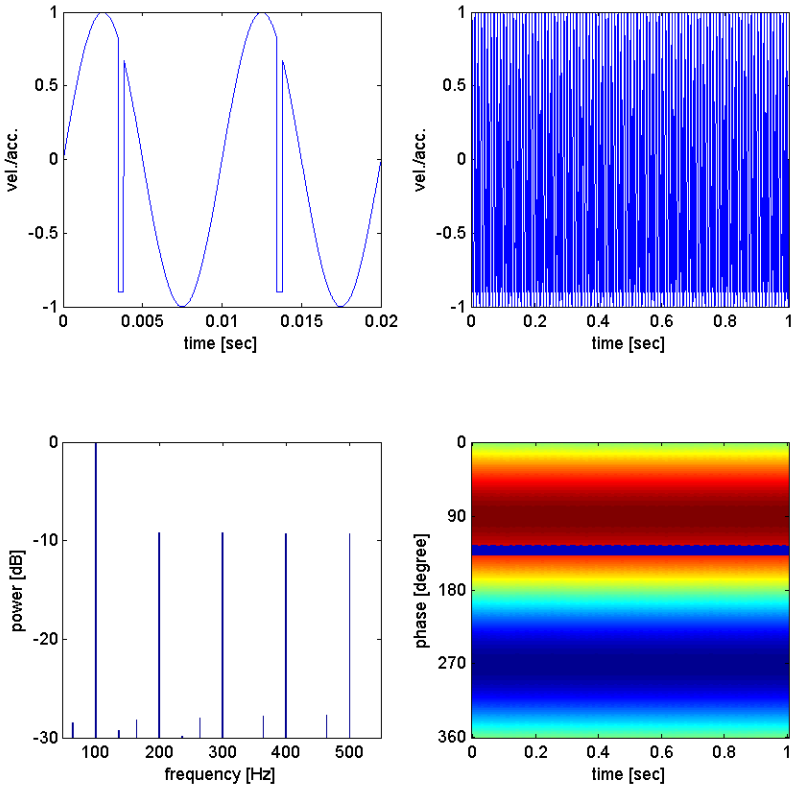
Much like the time waveform, sunics allow to determine the timing and location of impacts

Impacts

Much like the time waveform, sunics allow to determine the timing and location of impacts

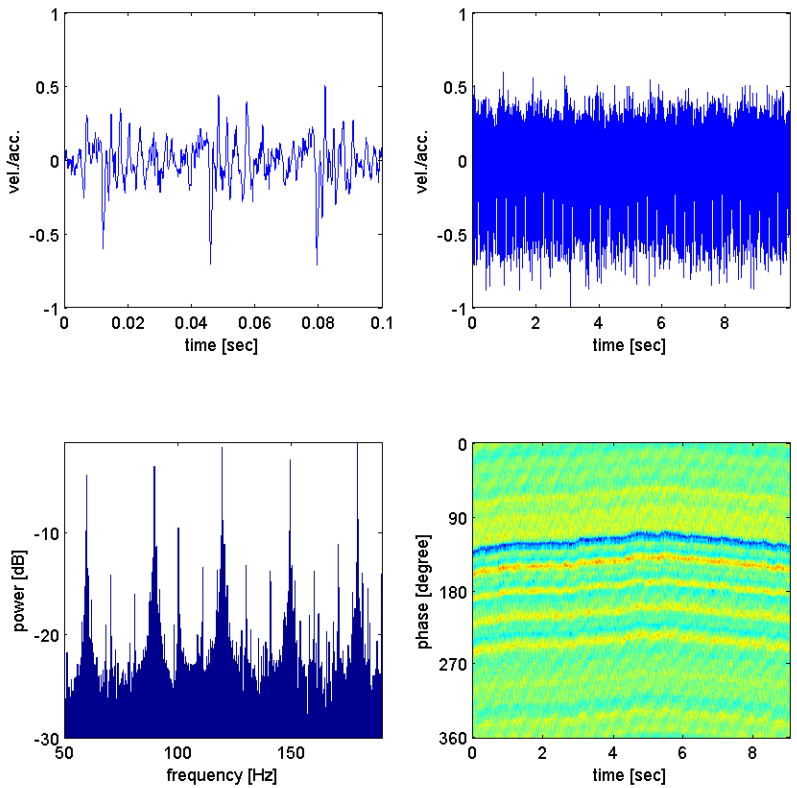
but more easily.

Impacts at Constant Phase



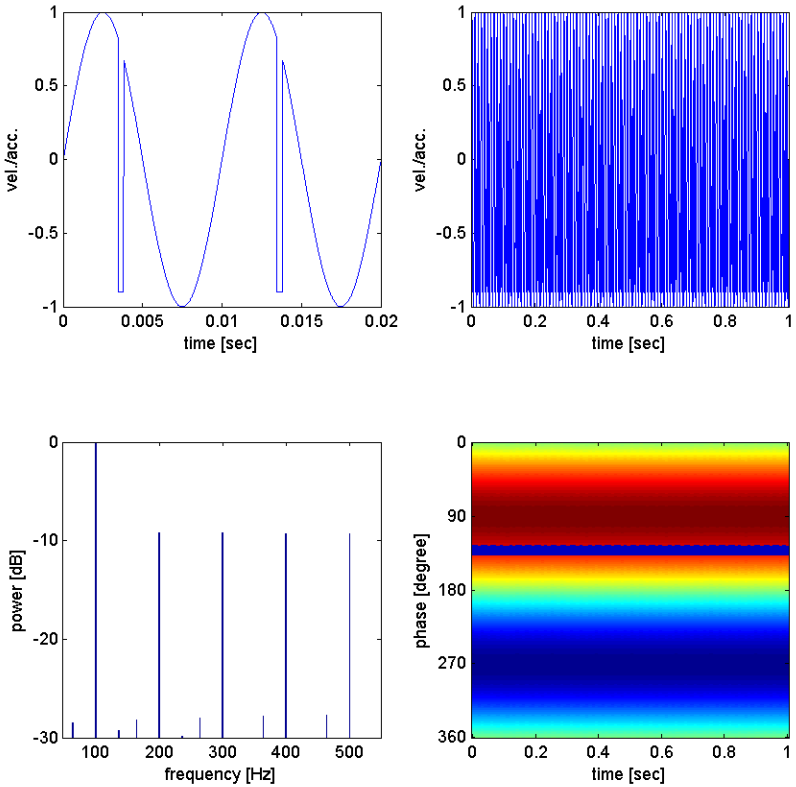
(simulated)

