FX Basics

Introduction

STOMPBOX DESIGN WORKSHOP

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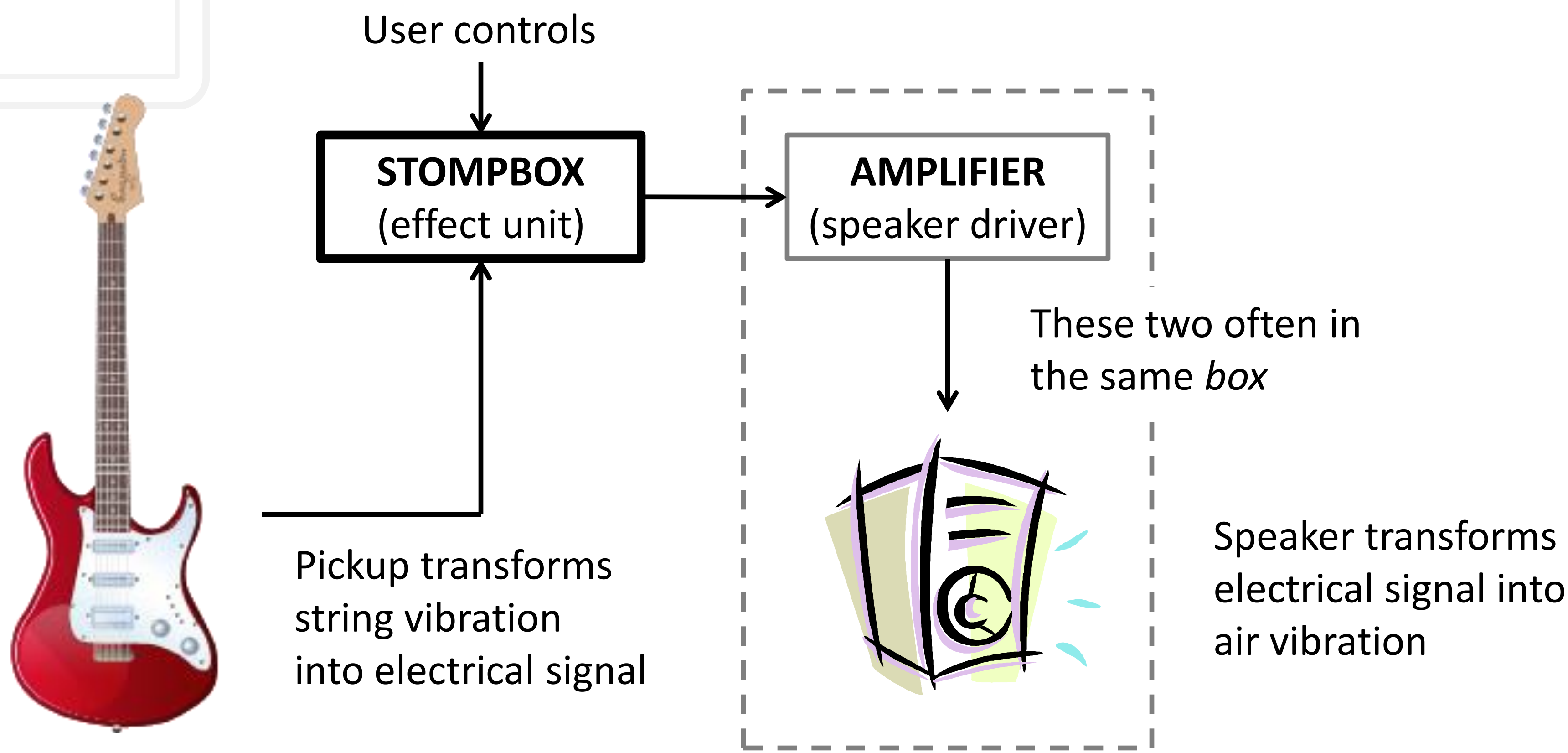
FX Basics: **Introduction**



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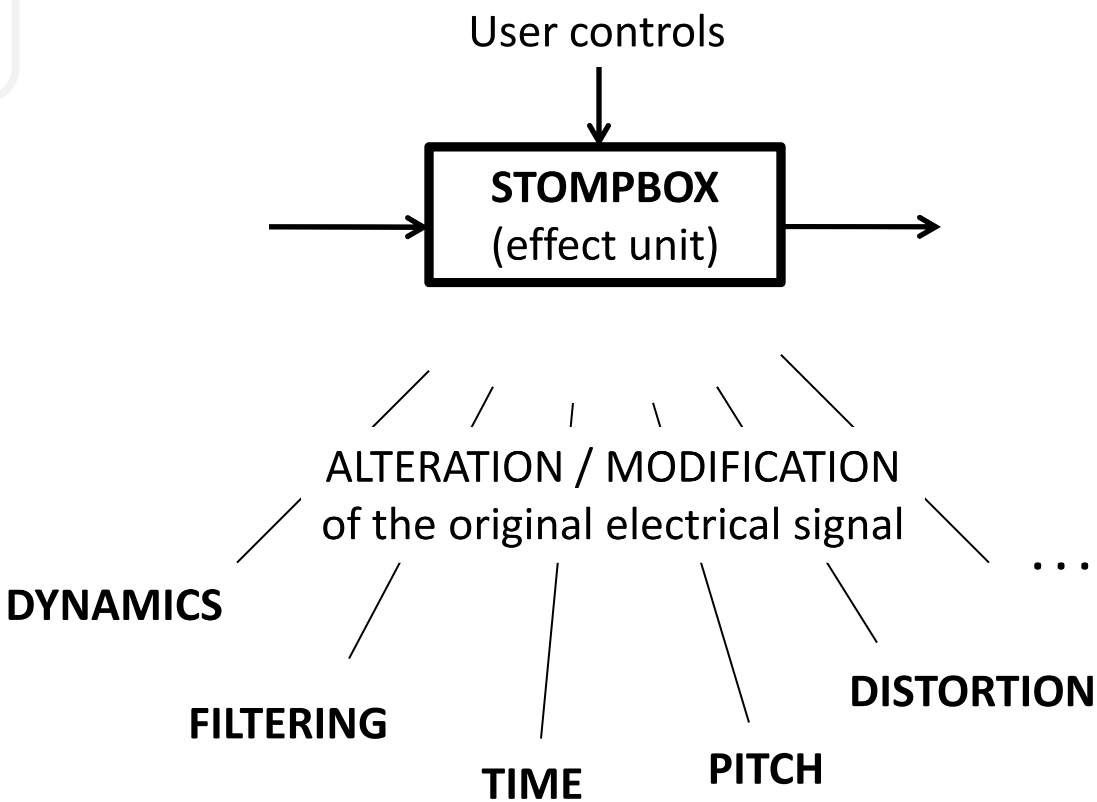

