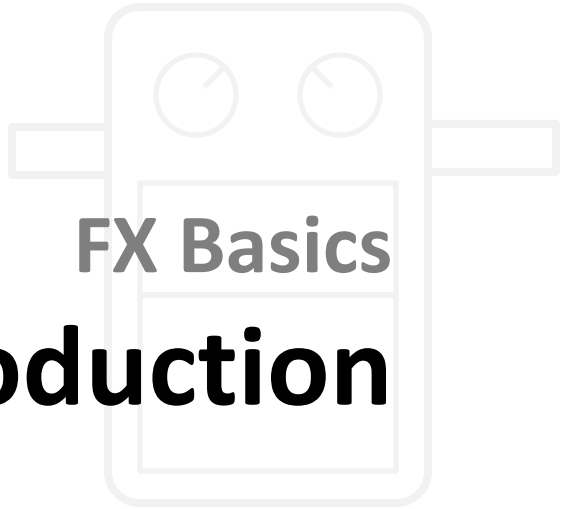


FX Basics

Introduction

STOMPBOX DESIGN WORKSHOP

Esteban Maestre

CCRMA - Stanford University
August 2013

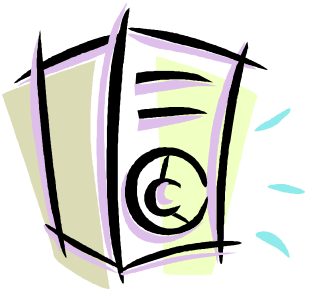
FX Basics: **Introduction**

User controls

STOMPBOX
(effect unit)

AMPLIFIER
(speaker driver)

