Wedge Impedance Analysis Program Documentation

Djamel Ouais and Hussain Alqahtani

November 26, 2024

Contents

1 Overview

This documentation describes a MATLAB-based program designed for calculating acoustic impedance and wave fields around a wedge structure. The program implements various mathematical functions to compute scattered and direct wave fields using complex acoustic calculations.

2 Key Components

2.1 Main Control Script (testscipt.m)

The main script initializes and controls the program execution with the following components:

- Global parameters initialization including:
  - Geometric parameters (r, ϕ, r', ϕ')
  - Wave parameters (θ_n, θ_0)
  - Physical constants ($c = 340$ m/s for speed of sound)
- Frequency range setup (20 Hz to 10 kHz)
- Wave field calculations and normalization
- Results visualization

2.2 Wave Field Components

The program consists of several specialized functions for different aspects of the wave field calculations:

2.2.1 Direct Field Calculations

- `u_d.m`: Direct wave field calculator
- `u_ss.m`: Source-source interaction computation
- `u_sd.m`: Source-diffraction interaction handler
- `u_ds.m`: Diffraction-source interaction computation
- `u_dsw.m`: Diffraction-source-wedge interaction calculator

2.2.2 Mathematical Support Functions

- `A_n.m`, `M_n.m`: Coefficient calculations
- `P_l_m.m`: Legendre polynomial implementations
- `omega_n.m`: Angular frequency calculations
- `epsy_n.m`, `epsy_cap.m`: Phase calculations
- `g_small.m`, `h_small.m`: Field calculation helper functions

3 Program Flow

The program follows a systematic approach to compute acoustic fields:

3.1 Initialization Phase

1. Global parameter setup
2. Geometric configuration definition
3. Material properties initialization

3.2 Computation Phase

1. Frequency range iteration (20 Hz - 10 kHz)
2. Wave number calculation per frequency
3. Field computations:
   - Normal incidence field
   - Direct field
   - Scattered field components
   - Field combination

3.3 Output Phase

1. Results normalization
2. Frequency response plotting

4 Mathematical Foundation

The program implements complex acoustic theory including:

4.1 Wave Propagation

The wave equation in cylindrical coordinates:

$$\nabla^2\Phi + k^2\Phi = 0 \tag{1}$$

where k is the wave number and Φ is the velocity potential.

4.2 Scattered Field

The total field is composed of incident and scattered components:

$$\Phi_{\text{total}} = \Phi_{\text{incident}} + \Phi_{\text{scattered}} \tag{2}$$

4.3 Impedance Boundary Conditions

At the wedge surface:

$$\frac{\partial\Phi}{\partial n} + \beta\Phi = 0 \tag{3}$$

where β is the surface admittance and n is the normal direction.

5 Usage Instructions

To use the program:

1. Ensure all MATLAB files are in the same directory
2. Execute `testscipt.m`
3. Review the generated plots showing field ratio vs. frequency

6 Code Structure

Example of the main calculation loop:

```
for index = 1:length(f)
    k = 2*pi*f(index)/c;
    normal_quin(index) = exp(-1j*k*r_)/sqrt(k*r_);
    A = u_sw_t();
    if ((isnan(real(A))||(isnan(imag(A))))
        A = 0;
    end
    total_feild(index) = u_d() + A;
end
```

7 Conclusion

This implementation provides a comprehensive solution for analyzing acoustic behavior around wedge-shaped structures. It combines theoretical acoustic models with numerical methods to provide accurate simulations of wave propagation and interaction phenomena.