Project Overview

Goal. Build a rigorous, reproducible simulation study of a Perfect Electric Conductor (PEC) rectangular waveguide, culminating in an extension with *simultaneous longitudinal metallic fins* placed at fixed x and fixed y. Deliver clean field visualizations (top/front/side), dispersion/impedance plots, cutoff tables, and a coupling study demonstrating how fin-imposed symmetry selects the effectively excited modes.

Baseline geometry (Part I). Air-filled waveguide, inner cross-section

$$a = 60\,\text{mm}, \qquad b = 40\,\text{mm}.$$

Nominal frequency span: 4 GHz–15 GHz.
Finned geometry (Part II, simultaneous).

- **x-fins (planes $x = $ const)** at $x = a/3$ (top half: $y \in [b/2, b]$) and $x = 2a/3$ (bottom half: $y \in [0, b/2]$).
- **y-fins (planes $y = $ const)** present *together with* the x-fins in two options:
  (a) **XY1:** single mid-height fin at $y = b/2$ (full width).
  (b) **XY2:** dual fins at $y = b/3$ and $y = 2b/3$ (full width).

1 Part I - Baseline Rectangular Waveguide (No Fins)

1.1 Task A - Cutoff Map and Mode Table

A.1 Compute f_c for TE_{mn} and TM_{mn} with $0 \le m, n \le 4$, $(m, n) \ne (0, 0)$. Tabulate; highlight the three lowest cutoffs.

A.2 Plot f_c vs. mode index; annotate TE_{10} and TE_{01} for $a = 60\,\text{mm}, b = 40\,\text{mm}$.

1.2 Task B -Field Visualizations (Top/Front/Side):

For TE_{10}, TE_{20}, TE_{01}, and one higher-order mode (e.g. TE_{30} or TM_{11})- Label axes/legends clearly.

1.3 Task C - Dispersion & Impedance

C.1 For TE_{10} and TE_{01}, plot $\beta(f)$, $\lambda_g(f)$, $v_p(f)$, $v_g(f)$ from $\max(1.05 f_c, 4\,\text{GHz})$ to 15 GHz.

C.2 Plot $Z(f)$ for TE_{10} and $Z(f)$ for one TM mode above cutoff; comment on near-cutoff behavior.

2 Part II - Simultaneous Longitudinal Metallic Fins along x and y

2.1 Launcher Symmetry via Overlap Integrals (Clear & Self-contained)

Coordinate/sign conventions (class): width a along x, height b along y, propagation $+z$; time $e^{+j\omega t}$, z-harmonic $e^{-j\beta z}$. Air fill.

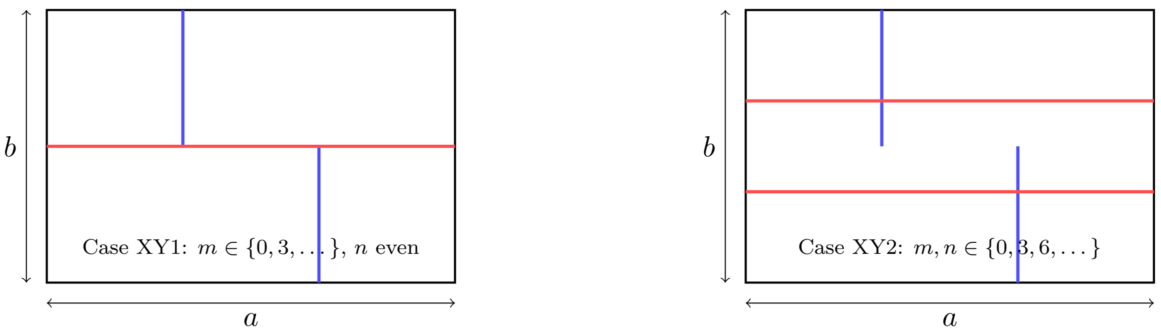
2.2 Tasks for Part II (Simultaneous Fins)

D.1 **Selection (XY1 vs XY2):** Derive the admitted (m, n). For $a = 60\,\text{mm}, b = 40\,\text{mm}$, list and rank by f_c the six lowest admitted TE modes for each case.

D.2 **Coupling (proof by symmetry):** For a $\hat{\mathbf{y}}$-probe near mid-height, argue $\eta_{0n} \approx 0$ but $\eta_{30} > 0$ off an E_y-node; for a $\hat{\mathbf{x}}$-probe near mid-width, argue $\eta_{m0} \approx 0$ but η_{02} (XY1) or η_{03} (XY2) can be nonzero.

D.3 **Numerical support:** Using the MATLAB/Python scripts, compute normalized η_{mn} for TE_{01}, $TE_{02/03}$ (per XY1/XY2), TE_{10}, and TE_{30} at a chosen $f > f_c$. Report probe orientation, (x_0, y_0), and spot size σ.

D.4 Why are the y-directed fins specified to run across the full width ? Is this a deliberate modeling choice? If yes, explain how a full-width fin changes the boundary condition and the admissible TE indices compared with a partial-width fin.



(a) Simultaneous x-fins and $y = b/2$ fin (XY1). (b) Simultaneous x-fins and $y = b/3, 2b/3$ fins (XY2).

Figure 1: Simultaneous-fin geometries and TE selection rules (fins run along z).

3 What to Submit

Report (PDF)

1. **Executive summary**: objectives, key findings, figure.
2. **Method**: formulas, simultaneous-fin selection rules, parameter table.
3. **Results**: required plots/tables; clear captions; concise discussion.
4. **Validation**: one numerical cross-check (e.g., λ_g from β).
5. **Conclusion & frequency plan**: 2–4 bullets linking fins, selection, and excitation.
6. Matlab/Python code used (which could be run in my PC)

4 Grading (100 points)

Item	Points
Part I: Cutoff map & table	15
Part I: Field plots (clarity, labels)	20
Part I: Dispersion & impedances	15
Part II: Simultaneous-fin selection (XY1, XY2)	15
Part II: Coupling study (x- and y-probes)	20
Report quality (structure, validation)	15
Total	**100**