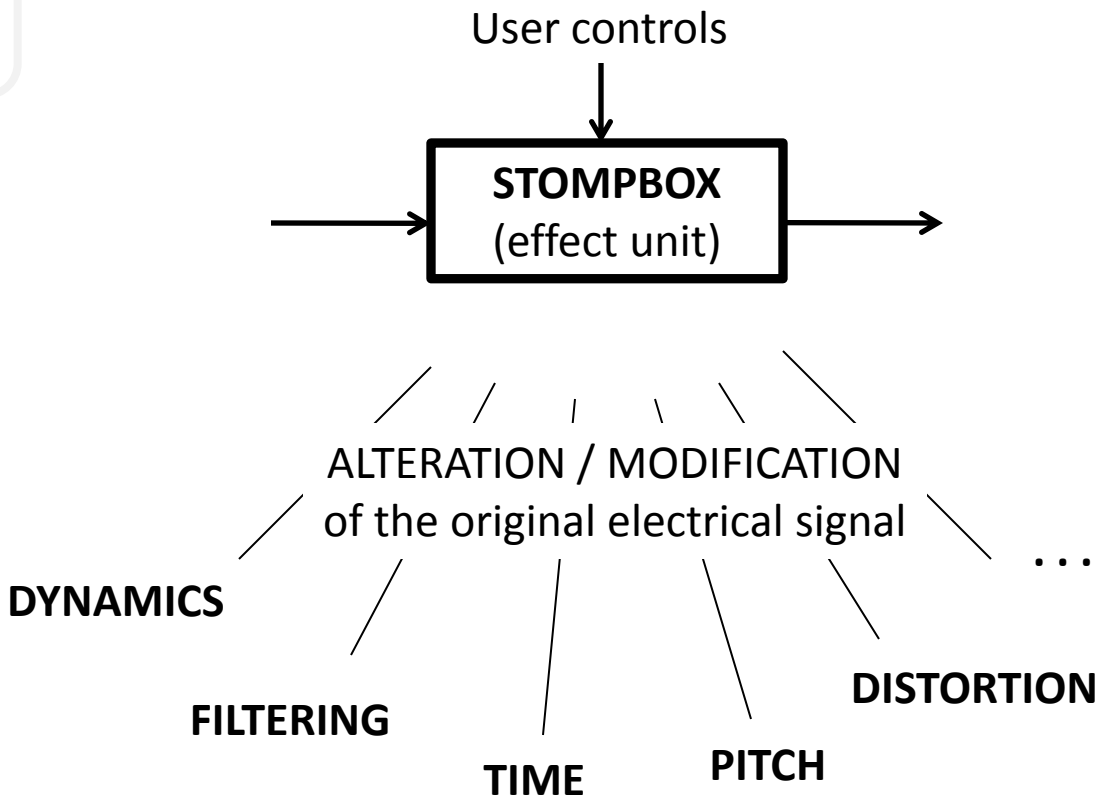
These two often in the same *box*



Pickup transforms string vibration into electrical signal

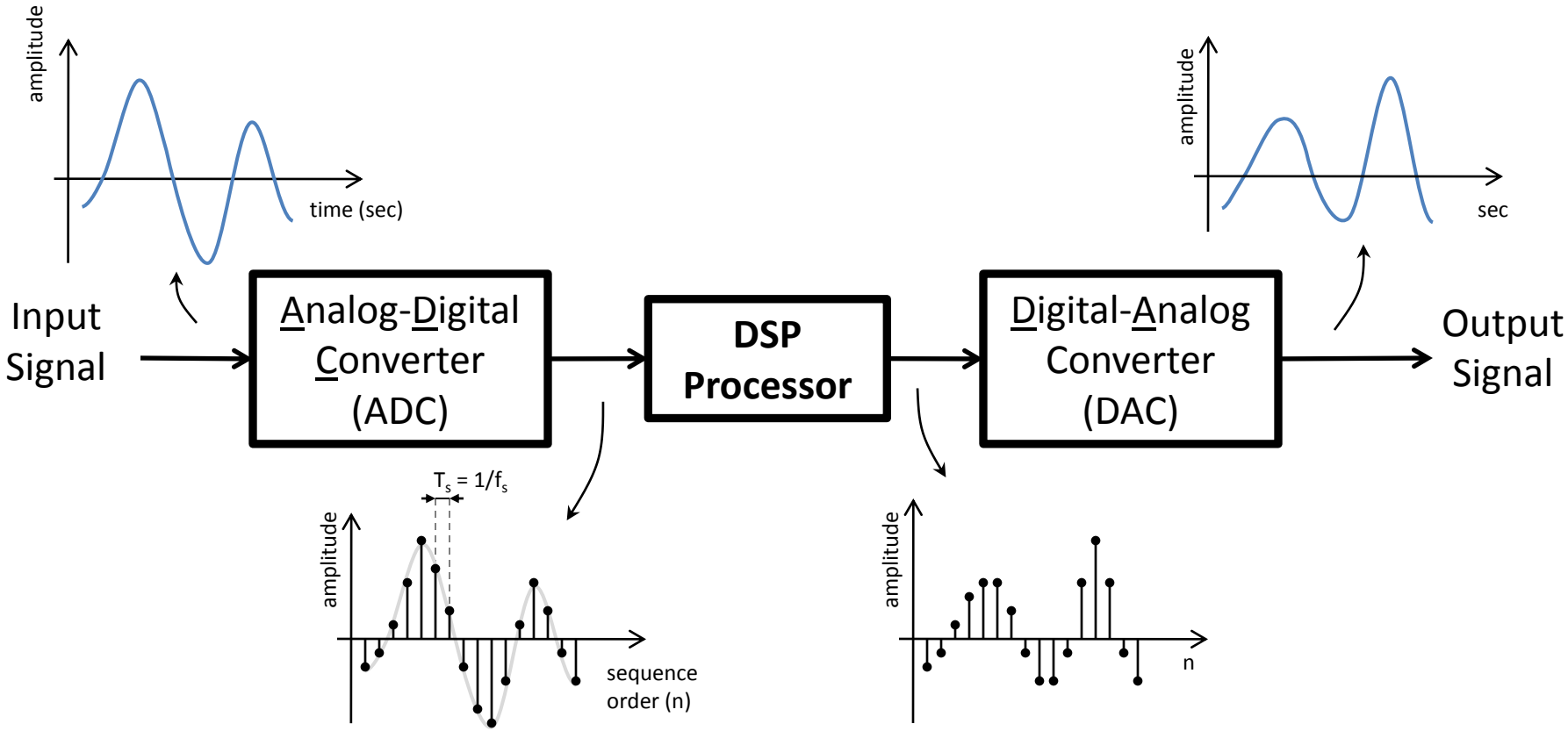
Speaker transforms electrical signal into air vibration

FX Basics: **Introduction**



FX Basics: **Introduction**

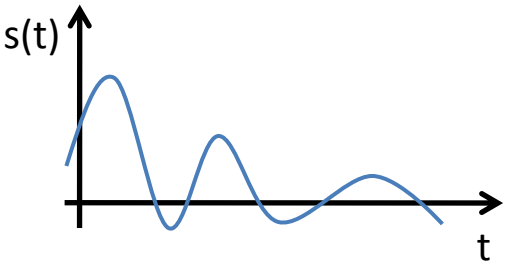
