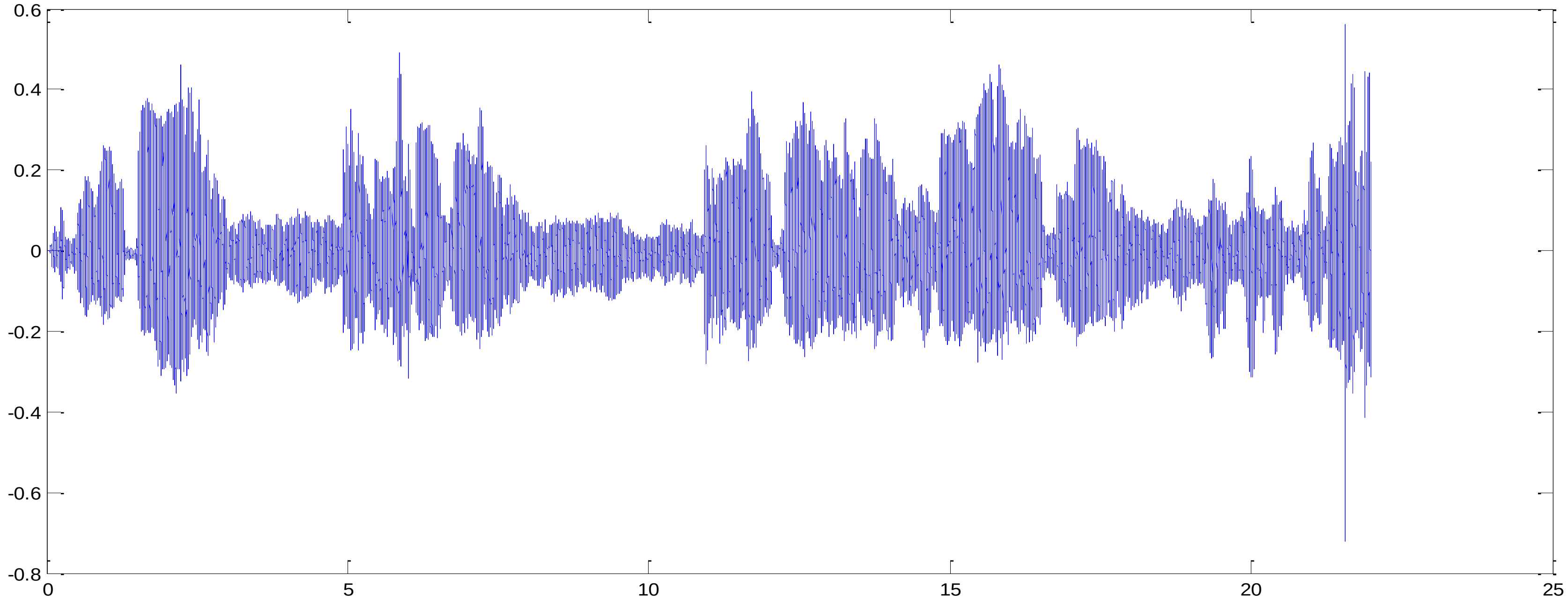
# DIGITAL SIGNAL PROCESSING

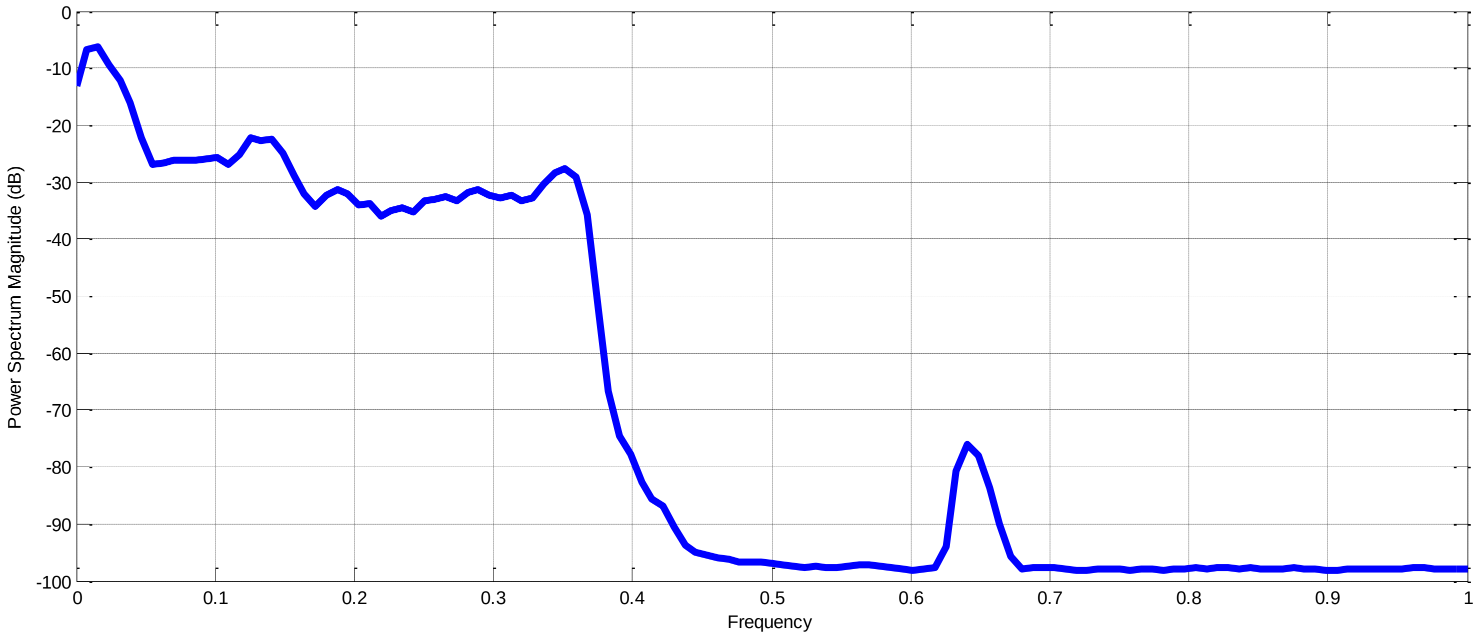
INTRODUCTION

# IF I WERE A BOY – BEYONCÉ
# amplitude-time graph