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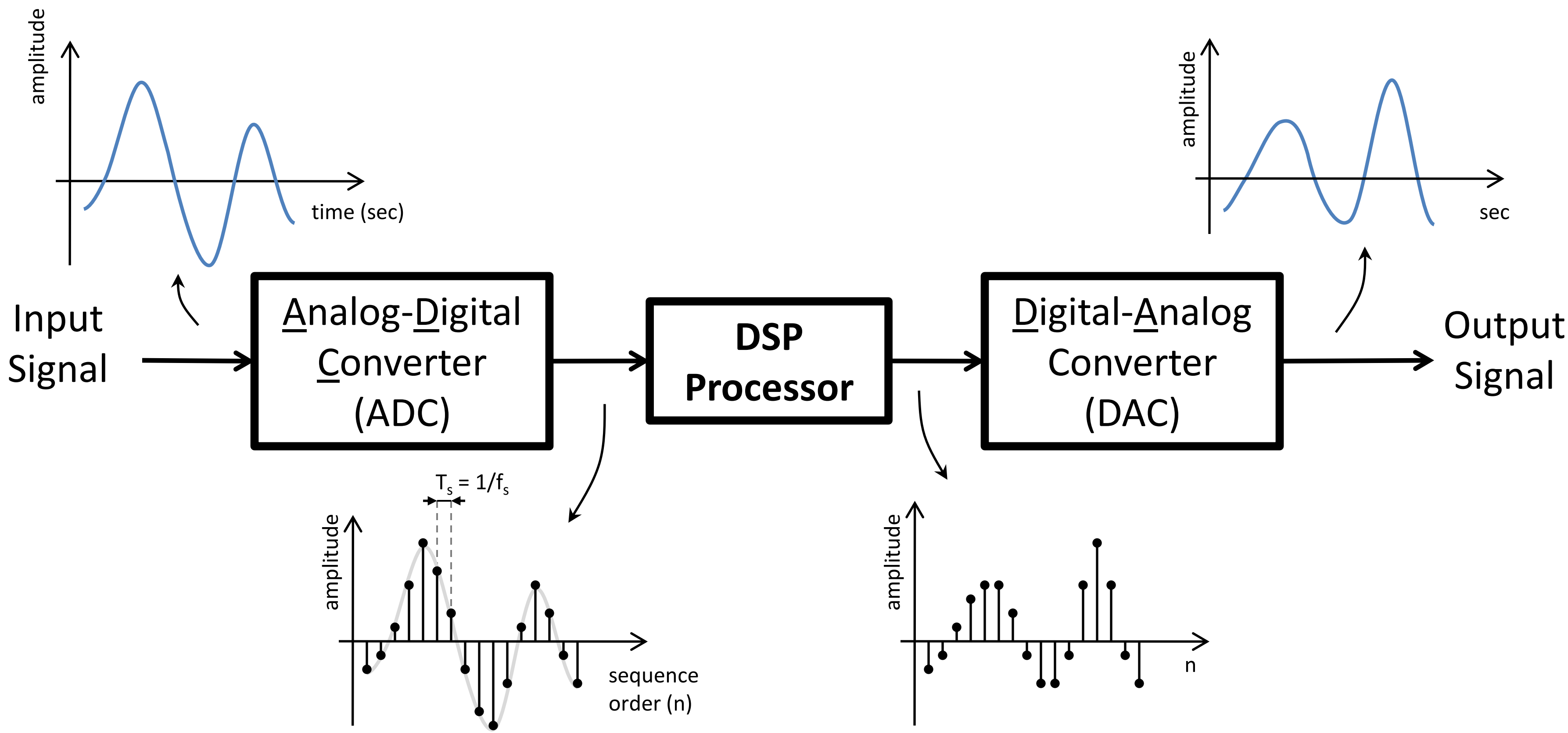
Stompboxes traditionally operated in the analog domain.
Here we will work with signals in the digital domain, by means of Digital Signal Processing (**DSP**) techniques.