Impacts at Constant Phase



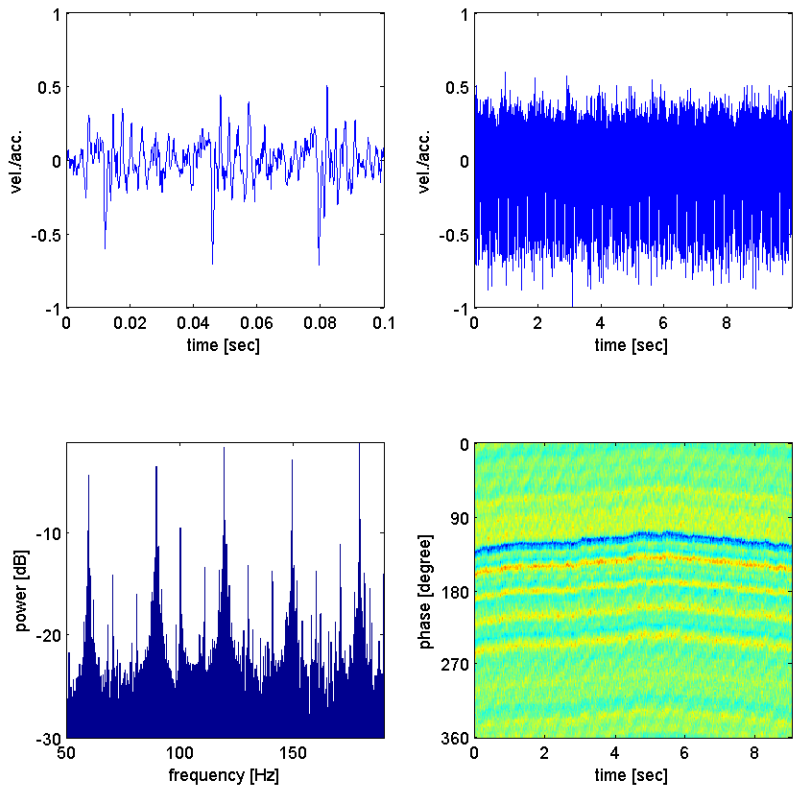
(real bearing)

Impacts at Constant Phase



(simulated)

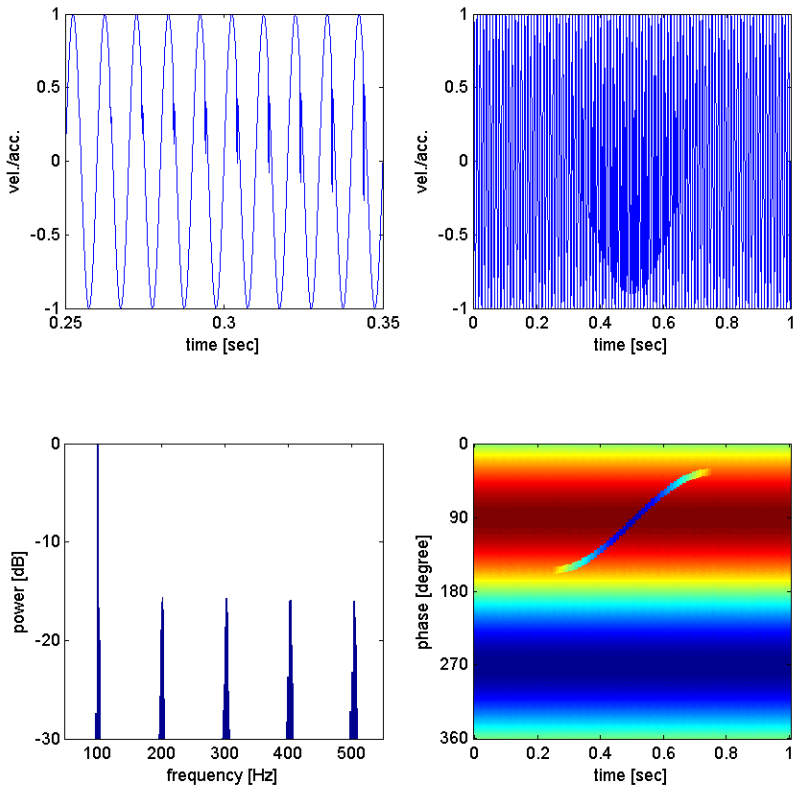
Impacts at Constant Phase



(real bearing)

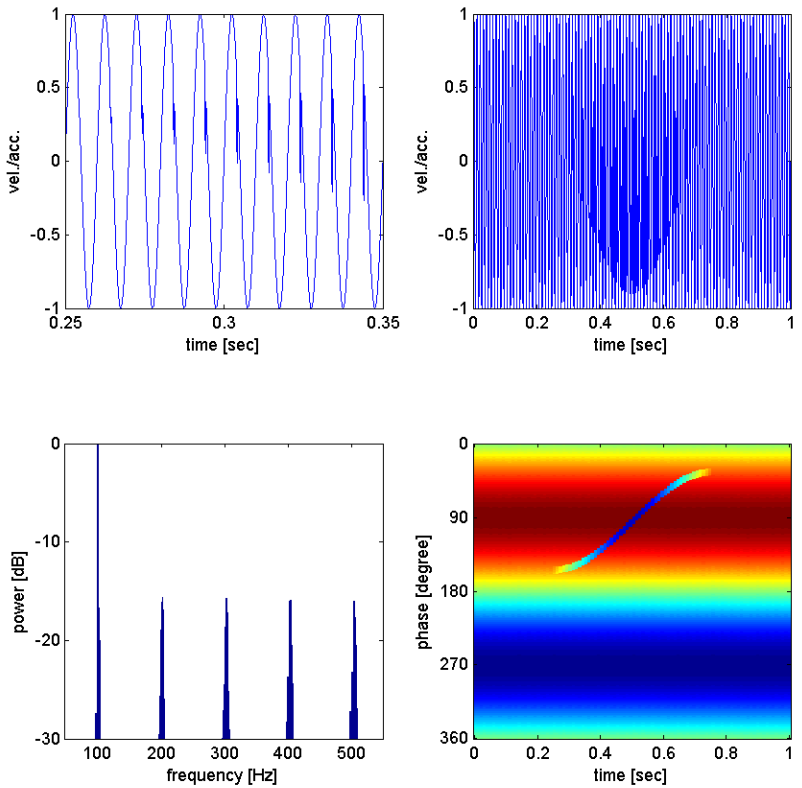
Impacts at $\approx 130^\circ$ of each cycle

Impacts at Changing Phase



For impacts at changing phase location, the sunic allows to locate the impact in time and phase.

Impacts at Changing Phase



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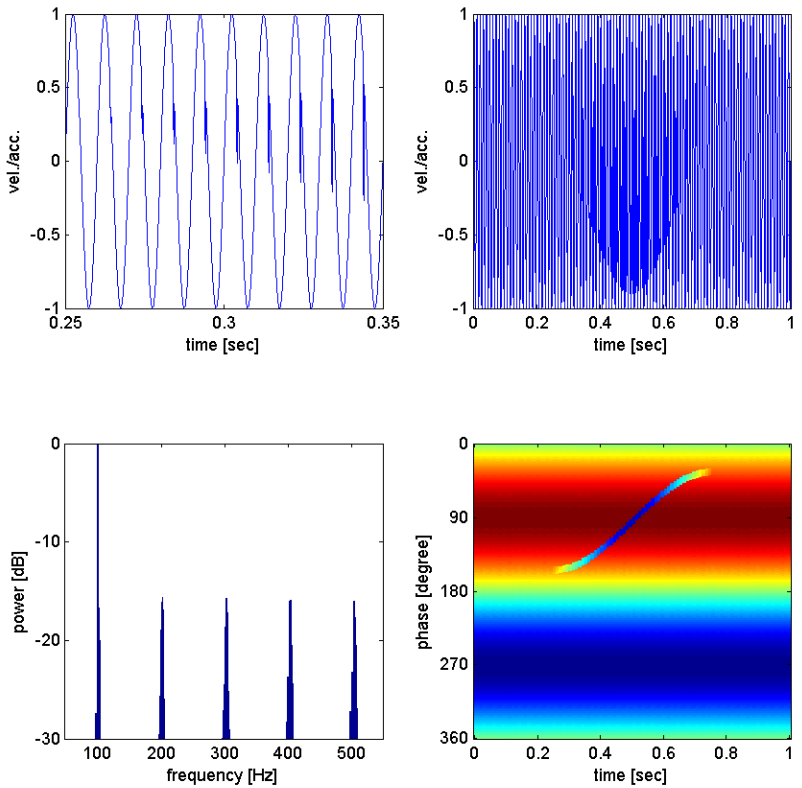

For impacts at changing phase location, the sunic allows to locate the impact in time and phase.