Duration is 22s [0:00-0:22]. There are 10000000 samples. ADC Sampling frequency is 44.1KHz

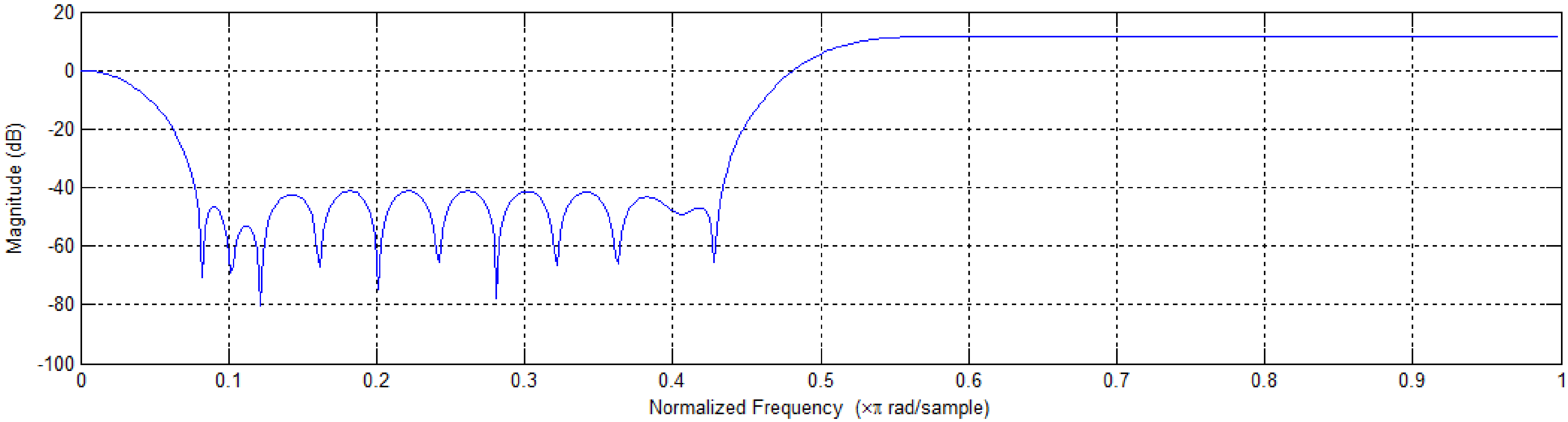
# If I were a boy – Beyoncé
# Power Spectral density