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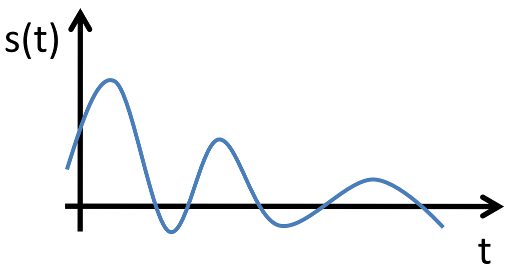
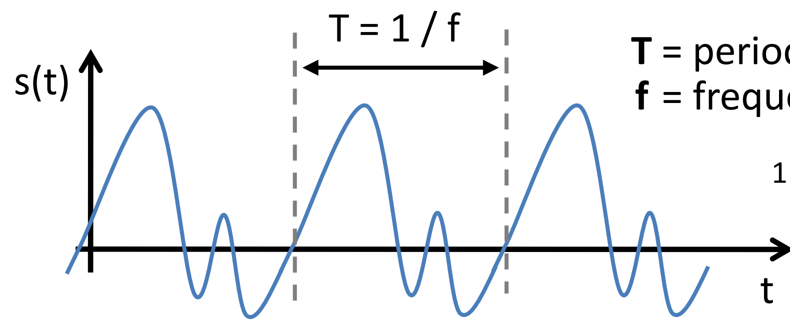
SIGNAL | PERIODIC SIGNAL

Signal: function of time, representing a given magnitude



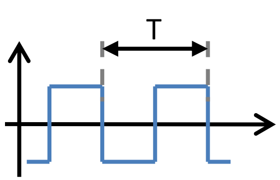
Periodic Signal: signal whose value profile repeats over time: s(t+**T**) = s(t)



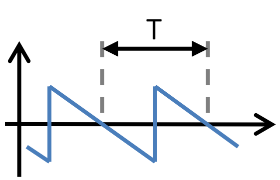
T = period (sec)
f = frequency (Hz)

1Hz = 1/sec

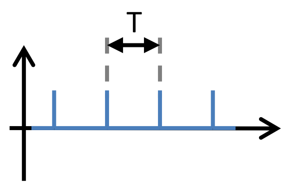
Some examples of basic periodic signals:



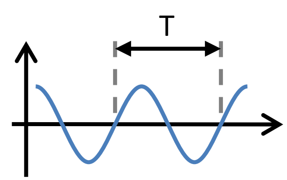
SQUARE



SAWTOOTH



IMPULSE TRAIN



SINUSOIDAL

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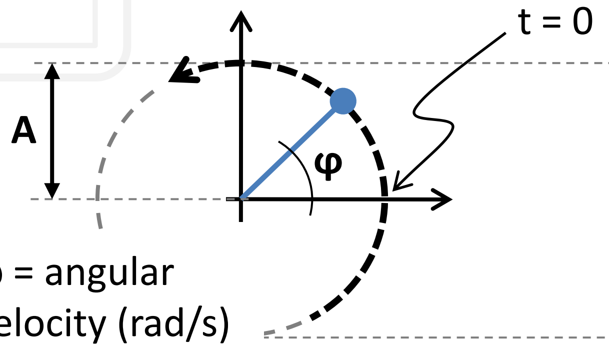
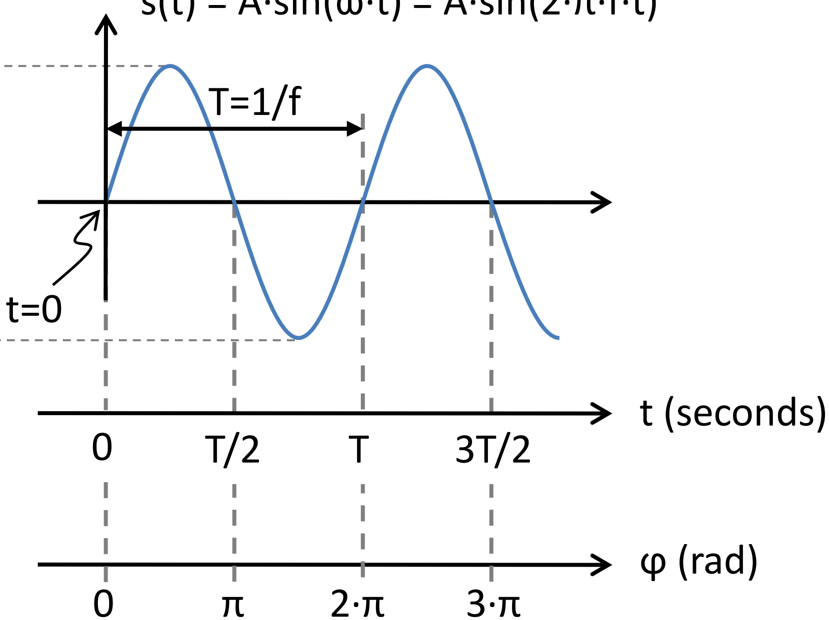
SINUSOIDAL SIGNAL

Angle φ at time t

$s(t) = A \cdot \sin(\omega \cdot t) = A \cdot \sin(2 \cdot \pi \cdot f \cdot t)$

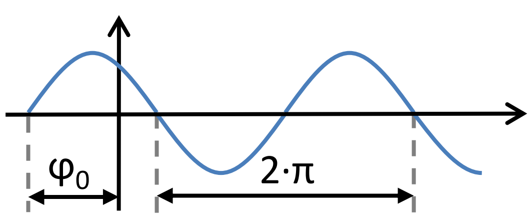
$\omega = 2 \cdot \pi \cdot f$





ω = angular velocity (rad/s)

A = amplitude

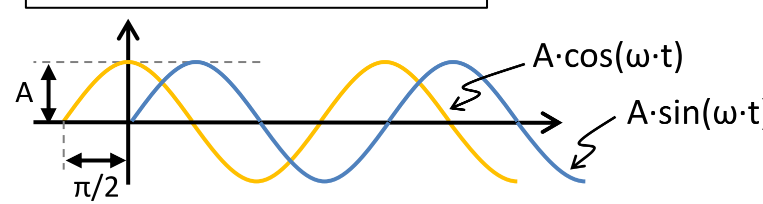


φ_0 = phase (initial φ at time t =0)