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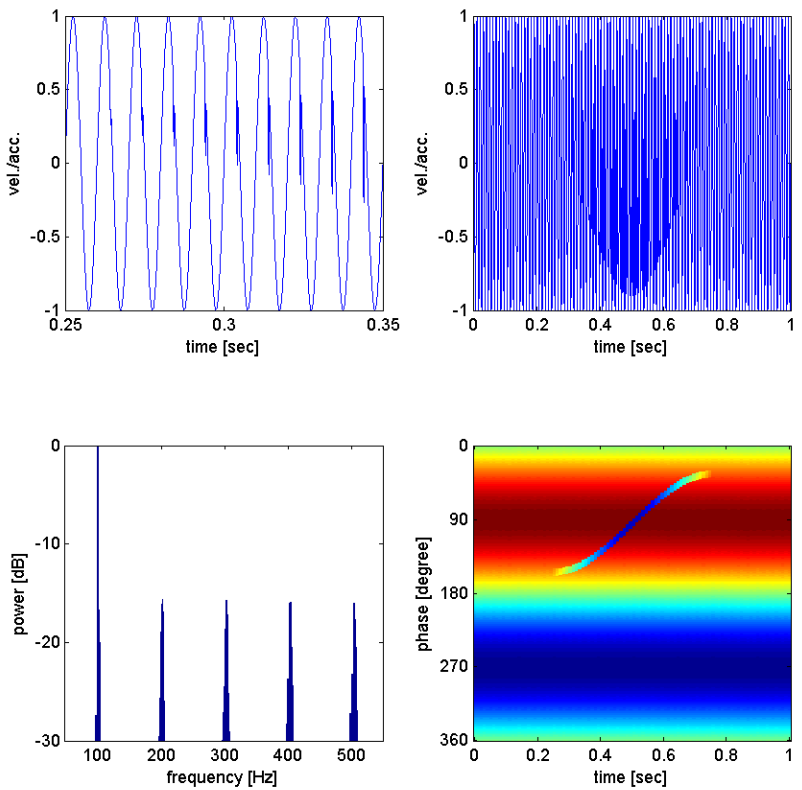
and impossible with the spectrum.

Impacts at Changing Phase



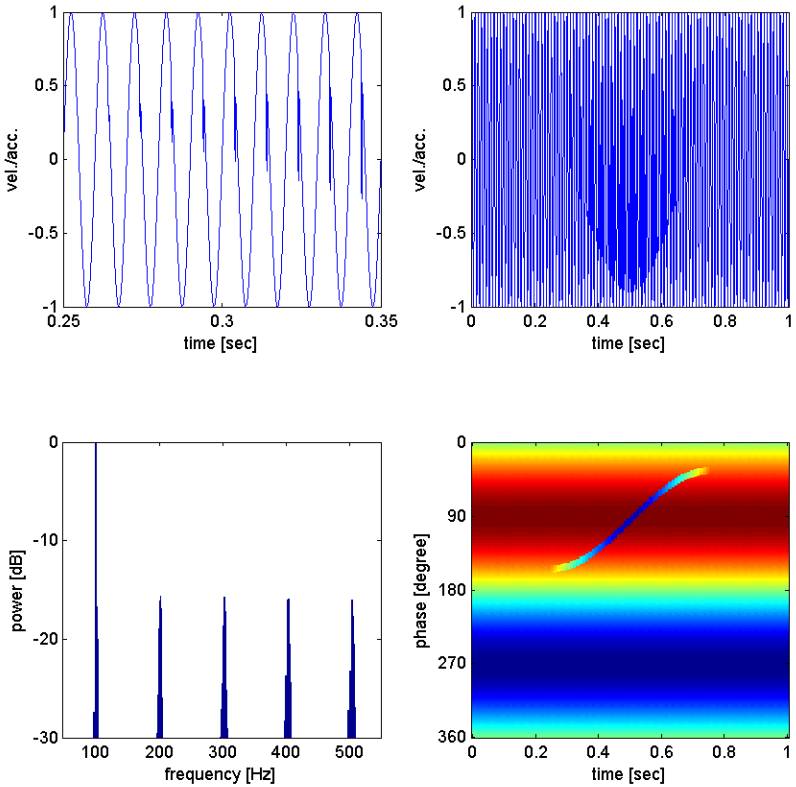
For impacts at changing phase location, the sunic allows to locate the impact in time and phase.

This is more difficult with the time waveform

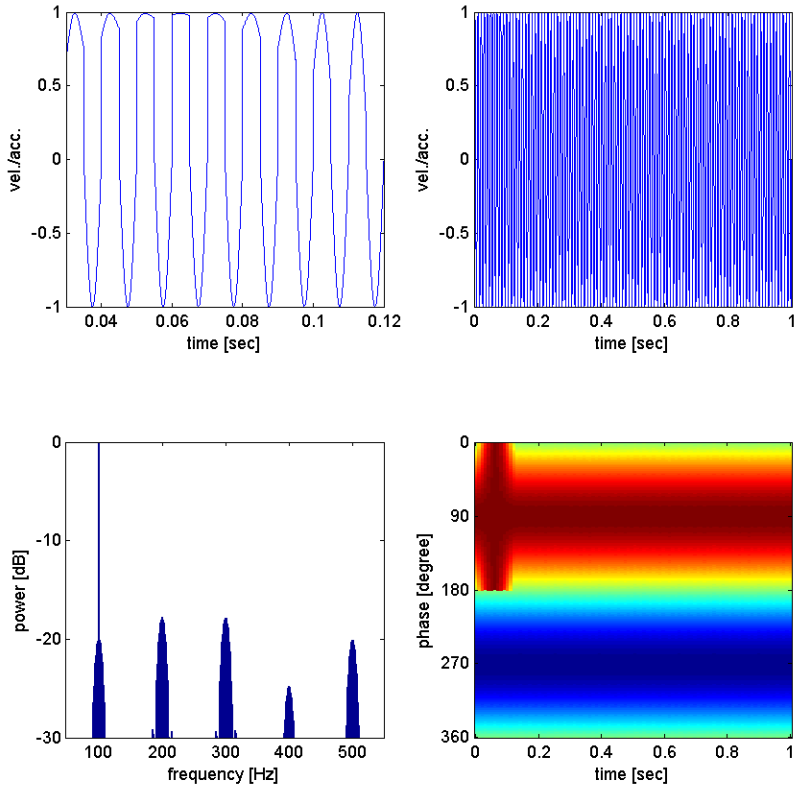
and impossible with the spectrum.

Spectra do not produce such distinct patterns for impacts:

Impact at Changing Phase



Temporary Flattening



Flattening, for instance, may produce a similar spectrum.

Transients

Transients produce similar patterns like impacts, but flipped diagonally in the time–phase domain.