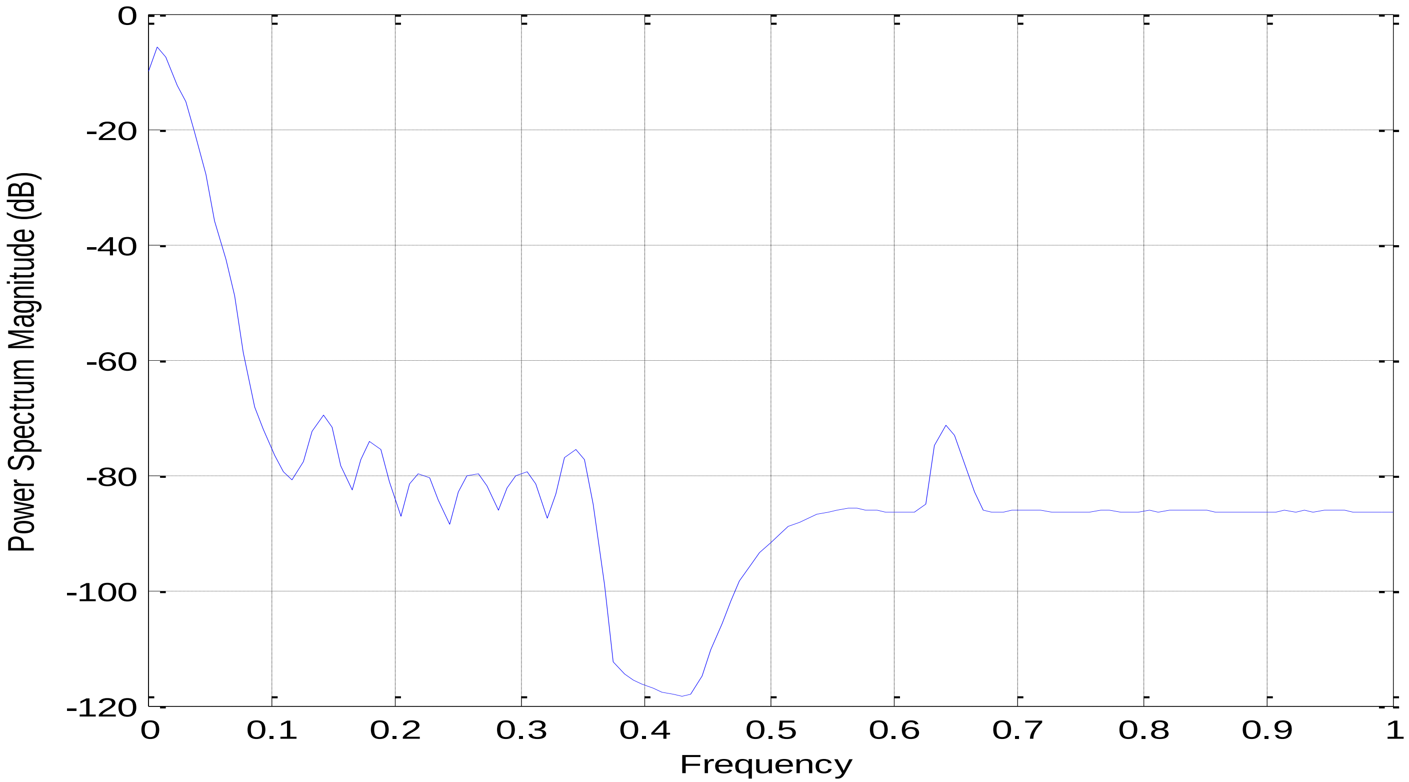

Power spectral density plot. Frequencies concentrated in 0-0.4π radians/sample. There is something in the song playing at frequencies between 0.6 π -0.7 π rad/sample.