Angle φ at time t

$s(t) = A \cdot \sin(\omega \cdot t + \varphi_0) = A \cdot \sin(2 \cdot \pi \cdot f \cdot t + \varphi_0)$

$A \cdot \cos(\omega \cdot t) = A \cdot \sin(\omega \cdot t + \pi/2)$



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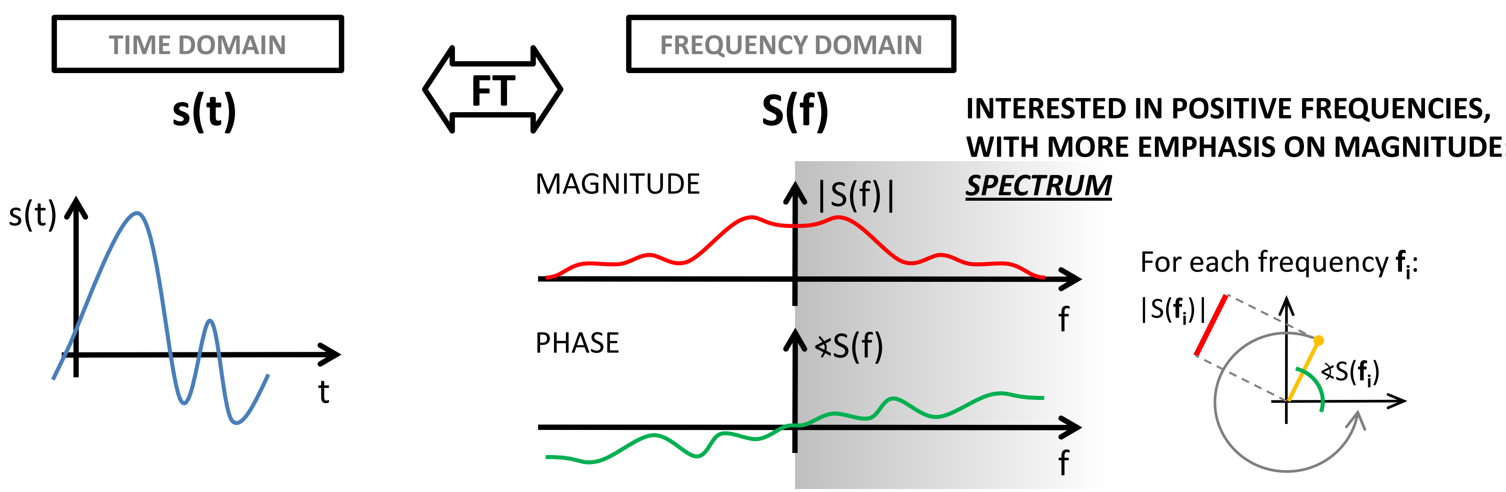
FOURIER ANALYSIS | FREQUENCY DOMAIN

Any function of time can be expressed as an **infinite sum of sinusoidal functions** of different frequencies, each function with a particular **amplitude** and **phase**.

Such function, previously expressed in the **Time Domain**, can therefore be expressed in the **Frequency Domain**.

The **Fourier Transform (FT)** is a **mathematical operator** that allows to go from Time Domain to Frequency Domain and vice-versa:



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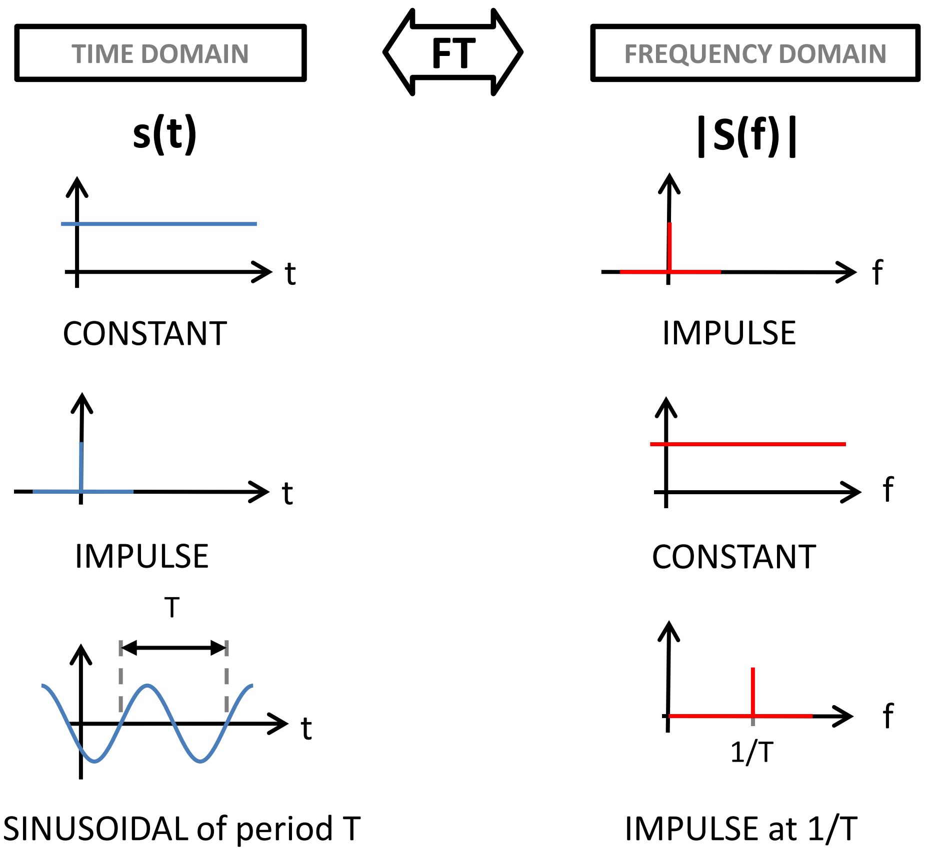
FOURIER TRANSFORM OF IMPORTANT SIGNALS