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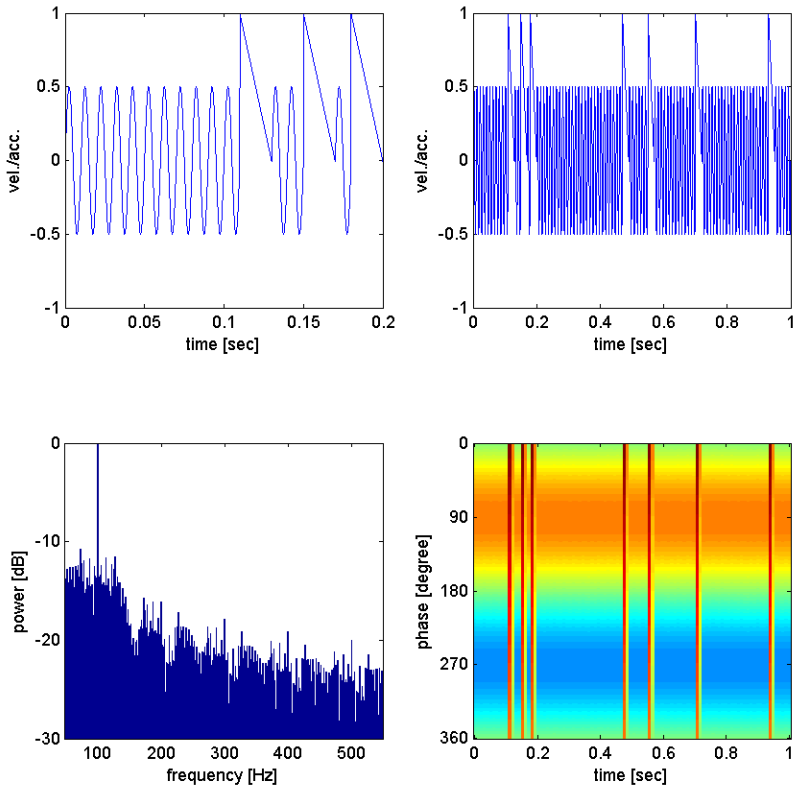
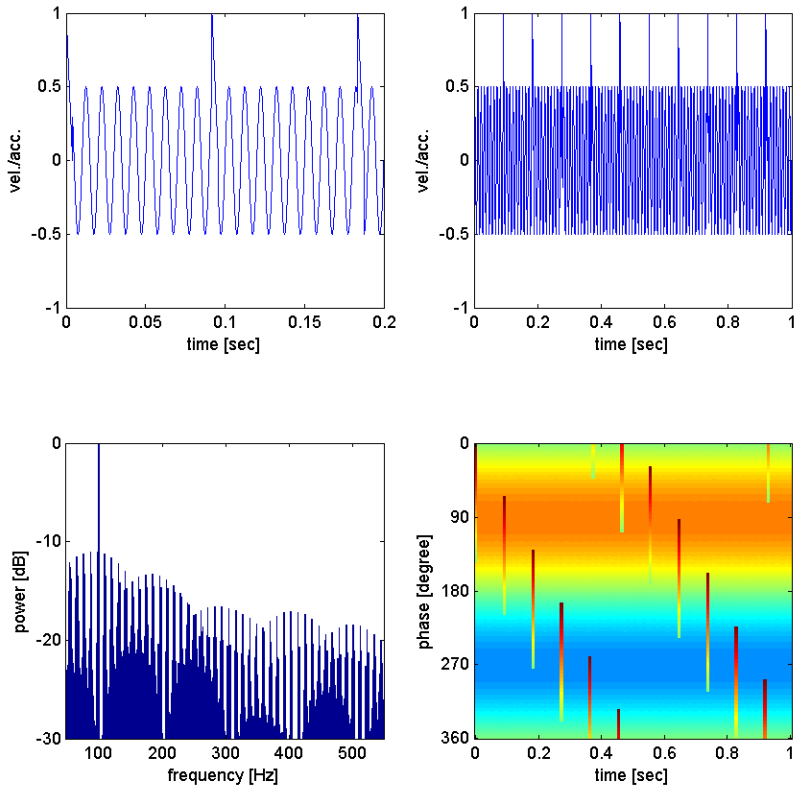
Let's see two examples:

Irregularly Occuring Transients



Repeating Short Transients



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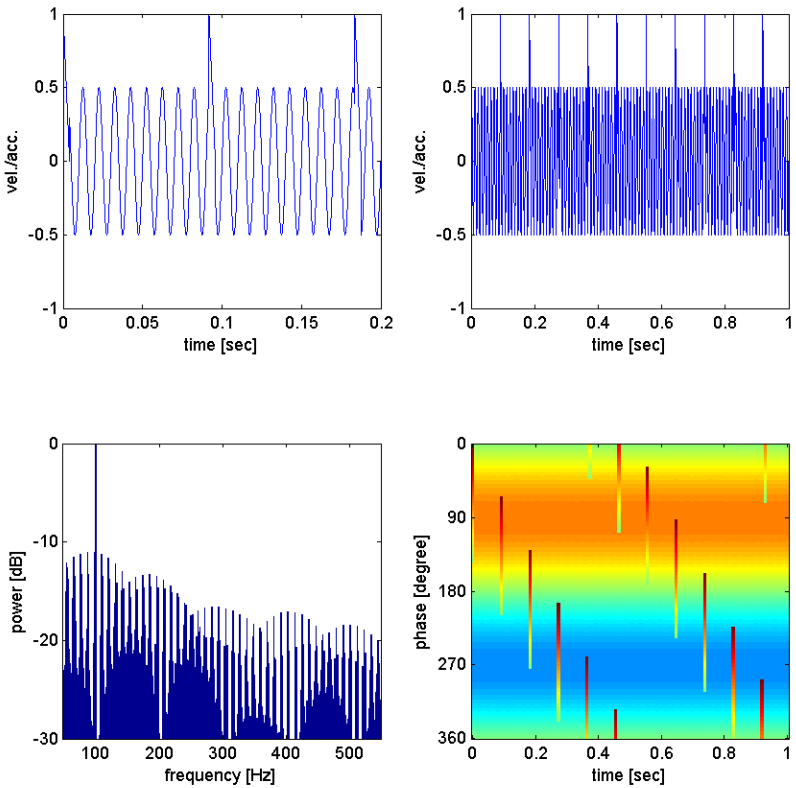
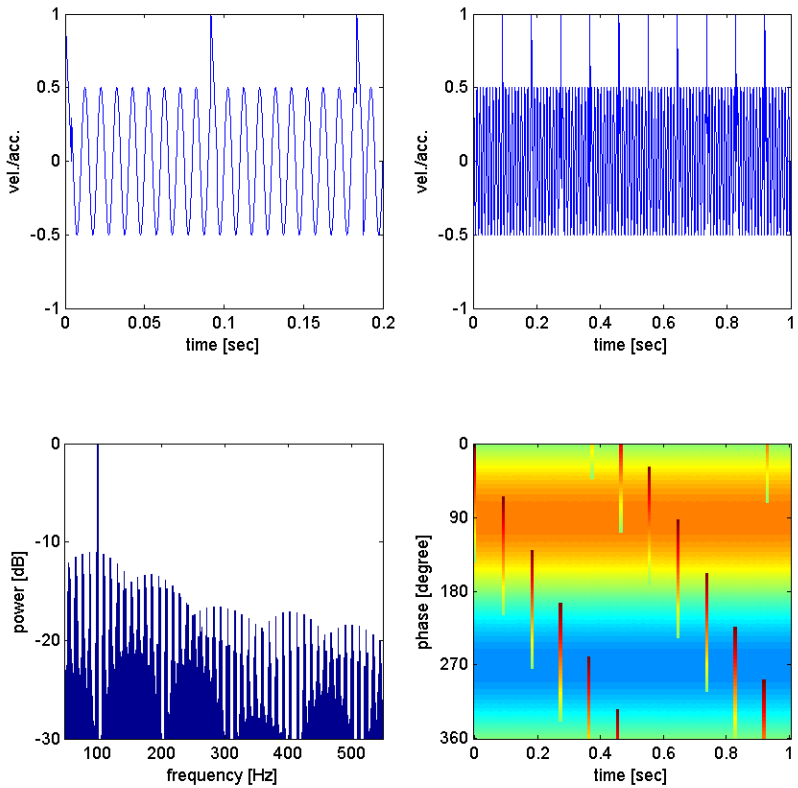