Stompboxes traditionally operated in the analog domain.
Here we will work with signals in the digital domain, by means of Digital Signal Processing (**DSP**) techniques.



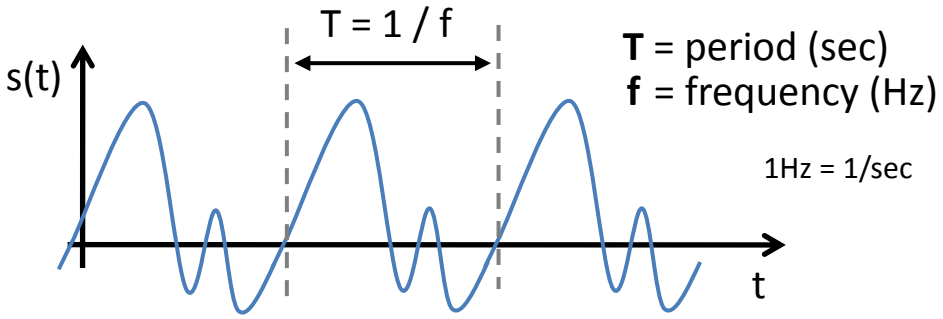
FX Basics: **Introduction**

SIGNAL | PERIODIC SIGNAL

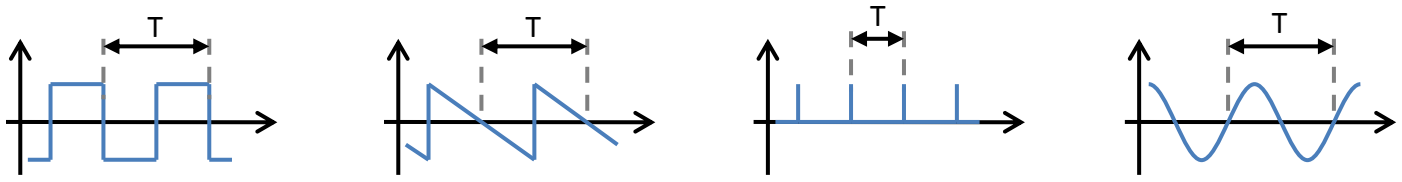
Signal: function of time, representing a given magnitude



