Signal Measurement System

GOATS measurement system app allows users to generate or record signals, analyse them, and visualize various aspects such as waveform, spectrogram, and frequency response. It also provides options to save, load, and play signals, as well as modify parameters like duration and frequency.

Once the measurement system app is executed it is required to choose a amplification mode.
-*None:* no amplification.
-*Simulated:* uses the GOATS simulated d-class amplifier.
-*External:* this mode allows the user to connect his own amplifier.

Main controls:

Component	Function
Mode (*ModeDropDown*)	Selects the source of the signal: -*synthetic*: generate artificial signals -*recorded*: records a signal using the microphone
Signal Type (*SignalTypeDropDown*)	Define the type of use (only if *synthetic* selected): -*sine* -*square* -*triangle* -*chirp* -*saturated*
"Record" Button	Only available in *recorded* mode. Records a signal using the microphone after a 3 second countdown.
"Refresh" Button	Updates all plots and metrics based on the current configuration.

Signal Parameters:

Component	Function
Frequency (*FrequencyHzEditField*)	Sets the signal's frequency (only for *synthetic* signals). Allowed range: 1 Hz to 10 kHz.
Duration (*DurationEditField*)	Sets the duration in seconds for the signal to be generated or recorded. Allowed range: 0.1 s to 30 s.

Action Buttons:

Component	Function
Play	Plays the currently loaded or generated signal.
Import	Allows importing a *.wav* file from your device.
Export	Saves the current signal as a *.wav* file.
Save config	Saves the current configuration (mode, type, duration, frequency, signal) to a *.mat* file.
Load config	Loads a previously saved configuration from a *.mat* file.
Run	Executes the main operation: -If mode is *synthetic*: generates the signal. -If mode is *recorded*: records from the microphone (includes 3-second countdown).

Visualization and results:

Component	Function
Waveform	Displays the time-domain signal. The curve color depends on the THD value: - Green: THD < 10 - Orange: 10 ≤ THD < 20 - Red: THD ≥ 20
Spectrogram	Shows how the signal's energy varies over time and frequency.
Frequency Response	Displays the Fourier Transform (FFT) of the signal.
Power (*PowerEditField*)	Shows the signal power (mean square value).
Gain (*GainEditField*)	Logarithmic ratio (in dB) between the generated (*synthetic*) and received (*recorded*) signals.
THD (*THDEditField*)	Displays the Total Harmonic Distortion percentage of the signal.

Step-by-step Instructions:

To generate a synthetic signal:

1. Select **synthetic** in the Mode menu.
2. Choose the **desired signal type** from the SignalType dropdown.
3. Set the **frequency** and **duration** values.
4. Click **Run** to generate and visualize the signal.
5. Use **Play** to listen, or **Export** to save it as a .wav file.

To record a signal:

1. Select **recorded** in the Mode menu.
2. Set the **desired duration**.
3. Click **Run**. A 3-second countdown will start before recording.
4. The recorded signal will be automatically analyzed and displayed.
5. You can use **Play** to listen or **Export** to save it.

To import an existing signal:

1. Click **Import**.
2. Select a .wav file from your device.
3. The signal will load and its analysis will appear automatically.

To save or load configurations:

- Use **Save config** to save the current setup to a .mat file.
- Use **Load config** to restore a previously saved setup.

Recommendations

- Make sure your microphone is enabled when using the recorded mode.
- Verify frequency and duration values before clicking Run.
- Avoid importing very large .wav files, as they may slow down the analysis

Equalizer

The GOATS equalizer allows users to load audio files, apply different filters (Bell, Shelf, Band, HighCut, LowCut), visualize the frequency spectrum, and export the modified audio.

Toolbar Functions:

Component	Function
Filter Toggle	Enables or disables the filter overlay view. Toggle between viewing the raw spectrum or the spectrum with filters applied.
Add Filter	Opens the filter panel to add a new audio filter to the current selection.
Edit Filter	Opens the filter editor to modify parameters of the currently selected filter.
Delete Filter	Deletes the selected filter from the list.
Save	Saves the current session or configuration
Export Audio	Opens the export panel to save the processed audio to a file.