This second signal features repeating, short transients occuring only during a part of some cycles.

Repeating Short Transients



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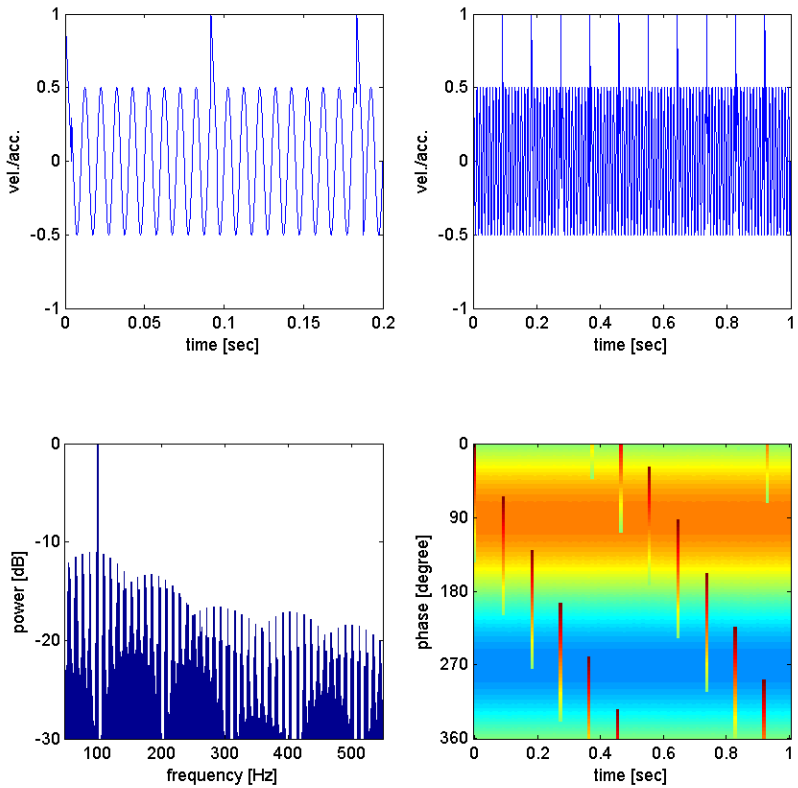
Repeating Short Transients



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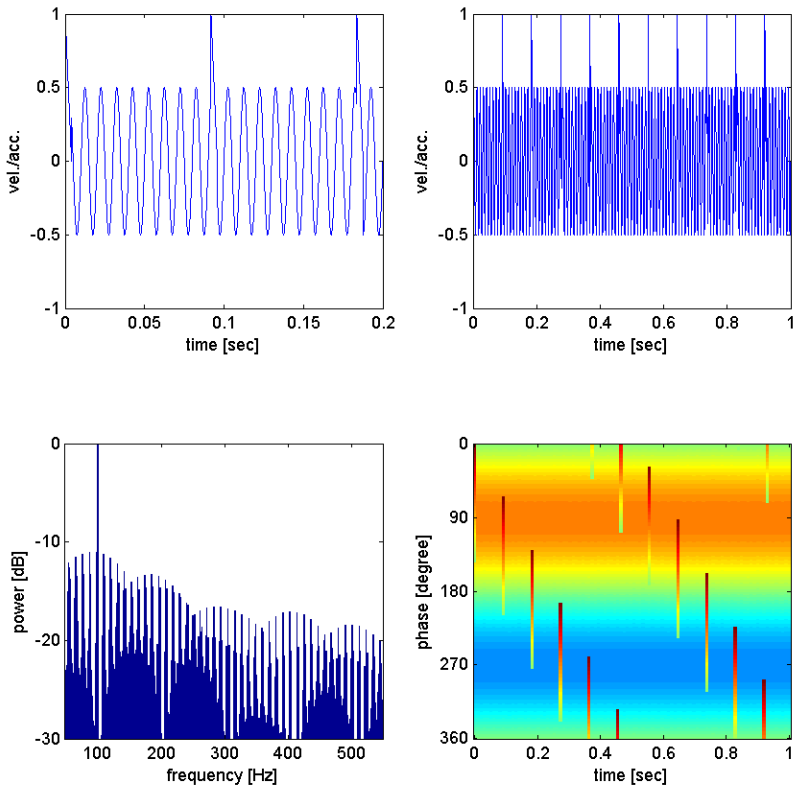

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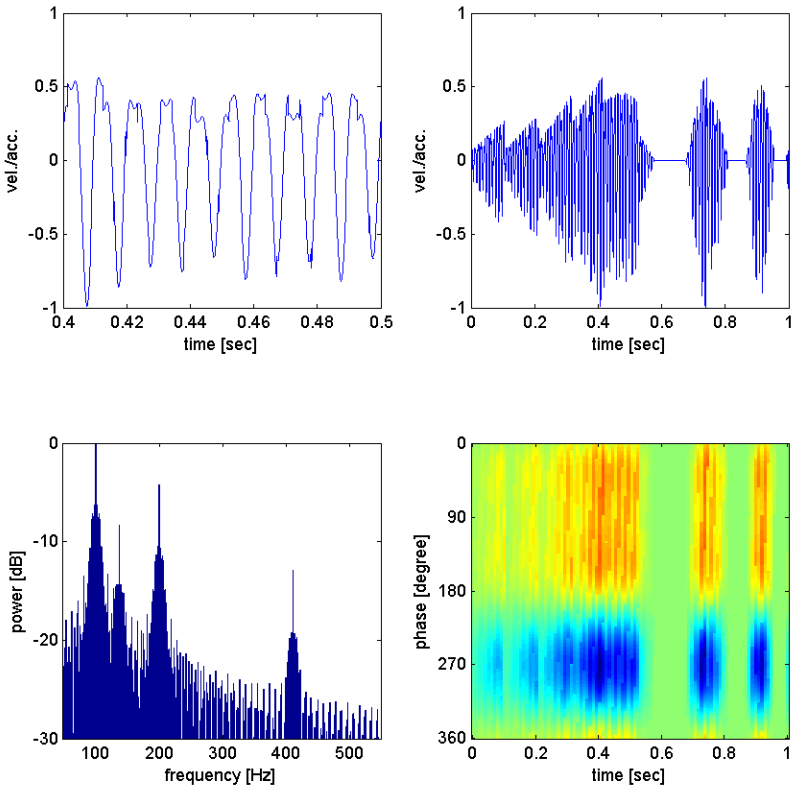
Their phase location varies over time.