Periodic Signal: signal whose value profile repeats over time: $s(t+\mathbf{T}) = s(t)$

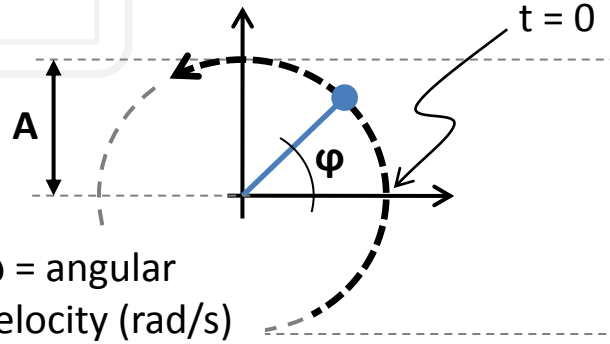


Some examples of basic periodic signals:



FX Basics: **Introduction**

SINUSOIDAL SIGNAL



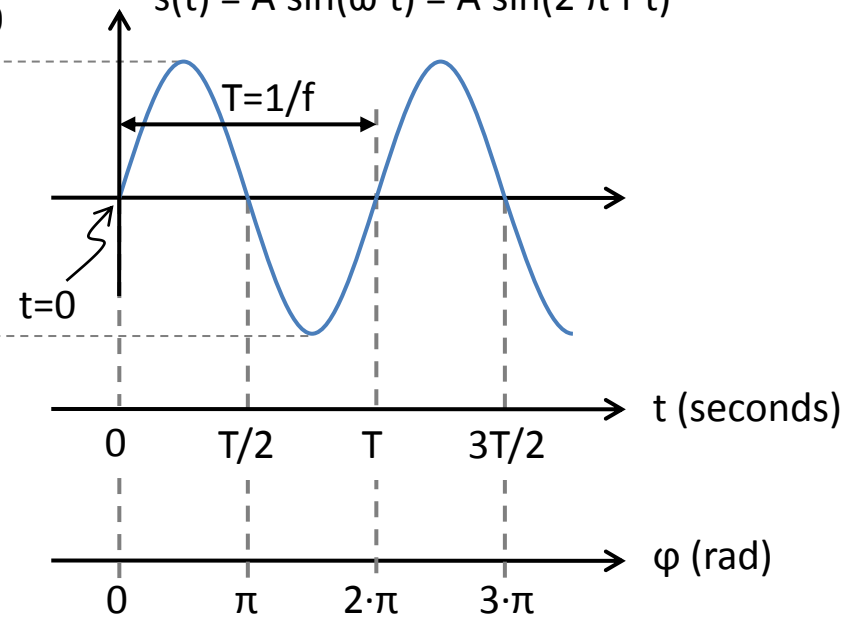
ω = angular velocity (rad/s)

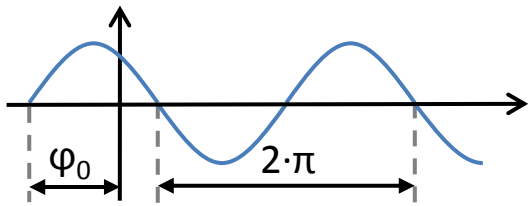
A = amplitude

Angle φ at time t

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

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



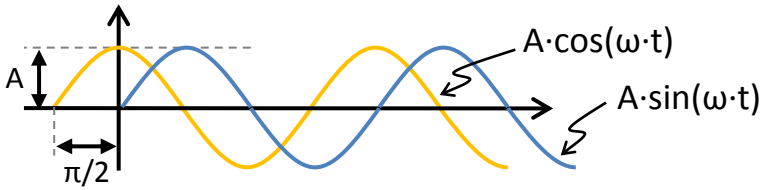


φ_0 = phase (initial φ at time t =0)