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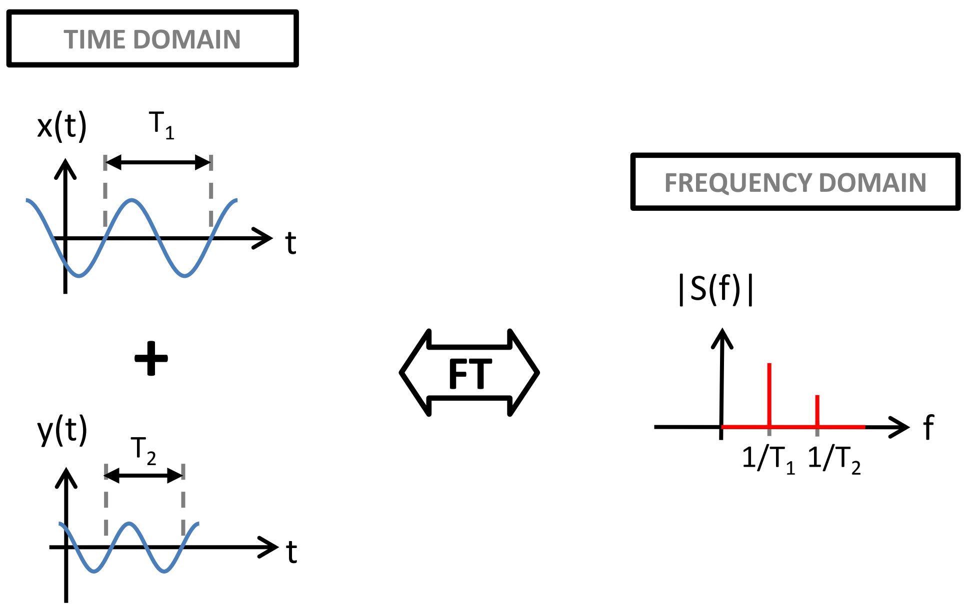
LINEARITY

The **Fourier Transform, F[]**, is a **linear operation**:

$$F[a\cdot x(t) + b\cdot y(t)] = a\cdot F[x(t)] + b\cdot F[y(t)]$$



s(t) = x(t) + y(t)

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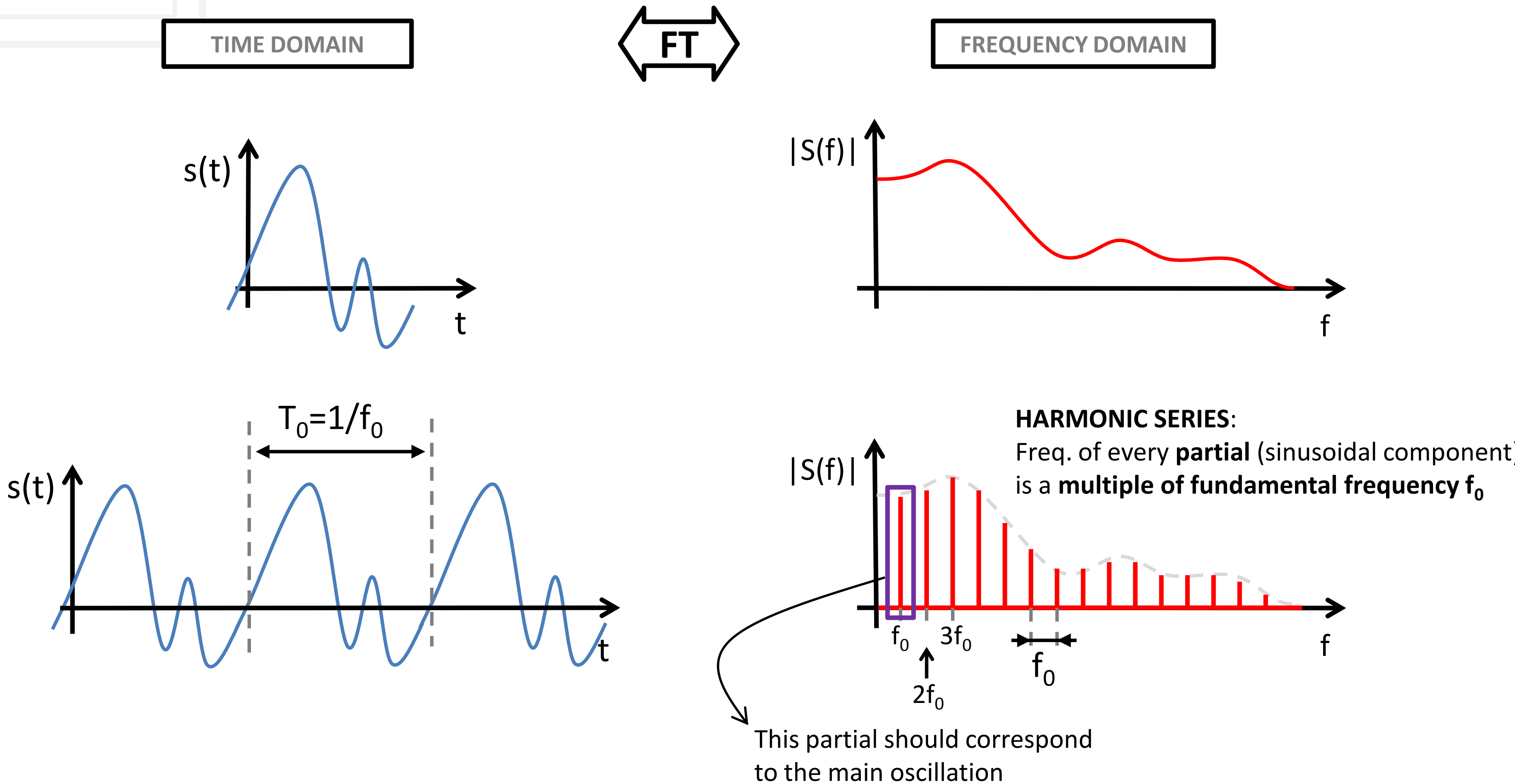
FOURIER TRANSFORM OF PERIODIC SIGNALS