This is difficult to see in the time waveform

and impossible to see in the spectrum.

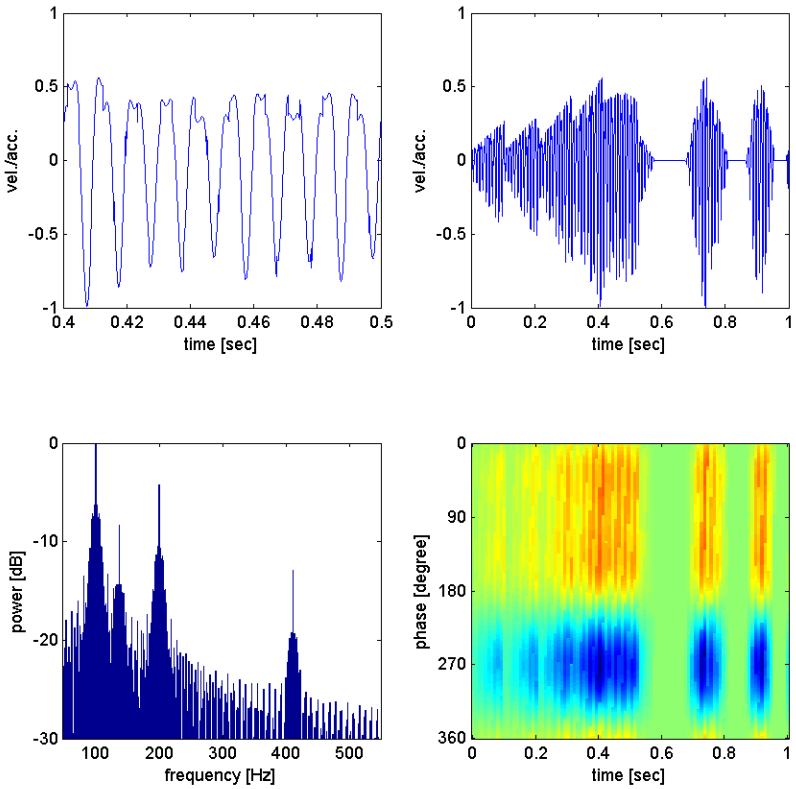
Transient Vibrations



Time waveform and sunic both allow separation of transient vibrations into:

- fast changes defining the vibration
- slow changes defining the transient envelope.

Transient Vibrations



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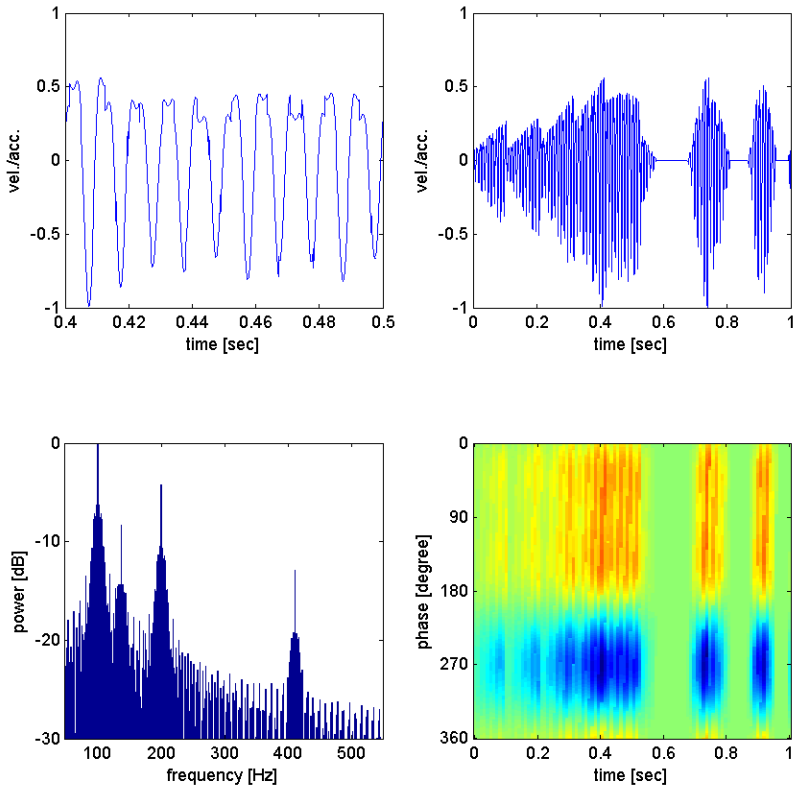

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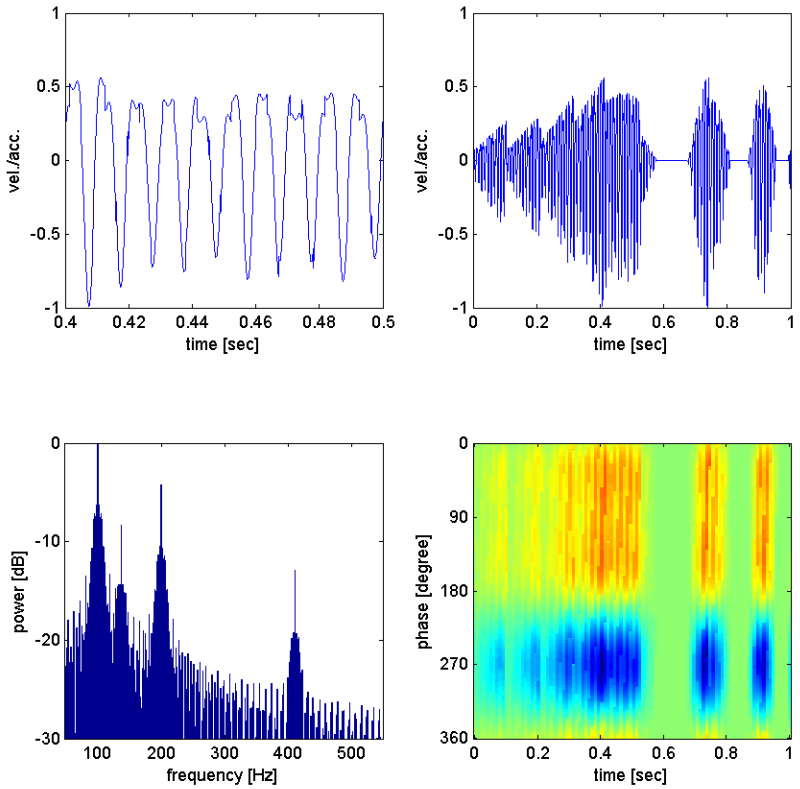

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These aspects can not be seperated in the spectrum.