Angle φ at time t

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

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



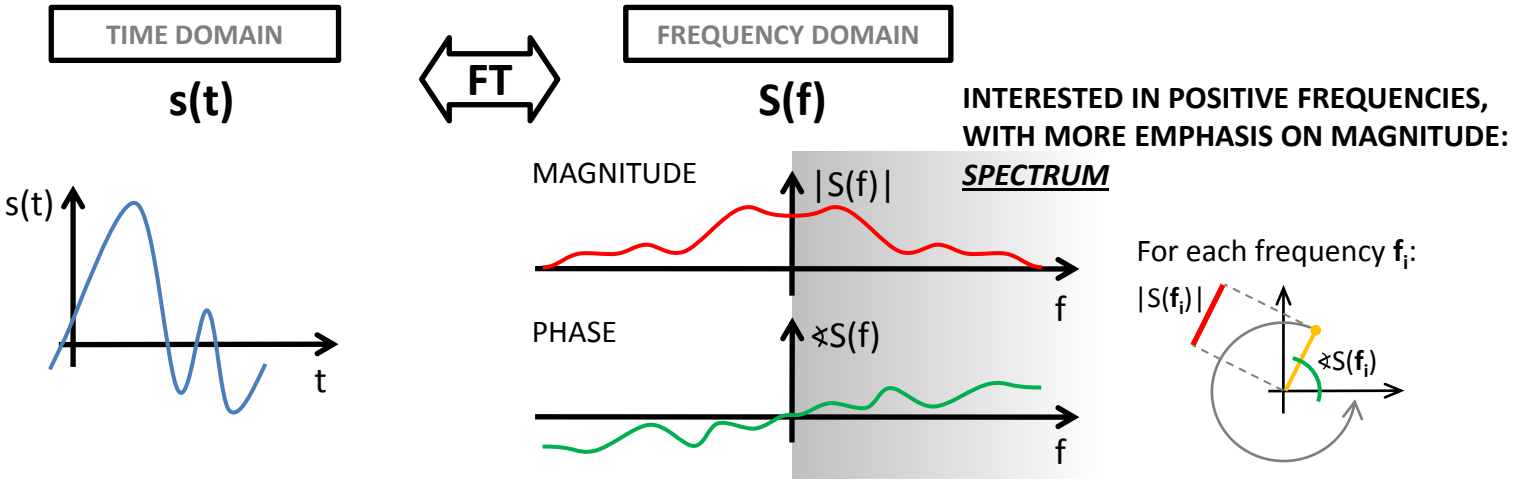
FX Basics: **Introduction**

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**.

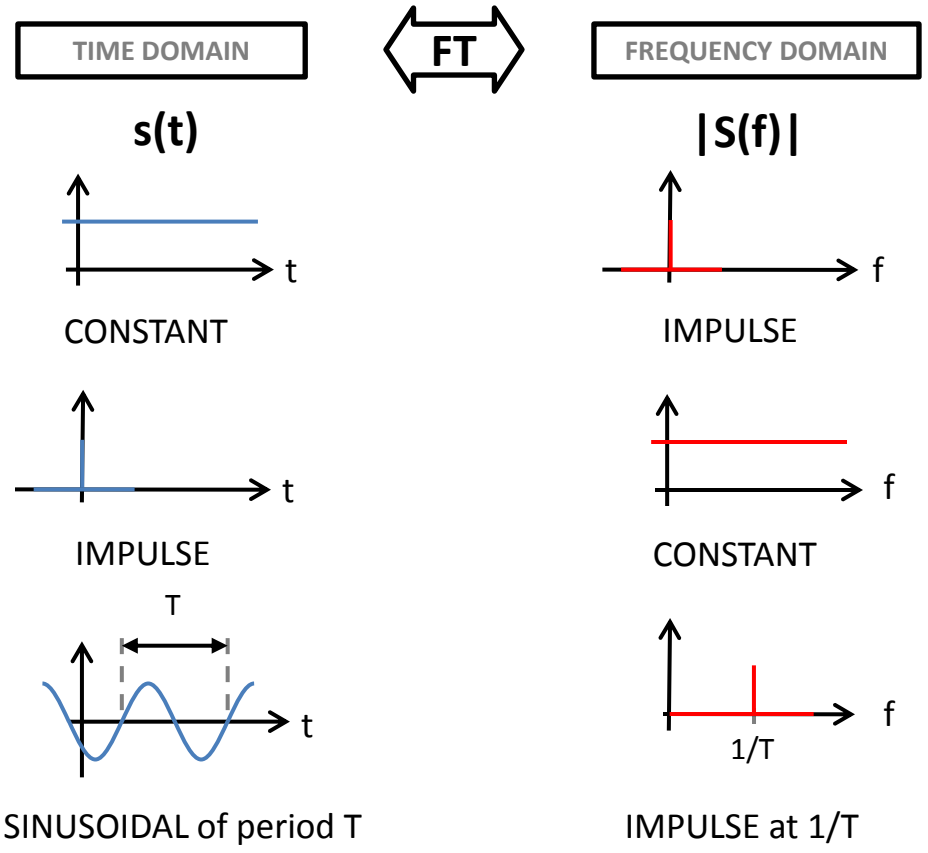
Such function, previously expressed in the **Time Domain**, can therefore be expressed in the **Frequency Domain**.

