

# ITA-Toolbox – An Open Source MATLAB Toolbox for Acousticians

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## Introduction

Recently, a toolbox for MATLAB has been developed to solve common post-processing tasks in the field of acoustic research, including data import and export as well as different graphical representations of the data. This toolbox has also been successfully applied to laboratory exercises and measurement tasks within the institute as well as at partner universities, as already published by the authors [1, 2, 3]. In the past, a license was available only for academic and/or educational purpose, excluding potential users from the industry. In 2011 the conditions for using the ITA-Toolbox were changed to an open-source license in order to provide a larger audience with the taylor-made framework for acoustical signal processing in MATLAB.

## Concept – Object Orientation

Acoustical measurement or simulation data is commonly stored numerically in vector or matrix format. Associated with the data is the need to store meta information, e.g. sampling rates, comments, coordinates, domain or physical units. Programming a container for all these different types of data can be realized efficiently by using the concept of object-orientated programming (OOP). Even if still not very common, new versions of MATLAB support the basic concepts of OOP. Based on the need to

cal or spherical coordinates or vice versa. The object stores the data along with the information of the domain it is stored in (*itaCoordinates*). By simply using *.cart* for cartesian or *.sph* for spherical representation the data is converted according to its current and the target representation.

Audio data is commonly much more complicated than single values or coordinates. The same concept is therefor used and extended towards a class called *itaAudio* that stores equidistantly sampled audio data from measurements or simulations in either time or frequency domain. The time domain data can always be accessed by *.time* and the frequency data by *.freq*. The according time stamps or the frequency vector for plots are calculated by *.timeVector* and *.freqVector* respectively. Furthermore, simple mathematical operations, e.g. multiplication (*\**), division (*/*), summation and subtraction (*+*, *-*) are implemented for these audio objects. This enables the user to directly write formulation in a text book manner. Hence, multiplications and divisions are realized in the frequency domain. Some basic syntax can be seen in Figure 1, Figure 2 show *OOP* as one of the of the fundamental concepts.



Figure 1: Object-orientation for the ITA-Toolbox using MATLAB.

calculate with physical symbols including their physical unit a class called *itaValue* has been developed. The objects of the class store the value along with a physical unit. It is capable of calculating values and units for multiplication and division of two variables. Coordinates are a good example to show the benefit of using OOP for transformation purposes, e.g. from cartesian to cylindrical



Figure 2: Overview of the functionality of the ITA-Toolbox for MATLAB.

## Functionality

The basic functionality is shown in Figure 2 divided into different groups, with the concept of *OOP* already explained. The remaining circles are described in clockwise direction: the import and export routines are summarized in two functions `ita_read` and `ita_write` that are capable of reading and writing common data formats, e.g. `.wav`, `.uff`, `.unv`, `.csv`, `.mat`. The import routine automatically searches for meta data and integrates this information into the audio objects. Once data is stored in the `itaAudio` format various plot routines are directly available by using, e.g. `.plot_freq`, `.plot_time` and `.plot_spectrogram` for frequency, time and spectrogram domain plots as shown in Figure 3. Additionally, some basic GUIs to import data into the ITA-Toolbox format are shown. For post processing of the data several standard routines are available. The advantage of using m-files of the ITA-Toolbox lies in the meta data stored along with the audio data. There is no need to specify the sampling rate when filtering the data, as it is automatically read from the object itself. All functions, methods and properties of the classes can be accessed via the command line of MATLAB, with direct access to data in both time and frequency domain always possible without explicit Fourier transform.

```

%% Read from HDD (data included in ITA-Toolbox)
h = ita_read('loudspeaker_response_raw.ita');
% plot the frequency domain
h.plot_freq

%% Generate a nice standard sweep
s = ita_generate_sweep();

%% Adapt the sweep to your needs
s = ita_generate_sweep('freqRange',[30 16000]);
% or (these options appear in pairs)
s = ita_generate_sweep('mode','linear');

%% get the compensation for the sweep
comp = ita_invert_freq(s,[30 16000])
% or with an extra filter (this parameter is bool)
comp = ita_invert_freq(s,[30 16000],'filter')

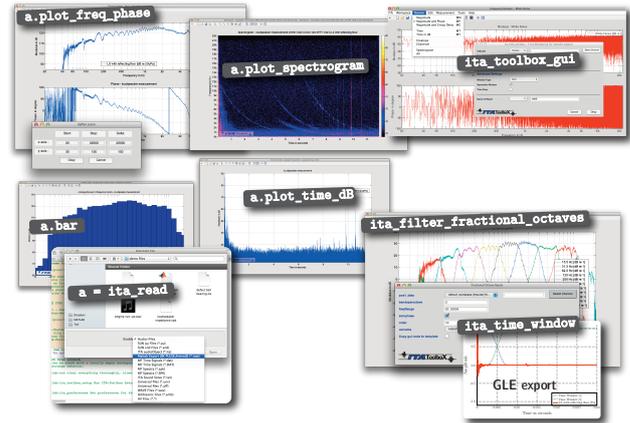
%% calculate the ideal impulse response
h = s * comp;

```

In order to enable a quick and easy start with the ITA-Toolbox some basic MATLAB knowledge is beneficial. An introductory tutorial comes as a MATLAB m-file and also as HTML using MATLAB's new help functionality. Each section starts with an explanation and is followed by an example that can be run out of the box. User tasks are included to directly apply the new approach hands-on. Additionally a *Getting Started* PDF document is included to explain basic concepts and syntax for new ITA-Toolbox users.

Interfaces are available for simultaneous multi-channel audio recording and playback realized using *playrec* and *PortAudio* and MIDI sysex communication via *RTmidi*.

Users of the ITA-Toolbox can easily implement measurement or post-processing tasks in a script-based manner. There is some additional support for so called *Applica-*



**Figure 3:** Various standard plots and basic GUI functionality along with the corresponding simple command line syntax.

tions. Applications use the kernel functions but extend the functionality, e.g. by room acoustic parameter calculation or psychoacoustic evaluation. These applications often regard the specific scientific work and are thus not included in the open-source version. Nevertheless, users are encouraged to write their own applications for in-house application only or in order to contribute to the project.

## System requirements and License

A copy of the ITA-Toolbox can be downloaded at [www.ita-toolbox.org](http://www.ita-toolbox.org). It is published under the original BSD-License, allowing the free use of the software, any modifications and the usage in commercial or non-commercial software, as long as credits to our institution are given. The ITA-Toolbox is compatible with any operating system running MATLAB R2010a or higher. The signal processing toolbox is required for spectral bandpass or fractional octave band filtering and time windows.

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