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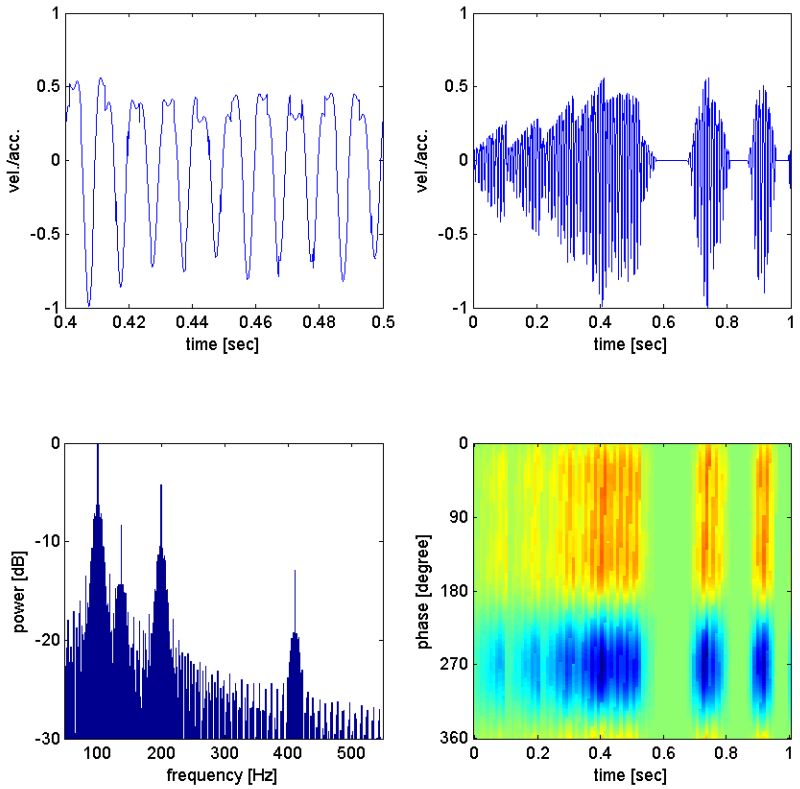

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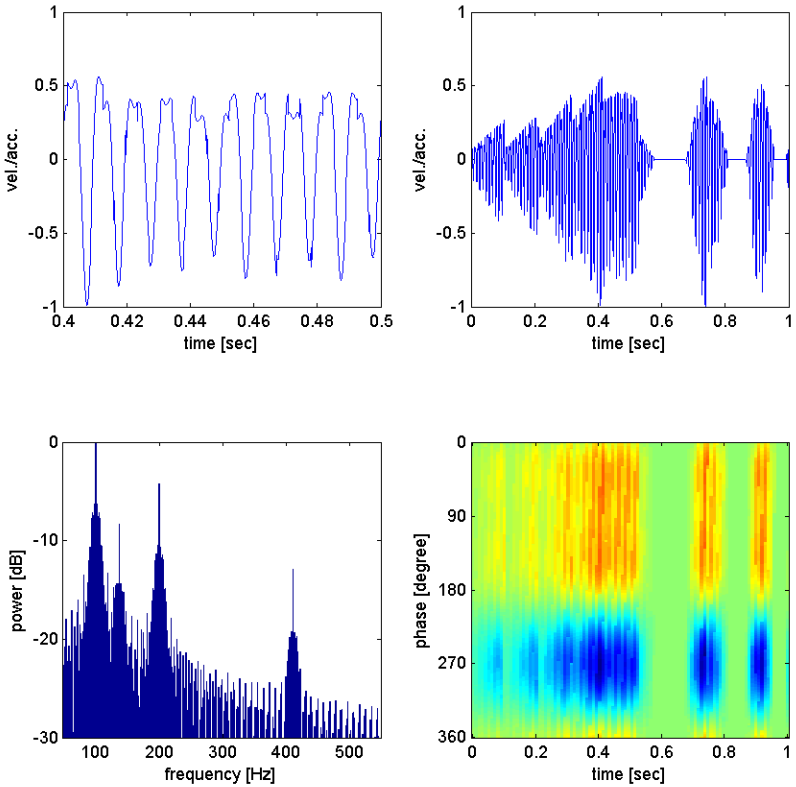
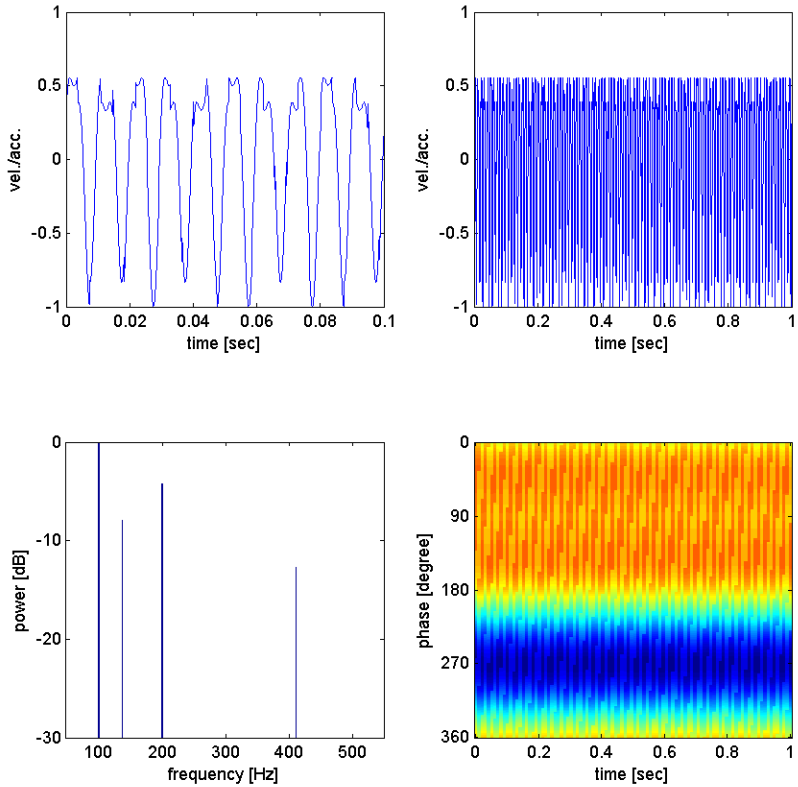
This is seen if the envelope is omitted:

Transient Vibrations



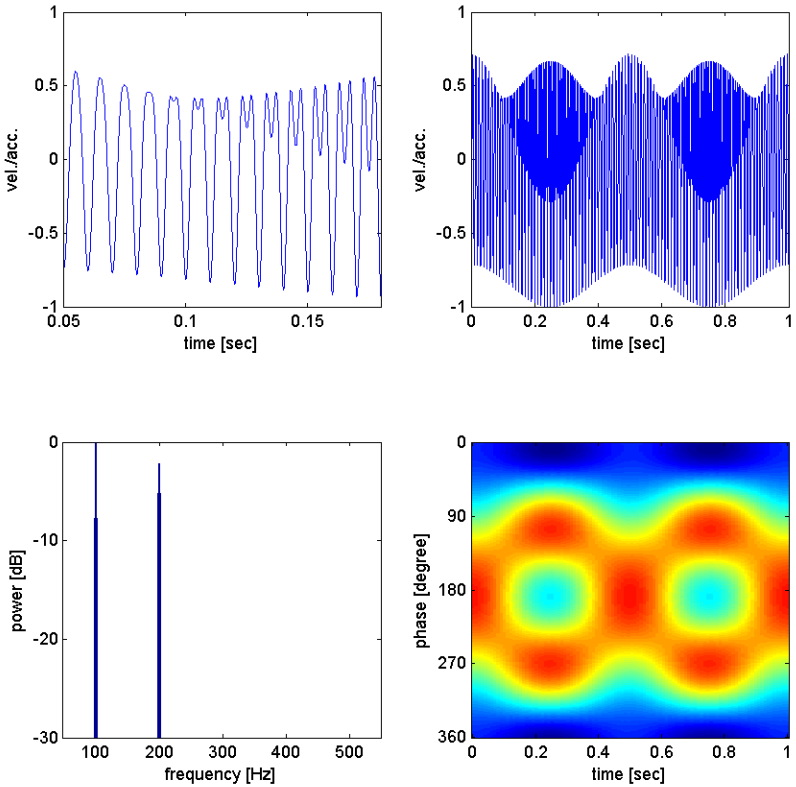
Constant Vibration



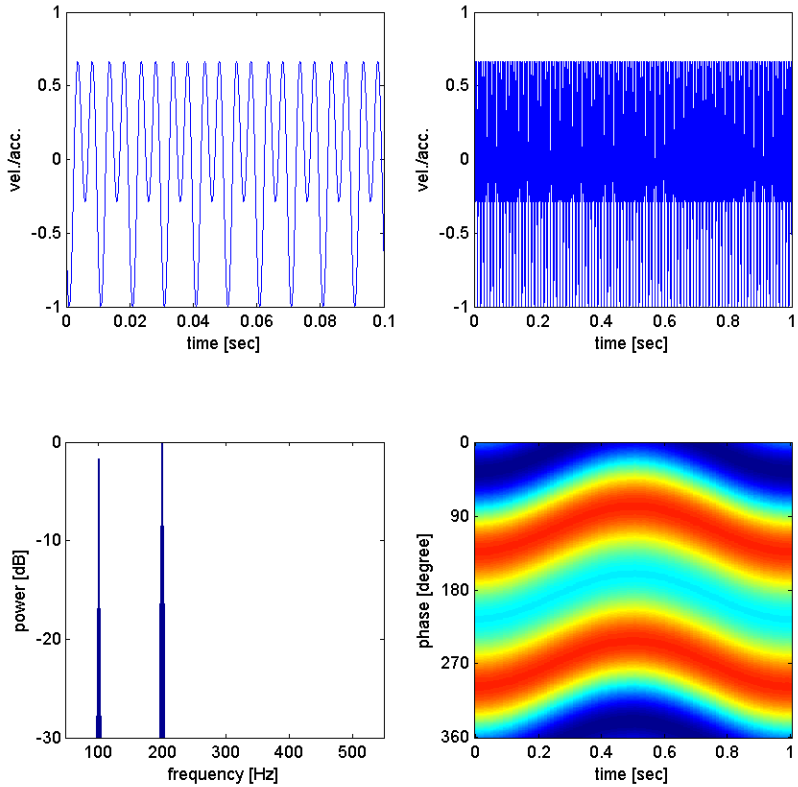
Misalignment

We conclude our examples with
two signals showing
slow variations in misalignment.

Slowly Pulsating Misalignment

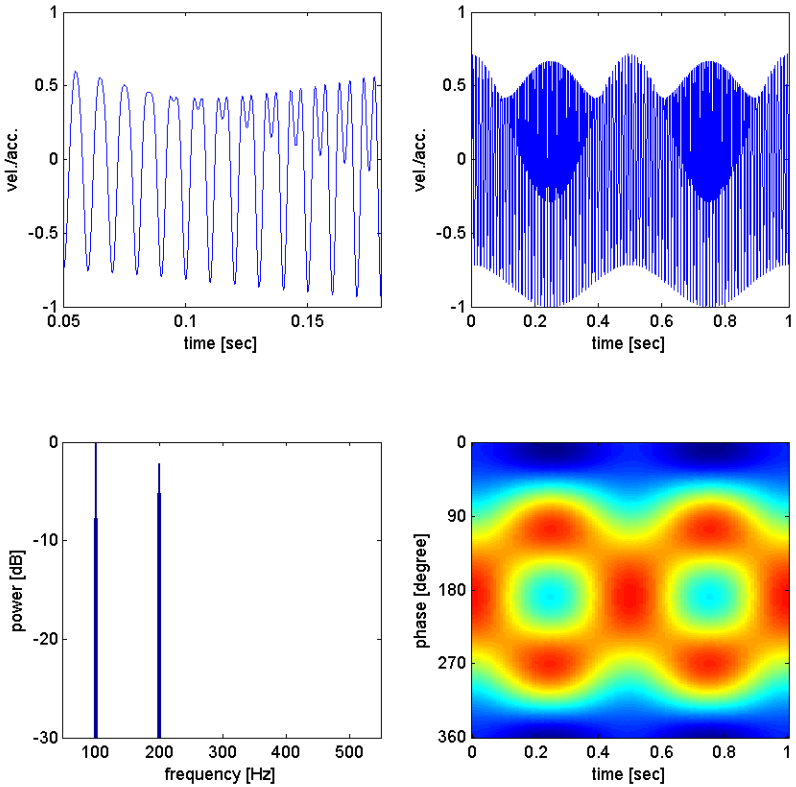


Changing Misalignment Location

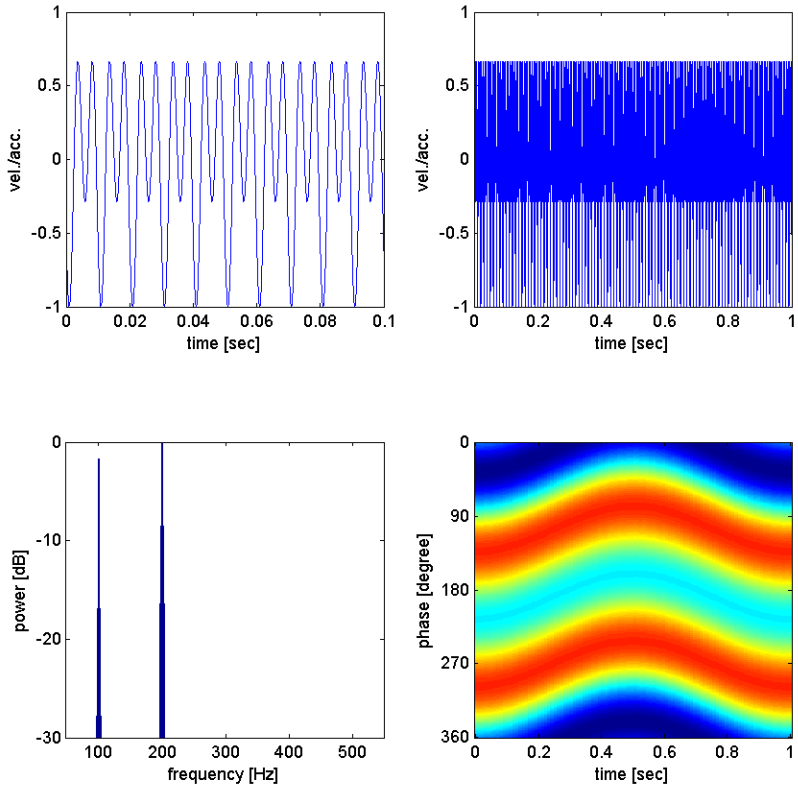


Left: the typical ”M” shape appears and disappears twice.

Slowly Pulsating Misalignment



Changing Misalignment Location



Right: the ”M” shape persists but changes its phase location.

What have we seen ?

- sunics produce very detailed and distinctive patterns
- they show fast and slow changes in two decoupled directions (phase and time)
- time waveform information is presented all at a glance
- sunics reveal information not accessible via the spectrum.

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Thank you very much for your attention.

More information can be found on www.sunics.com