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



FX Basics: **Introduction**

FOURIER TRANSFORM OF IMPORTANT SIGNALS

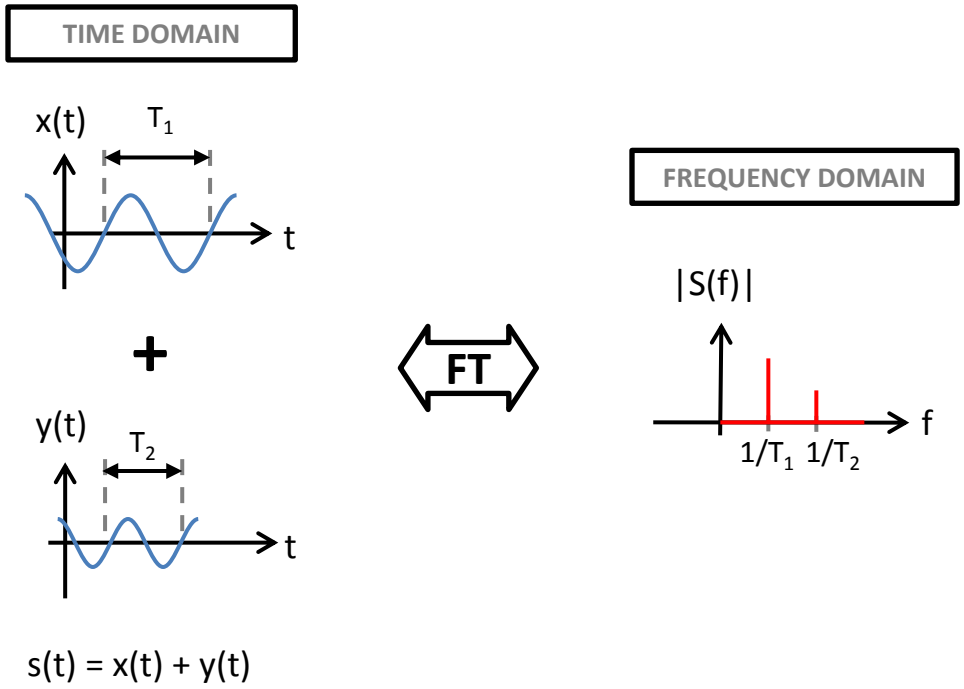


FX Basics: **Introduction**

LINEARITY

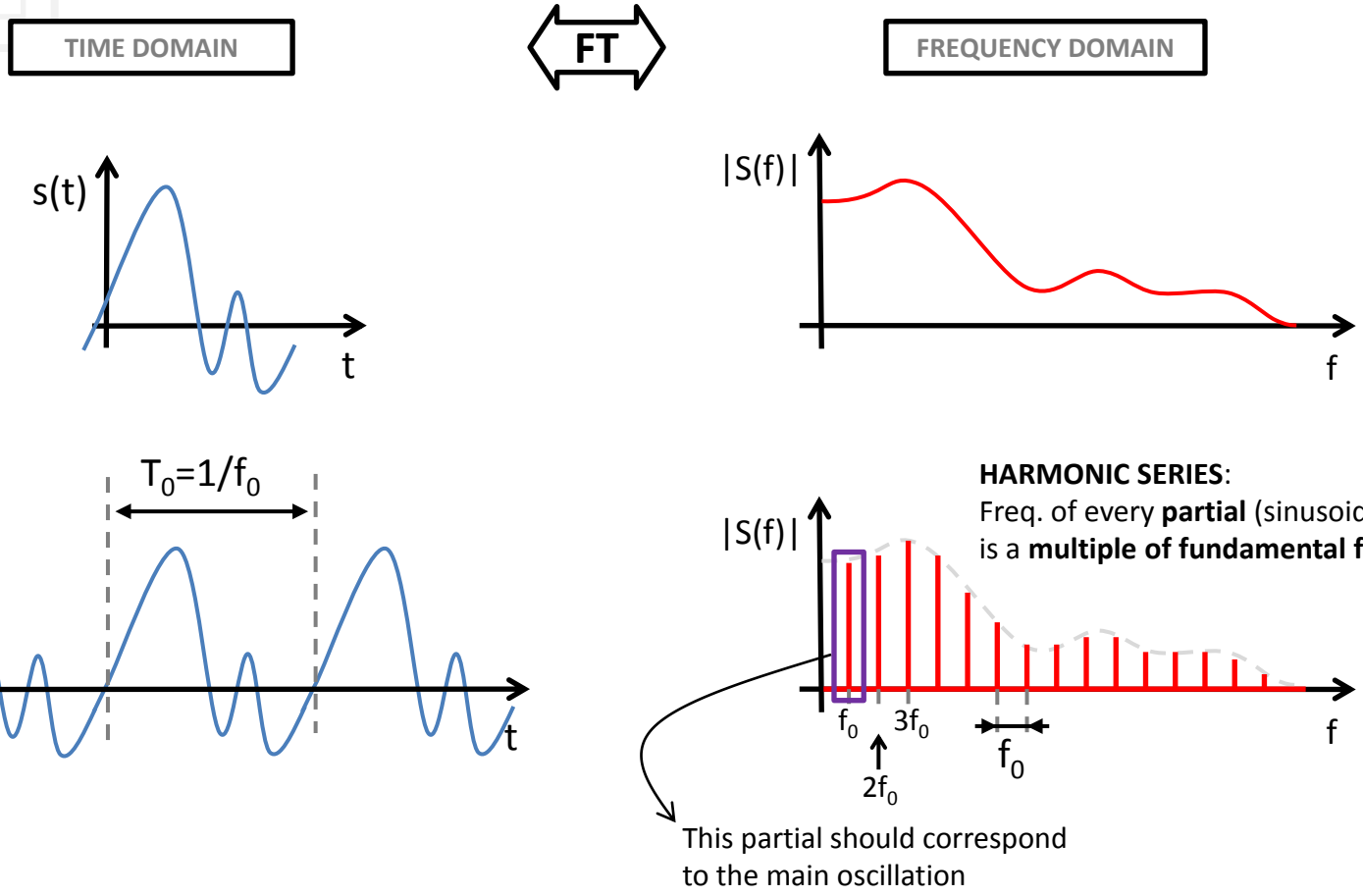
The **Fourier Transform**, **F[]**, is a **linear operation**:

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



FX Basics: **Introduction**

FOURIER TRANSFORM OF PERIODIC SIGNALS



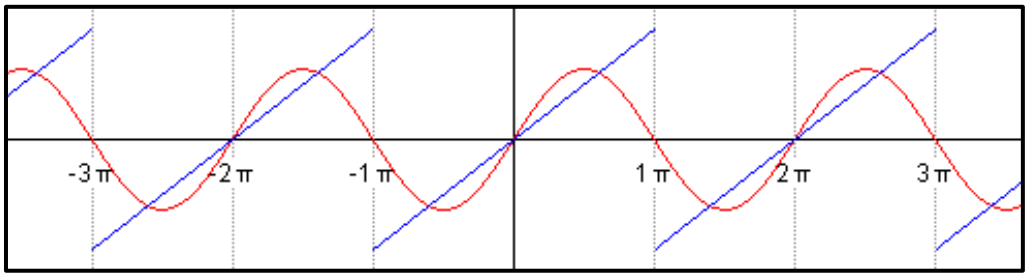
FX Basics: **Introduction**

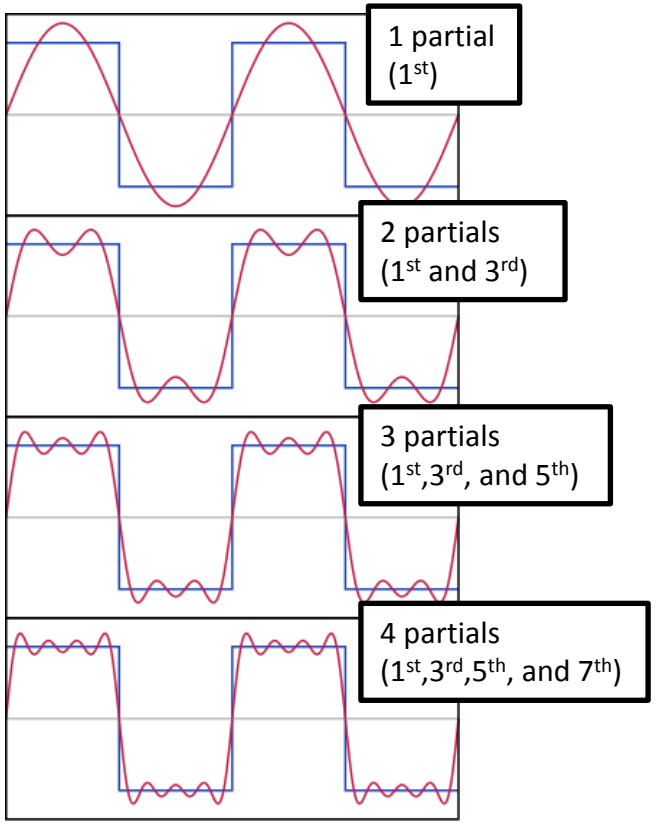
EXAMPLE

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

ORIGINAL SIGNAL

RECONSTRUCTED



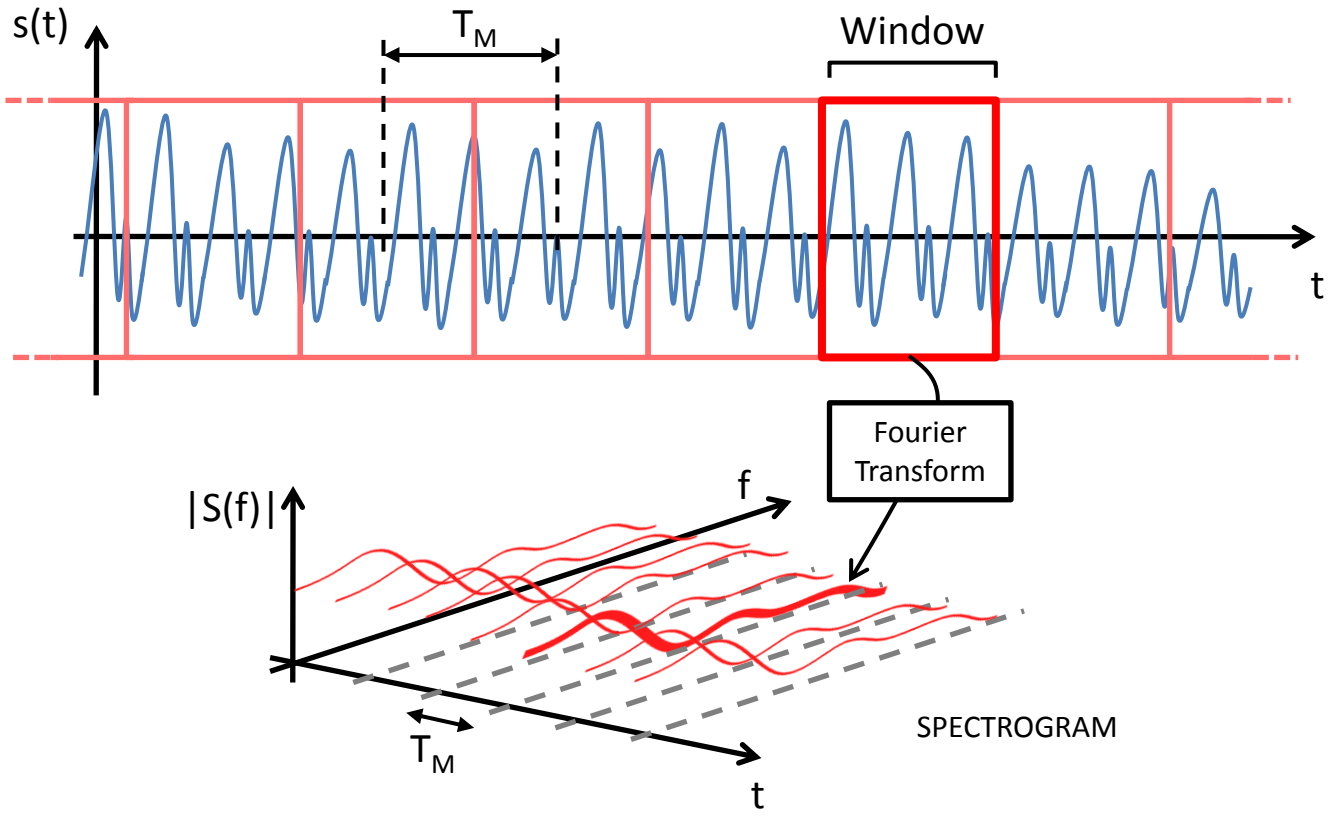


http://www.youtube.com/watch?v=Lu2nnvYORec
http://www.youtube.com/watch?v=SpzNQOOBeRg

FX Basics: **Introduction**

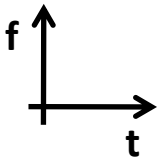
SHORT-TIME FOURIER TRANSFORM | SPECTROGRAM

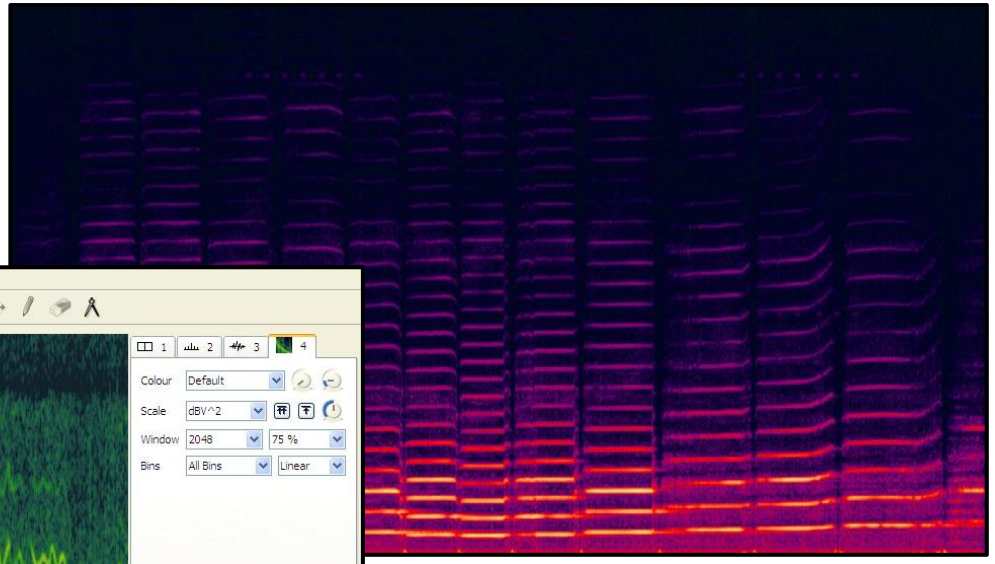
Time sequence frequency domain representations