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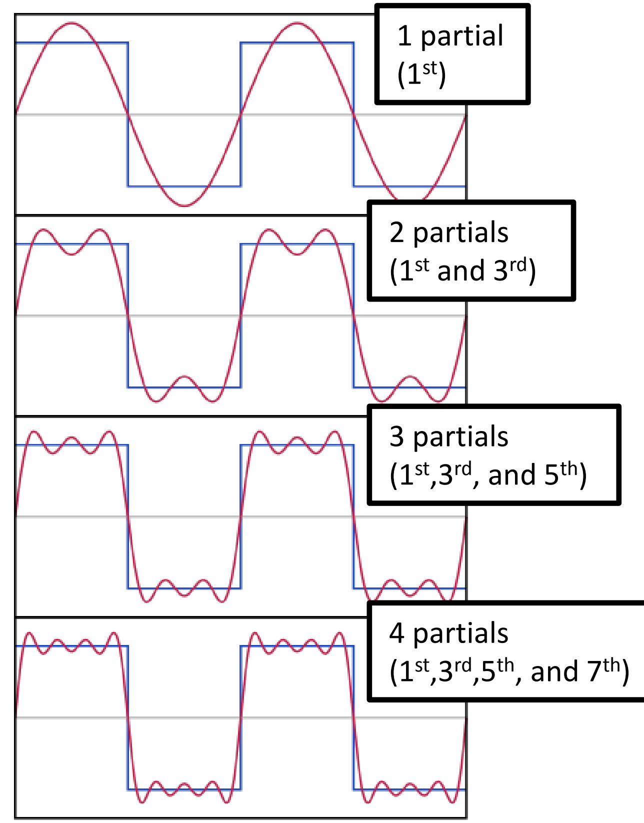
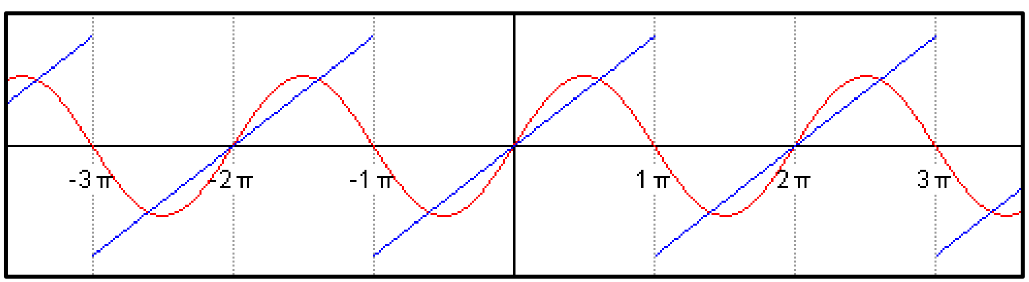
EXAMPLE

Reconstruction of periodic signals using finite number of partials / harmonics.

ORIGINAL SIGNAL

RECONSTRUCTED





http://www.youtube.com/watch?v=Lu2nnvYORec
http://www.youtube.com/watch?v=SpzNQOOBeRg