Graphic Panels:

Component	Function
Top Plot	Displays the filtered frequency response. **-X-axis**: Frequency (log scale). **-Y-axis**: dB gain (right axis).
Bottom Plot	Displays the input or output signal frequency content. **X-axis**: Frequency (log scale). **Y-axis**: Gain in dB.
Filter Dropdown	Lists all available filters. Select one to edit or remove.

Filter Panel (Afegir filtre):

How to Access: Right-click in the top plot.

Component	Function
Filter Type DropDown	Selects the filter type to add. Options: 'Bell', 'Shelf', 'Band', 'HighCut', 'LowCut'
"Afegir" Button	Confirms adding the selected filter.

Export Panel:

How to Access: Appears after clicking the "Export Button**"**

Component	Function
File Name Field	Input the name for the output audio file
"Export to..." Button	Initiates export process to a file with the name provided.

Audio Reproduction:

Component	Function
Audio Slider	Scrub through the audio playback timeline.
Play Button	Starts playing the audio with applied filters.
Pause Button	Pauses the current audio playback.

Close and Cleanup

- Closing the app (UIFigure) triggers cleanup actions.
- The app ensures proper deletion of UI elements and memory management.

Startup and Execution

Upon launching:

- All components are initialized.
- The app sets up the default filter dropdown and visuals.
- If input arguments are passed (e.g., from another script), they are handled in startupFcn.

Notes

- The application supports only one active session at a time.
- All UI components are color-themed in dark mode for comfortable viewing.
- Ensure the necessary image resources (.png icons) are in the same folder as the .mlapp file.

Amplifier

The GOATS amplifier it's a simulated Class-D amplifier made by using **PWM (Pulse Width Modulation)** techniques. It allows users to input a signal (either generated or imported), modulate it using a high-frequency triangular wave, amplify it, and observe the results in both time and frequency domains.

Toolbar Functions:

Component	Function
Input_fs	Sampling rate of the input signal. This sets the time resolution for signal generation and analysis. Fixed at 48000.
f_sin	Frequency (in Hz) of the sine wave to be generated.
"generate sin" Button	Generates a sine wave using the frequency from f_sin and the sample rate input_fs.
"select file" Button	Allows the user to load an external audio or data file (e.g., .wav) as the input signal. The imported signal will replace the generated sine wave and be plotted.
Fs_Amp	Sampling frequency used for the modulation process (oversampling rate for PWM).
f_triangular	Frequency (in Hz) of the triangular carrier wave used for the PWM. Adjust to control the resolution and quality of modulation.
G (Gain)	Amplification factor applied to the input signal. Enter a value to control signal amplitude before modulation
fc (Cutoff Frequency)	Cutoff frequency (in Hz) of the output low-pass filter that simulates the speaker/load filtering behaviour. Adjust this to control how much high-frequency noise is removed from the output.
"amplificar" Button	Executes the full modulation and amplification process. Generates triangular wave, performs PWM modulation via comparator, applies gain, simulates output filtering, and displays all intermediate and final signals in plots.

Plots and Graphs:

Left: Time-domain waveform
Right: Frequency-domain spectrum (FFT

Component	Function
entrada (input)	The original sine wave or loaded input.
entrada (resample)	Input signal resampled to match Fs_Amp.
triangular	The high-frequency triangular wave used in PWM.
comparador	The result of the comparator (PWM signal).
Fs_Amp	Sampling frequency used for the modulation process (oversampling rate for PWM).
f_triangular	Frequency (in Hz) of the triangular carrier wave used for the PWM. Adjust to control the resolution and quality of modulation.
G (Gain)	Amplification factor applied to the input signal. Enter a value to control signal amplitude before modulation
salida	Output signal after gain is applied and filtering is simulated.
salida (resample)	**:** Final output signal resampled back to input_fs for playback or comparison.

Recommended Workflow

1. Enter desired sine frequency in f_sin or click **select file** to import a signal.
2. Click **generate sin** to visualize the input.
3. Adjust **Fs_Amp**, **f_triangular**, **G**, and **fc** as needed.
4. Click **amplificar** to simulate the entire modulation and amplification chain.
5. Analyze each stage in the time and frequency domain using the plots.