# Bandstop filter

attenuates all frequencies between 0.1 π and 0.5 π samples per second



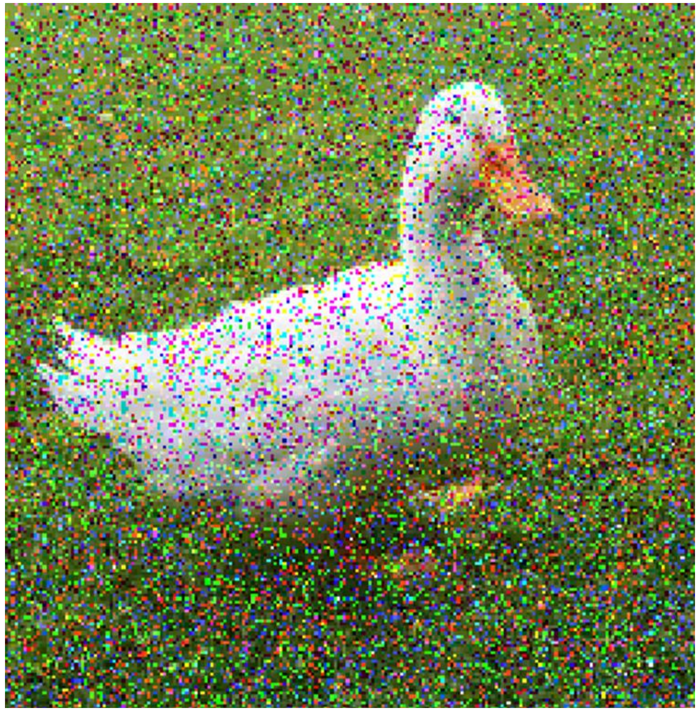
# new power spectral density




Notice the massive attenuation in the stop band

# Image processing application

humble duck on green background



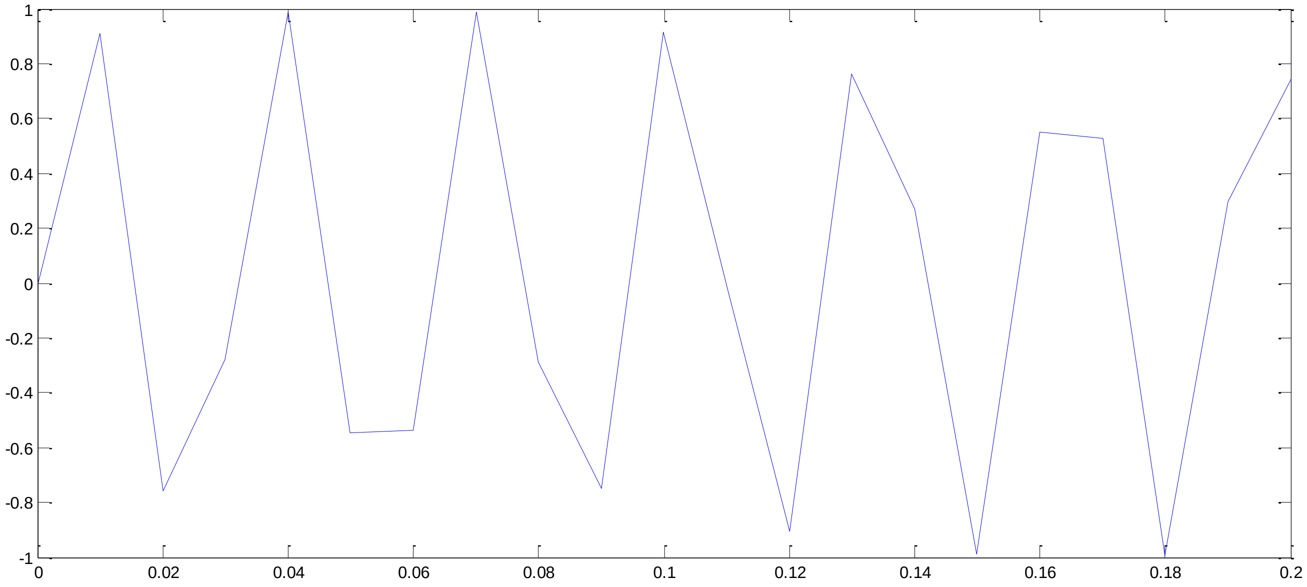
If the actual noise array that was added to the image is known, the image can be restored.