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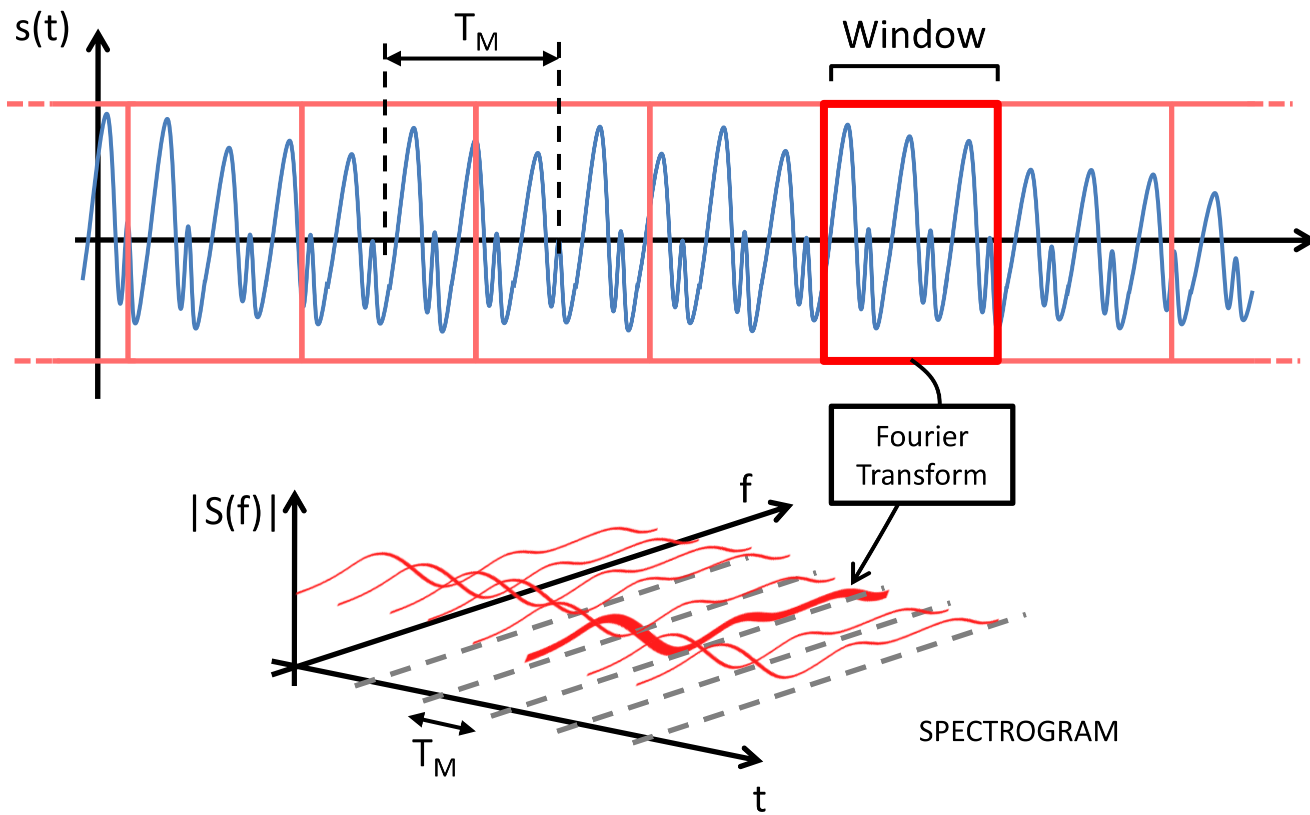
SHORT-TIME FOURIER TRANSFORM | SPECTROGRAM

Time sequence frequency domain representations



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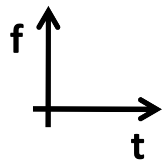
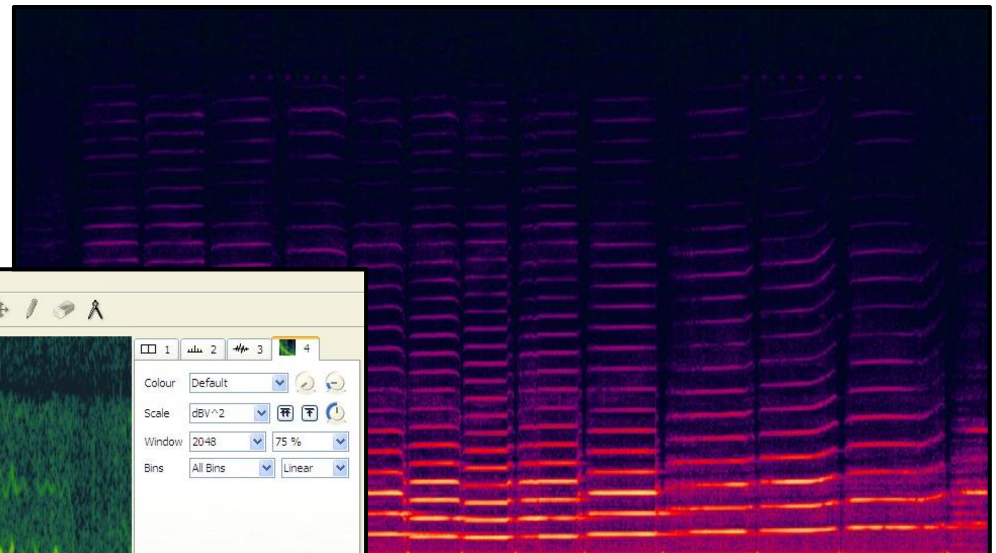
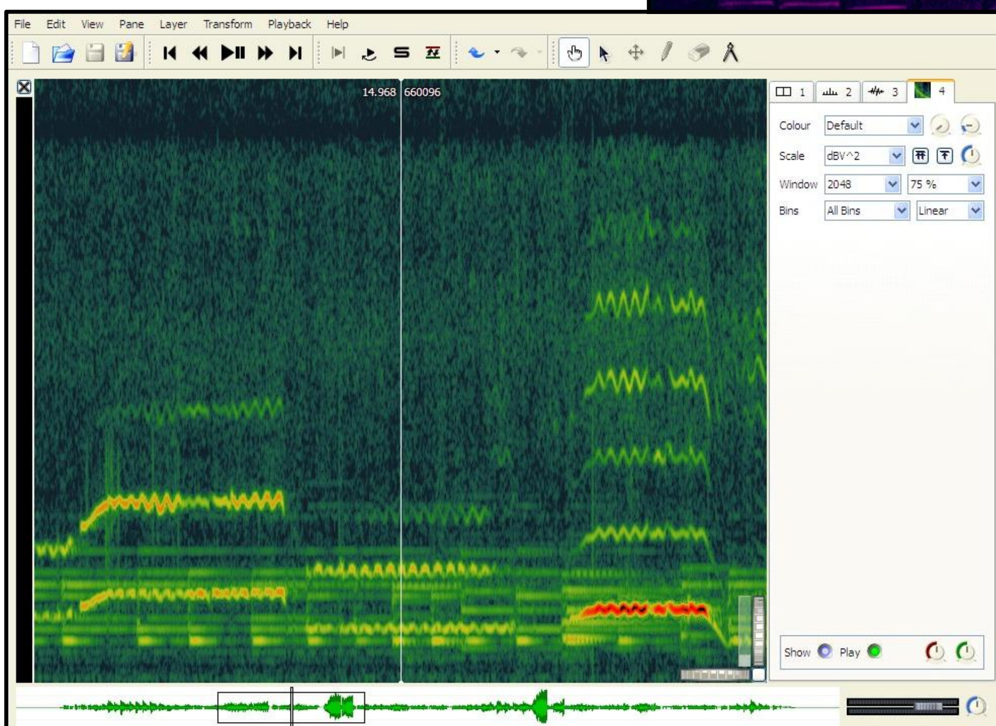
EXAMPLE SPECTROGRAMS