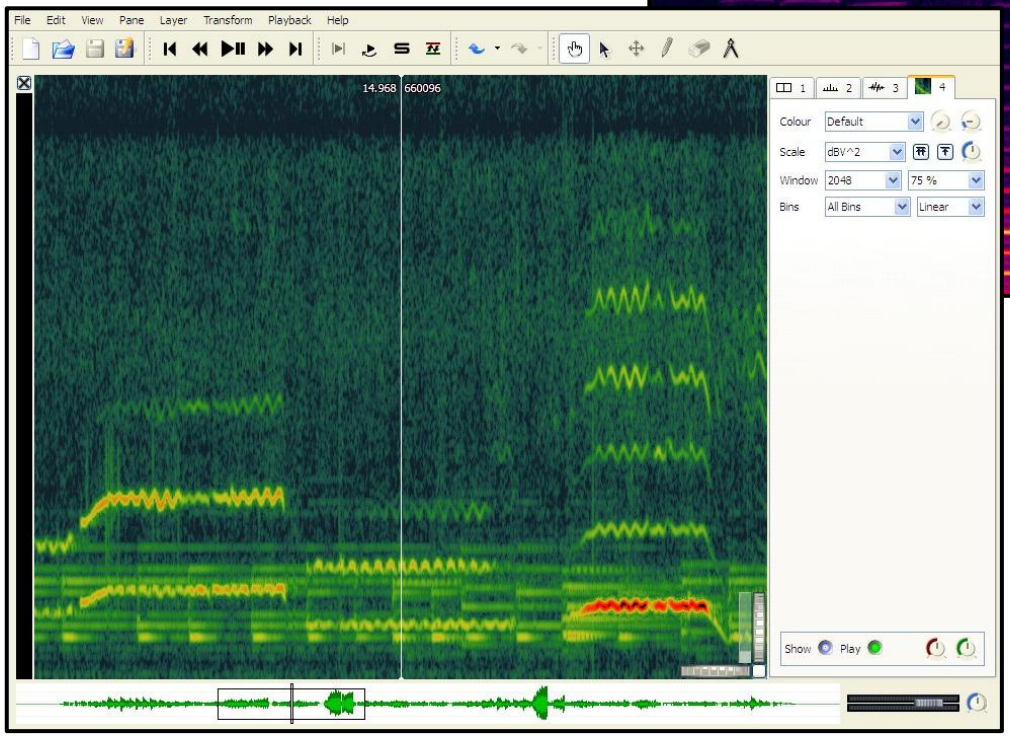
FX Basics: **Introduction**

EXAMPLE SPECTROGRAMS





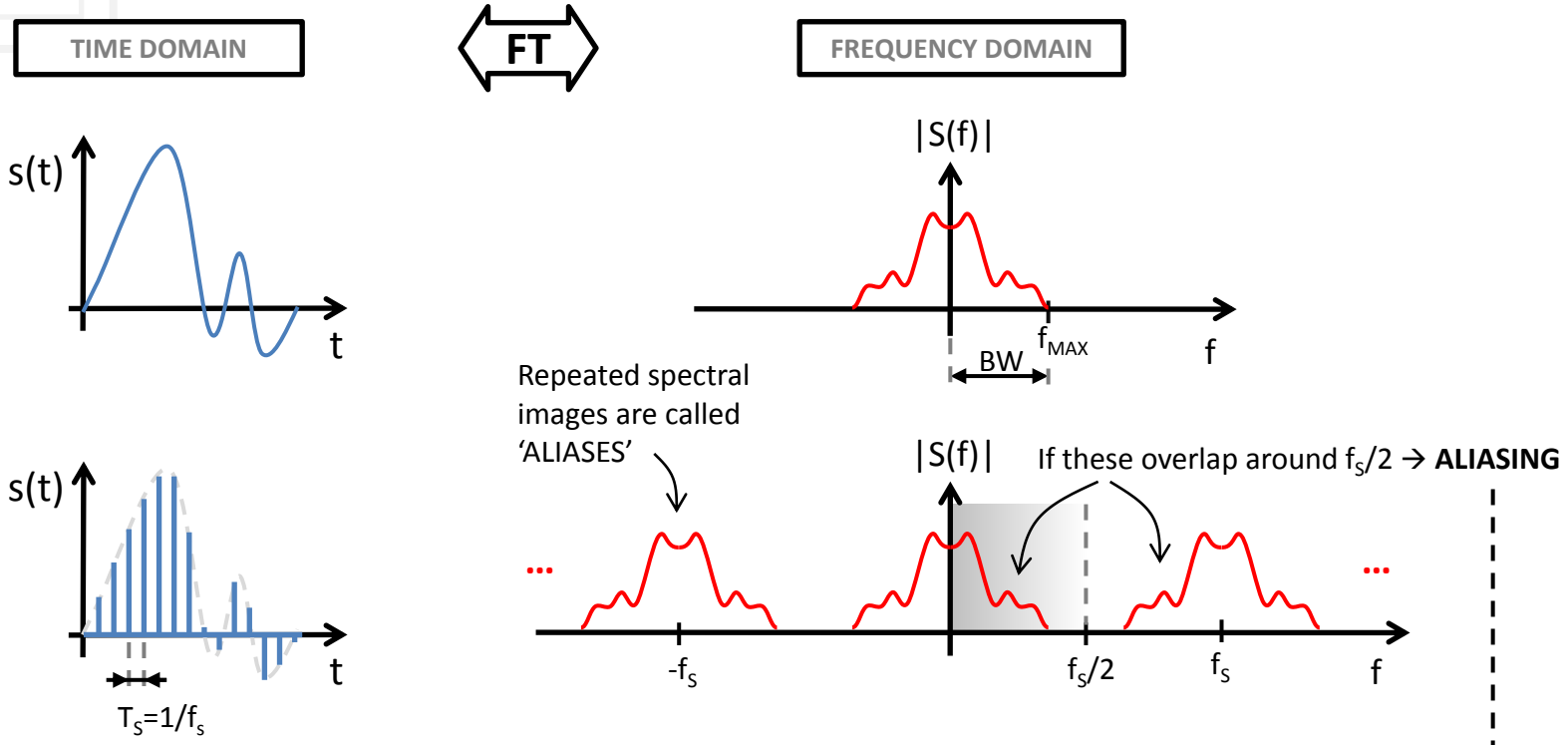
CELLO PLAYING LOW NOTES
LOW FUNDAMENTAL FREQUENCY
NO VIBRATO



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

FX Basics: **Introduction**

FOURIER TRANSFORM OF SAMPLED SIGNALS



f_s = sampling frequency

$f_s/2$ = Nyquist frequency
BW = Bandwidth

FX Basics: **Introduction**

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**.