# Signal analysis

Consider

$$y = \sin 200\, t$$

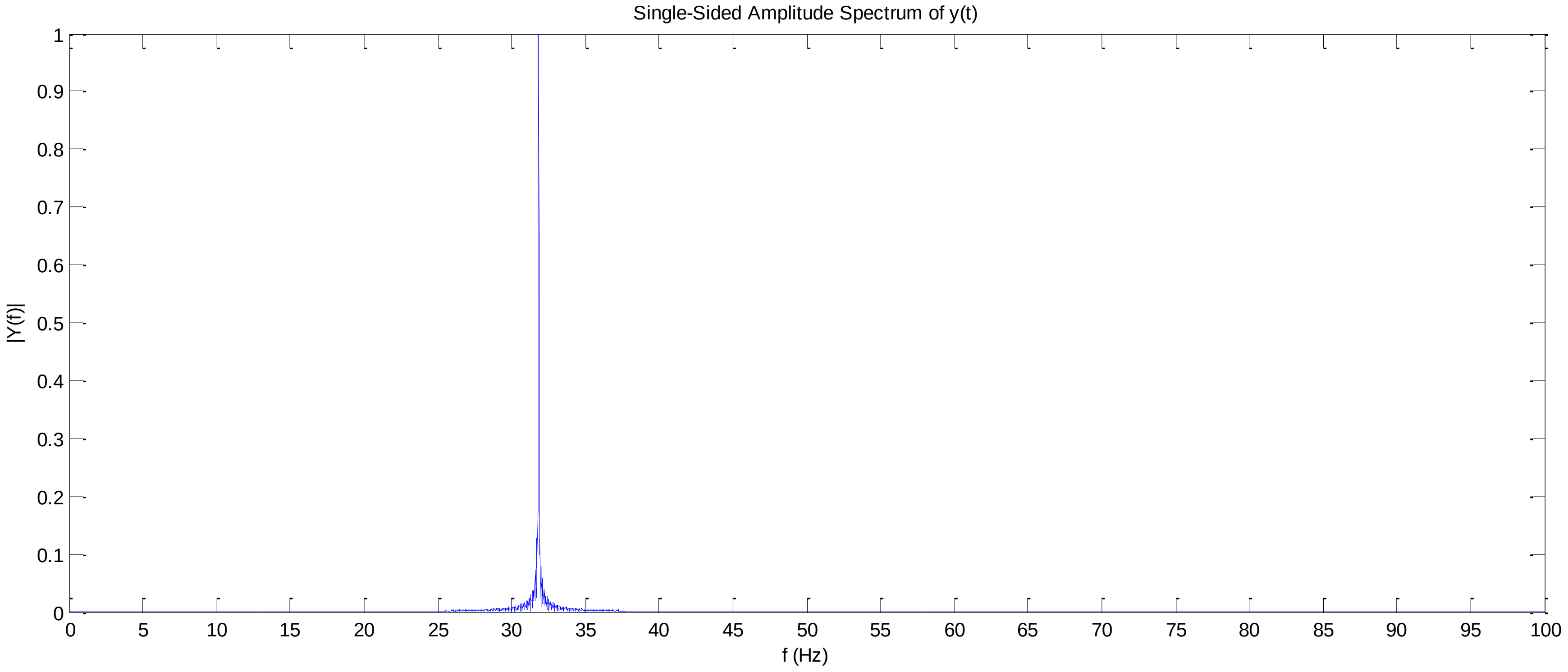
A plot of y is shown




MATLAB implementation:

```
t = [0:0.01:0.2;
y = sin(200*t);
Plot(y);
```

# Its (digital) Fourier transform




There is a peak at 32Hz. $200 = 2\pi f$

# Signal analysis

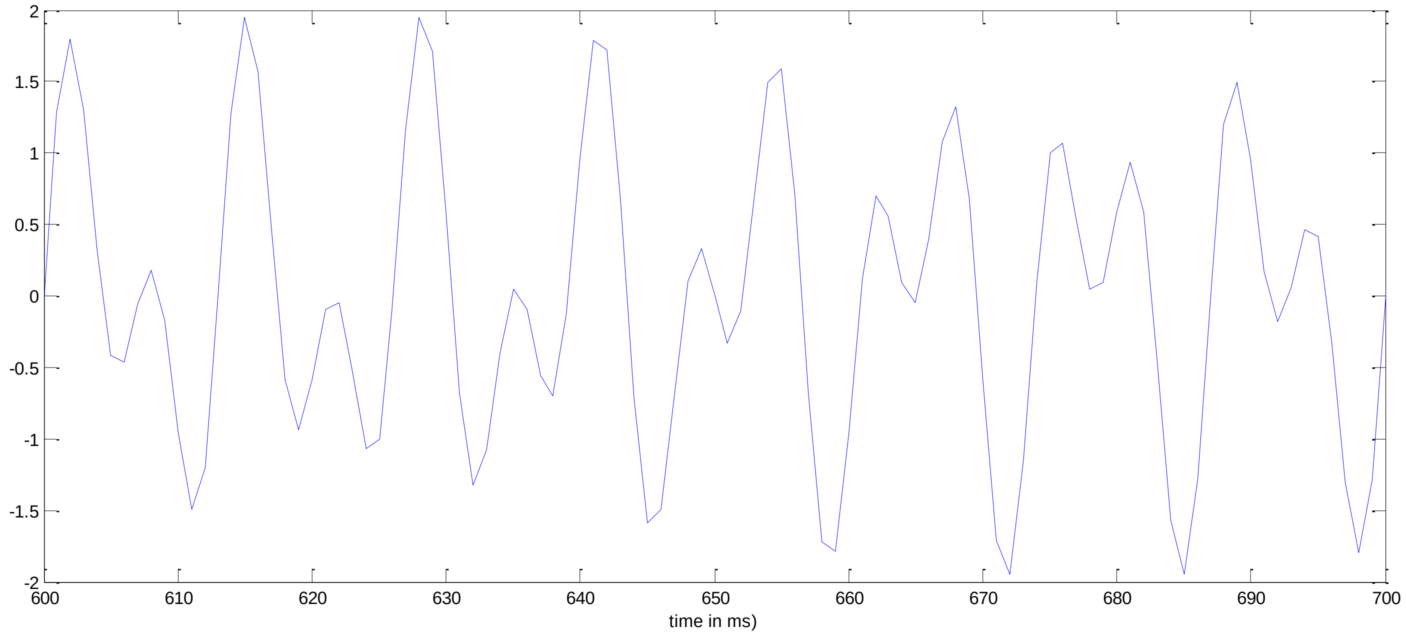
Consider

$$y = \sin 2\pi f_1 t + \sin 2\pi f_2 t$$

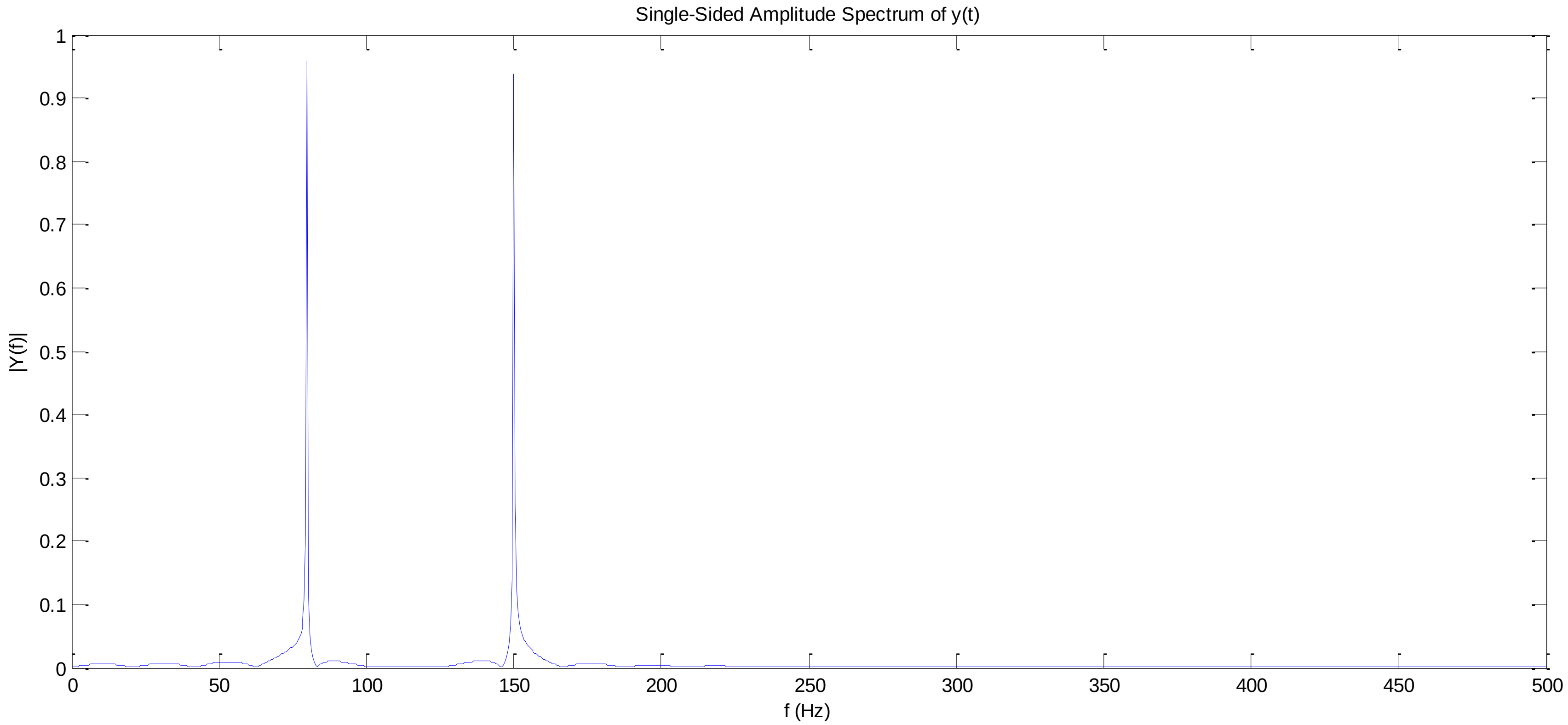
where

$$f_1 = 80\,; f_2 = 150$$

**A plot of this is shown**



# Fourier…




The Fourier analysis of the signal shows the frequency concentration at 80 and 150 Hz as expected.

# History and overview

The real world is analog. If we connect an analog-to-digital converter to a computing system and use it to acquire some real world data, everything that follows is DSP. In most cases, these analog originate as sensory data from the real world: seismic vibrations, visual images, sound waves, pressure pulses etc. Digital Signal Processing is the mathematics, algorithms, and