CELLO PLAYING LOW NOTES
LOW FUNDAMENTAL FREQUENCY
NO VIBRATO



SOPRANO SINGING VOICE (in very old recording)
HIGH FUNDAMENTAL FREQUENCY
VIBRATO [software *SonicVisualizer*]

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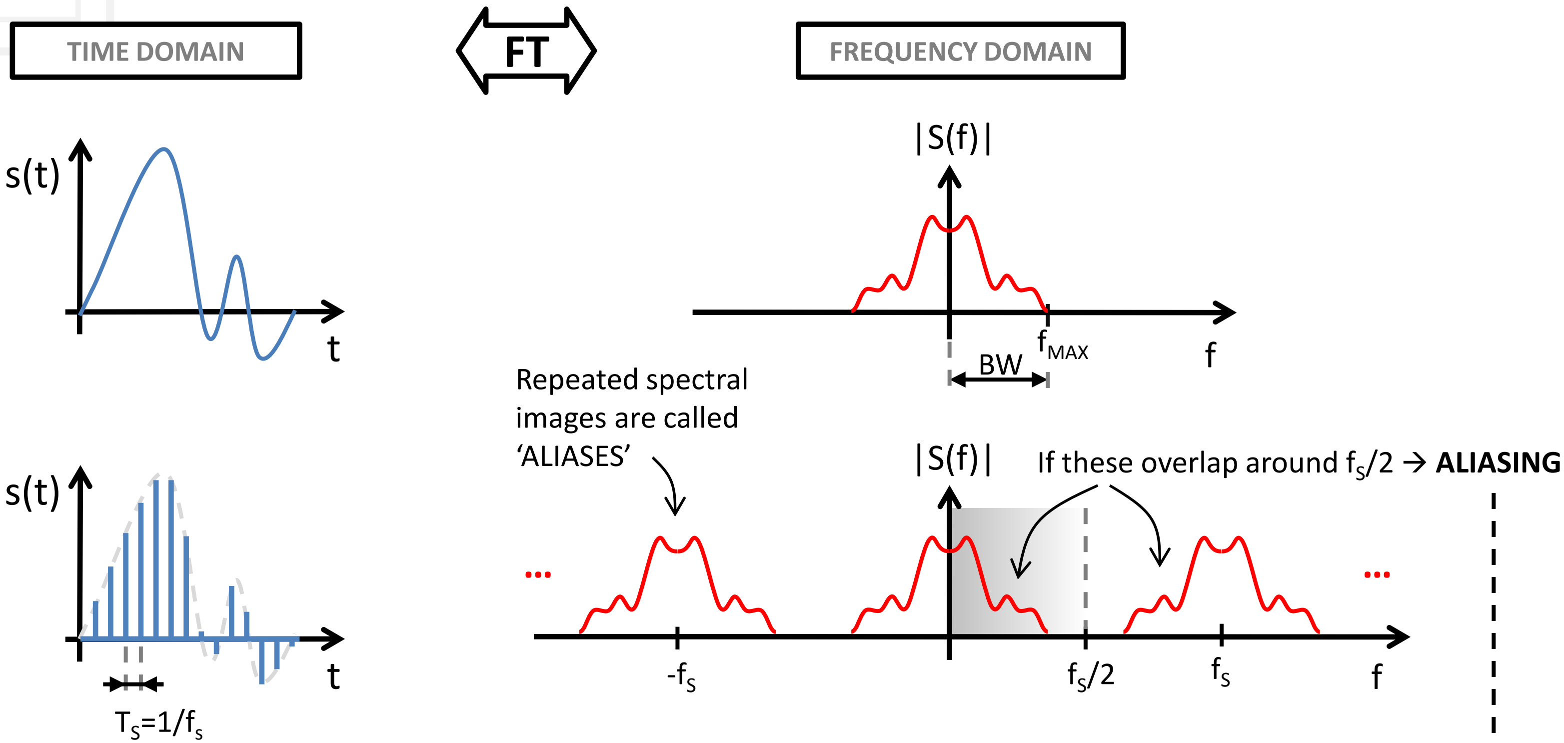
FOURIER TRANSFORM OF SAMPLED SIGNALS



$\mathbf{f_s}$ = sampling frequency

$\mathbf{f_s/2}$ = Nyquist frequency
BW = Bandwidth

NYQUIST-SHANNON THEOREM

Sampling frequency $\mathbf{f_s}$ must be at least twice the bandwidth **BW**

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DECIBELS | LOGARITHMIC SCALES

deciBel (dB)

[1920s - ***Bell Labs*** defined it to measure losses in telephone cable]

Logarithmic unit indicating the ratio of a physical quantity (power or intensity) relative to a specified/implied reference level:

- Power units (e.g. Watts): $L_{dB} = 10 \cdot \log_{10}(P/P_{ref})$
- Amplitude units (e.g. Volts): $L_{dB} = 20 \cdot \log_{10}(V/V_{ref})$

→ Logarithmic scales (intensity and frequency) are more representative of **human perception**.

frequency { **decade**: $\log_{10}(f/f_{ref})$; **octave**: $\log_{2}(f/f_{ref})$