techniques used to manipulate these signals after they have been converted into a digital form so as to achieve many things such as: image enhancement/restoration, speech recognition, speech generation, data compression etc. The ultimate aim is usually for storage, transmission or display. Applications are mainly in telecommunications, Multimedia and Instrumentation.

# subfields

DSP includes subfields such as audio and speech signal processing, digital image and video processing ,spectral estimation, sound signal processing (sonar), statistical signal processing, signal processing for telecommunications and medical signal processing

# DSP without knowing it

In Telecom:

1. Your mobile phone contains an 8-bit DSP that samples at 8KHz. Speech encoding in GSM compresses the speech waveform using Regular Pulse Excited - Linear Predictive Coding (RPE-LPC) before sending it over the air.

In Multimedia

CASE: MPEG4 (H.264 video, AAC audio)

Any .mp4 video will almost always be smaller than its MPEG-2 (in most DVDs) or AVI counterparts. NB: a DVD video object (VOB) contains MPEG-2 video, MPEG-1 or MPEG-2 encoded audio and subtitles.

In video compression, we want to throw away as much information as possible without affecting the experience of the viewer. MPEG-4 uses subsampled YUV instead of RGB values and cuts the video size by almost 1/2. This is possible as the human eye is not as sensitive to colour as it is to brightness. In YUV, Y= brightness, U and V values represent colour. Hence some of the colour information can be thrown away reducing the file size, without the viewer noticing any difference.

It also employs temporal and spatial redundancy.

In instrumentation

1. In signal acquisition in areas such as medical instrumentation, we usually need to condition the signal and remove unwanted parts. This may be done in the time domain or frequency domain

# Why DSP?

- DSP is cheap. Its really cheap
- DSP is portable.

- However,
- DSP is slow compared to use of analog filters