STUDENT PROJECT

PRINTED MONOPOLE ANTENNAS

Antennas

1. INTRODUCTION

The printed planar monopole exhibits wider bandwidth than a conventional wire monopole due to the flexibility of the printed monopole geometry. Such printed monopoles are usually microstrip fed and are popular in mobile communications due to their reduced size and moderate to wide impedance bandwidth.

The trapezoidal monopole's increased impedance bandwidth over a square or rectangular monopole is due to the step and/or tapered (bevelled) bottom edges which ensure a broadband impedance transition. The simplest trapezoidal monopole is the triangular monopole where the base is the same width as the microstrip line feeding the monopole.

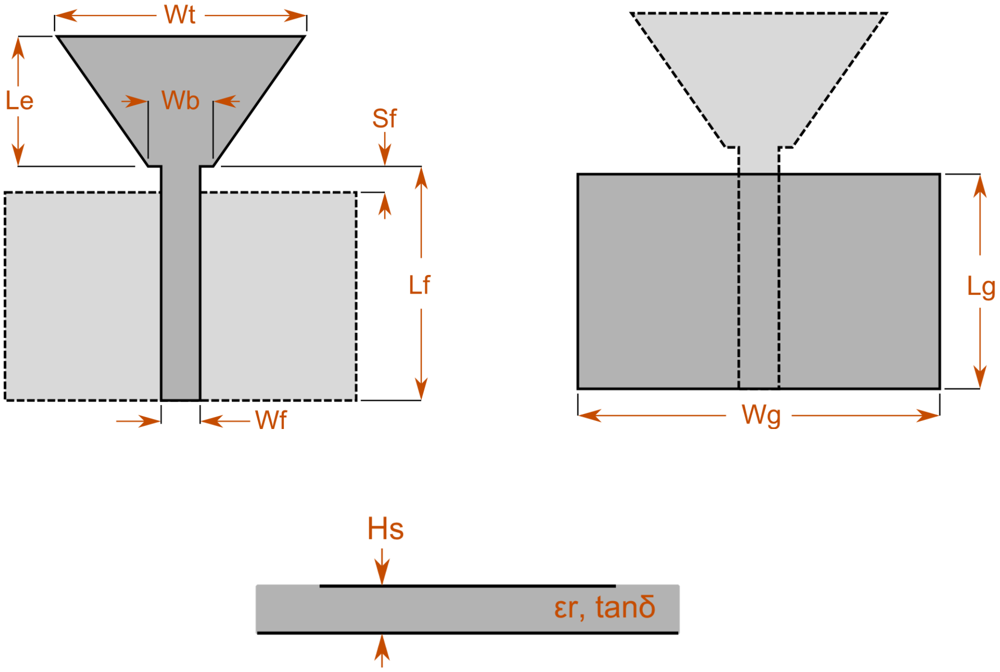

Figure 1. A printed monopole antenna, (up) top and bottom, and (down) side view.

2. DESIGN GUIDELINES

The trapezoidal monopole is designed to have a 50Ω input impedance.

- The length of the element determines the minimum operating frequency.

- The highest operating frequency is dependent on the base width of the monopole and the feed height (thickness of dielectric substrate between ground plane and base of monopole).
- The element's impedance can be lowered by widening the top width while keeping the base width the same.

Note: Antennas on thick and higher permittivity substrates may lead to performance degradation due to surface waves.

3. PROJECT PREPARATION

Given: Target frequency f_0 (e.g. 900 MHz or 2400 MHz).

Fixed parameters: Substrate parameters ε_r, $tan\delta$, H_s. The substrate should be FR4. Thickness ≈ 0.8 mm.

Output: $|S_{11}|$, input impedance Z_{in}, radiation efficiency/gain, resonance frequency f_r, radiation pattern.

STEP 1 — INITIAL RADIATOR LENGTH (QUARTER-WAVE ESTIMATE)

Task:

- Approximate total effective length $L_{eff} \approx \lambda_{eff}/ 4$.
- Choose $L_e \approx L_{eff}$.
- Start with a rectangular radiator.

Questions:

- If ε_r increases from 2.2 to 3.5, how much should L_e decrease (percentage-wise) and why?

STEP 2 — GROUND PLANE DIMENSIONS (WG, LG) AND FEED GAP (SF, LF)

Task:

- Choose $W_g \geq 0.3\lambda_0$, $L_g \geq 0.25\lambda_0$ as initial values.
- Set S_f and align L_f with the feed neck.
- Observe $|S_{11}|$ changes.

Questions:

- Reducing L_g or increasing S_f – how does it shift f_r and affect impedance matching?

STEP 3 — FEEDLINE AND NECK WIDTH (WF, WB)

Task:

- Calculate W_f for 50Ω microstrip using standard equations or tools.
- Sweep W_b and record $|S_{11}|$ and Smith chart response.

Questions:

- Why does increasing W_b usually lower input impedance and slightly broaden bandwidth?

STEP 4 — TAPERED RADIATOR (BROADBANDING WITH WT, LE)

Task:

- Transform radiator into a trapezoidal/flare type: base W_b → top W_t across ~0.3–0.5L_e.
- Sweep W_t while retuning L_e to keep f_r fixed.

Questions:

- How does increasing W_t shift the lower and upper frequency edges? Explain physically.

STEP 5 — FINE-TUNING (LE, EDGE CUTS)

Task:

- Adjust L_e slightly to correct small resonance errors (3–5% frequency drift).

Questions:

- Why can millimeter-scale changes in L_e cause tens of MHz frequency shifts?

STEP 6 — GROUND WIDTH AND SIDE CLEARANCE EFFECTS

Task:

- Sweep W_g = 0.2→0.4λ and observe gain and $|S_{11}|$.
- Keep radiator centered to ensure symmetry.

Questions:

- Which parameter – W_g or L_g – affects gain more strongly, and why?

STEP 7 — MINIATURIZATION OPTIONS

Task:

- Introduce meander/slot paths to increase L_{eff} without enlarging physical size.
- Measure impact on Q, bandwidth, and efficiency.

Questions:

- Why do compact/multifolding methods typically reduce bandwidth?

STEP 8 — RADIATION PATTERN AND POLARIZATION

Task:

- Plot radiation pattern at center and band edges.
- Confirm linear polarization and dipole-like shape.
- Analyze detuning when near the human body or metal (5–20 mm distance).

Questions:

- List two simple design tricks to mitigate environmental detuning without enlarging the antenna.

4. FINAL EVALUATION

Acceptance criteria:

$|S_{11}| < -10$ dB across the band, efficiency > 60 %, gain ≥ 2 dBi, dimensions within design limits.

Deliverables: Final geometry table (L_e, L_g, W_g, H_s, W_f, L_f, W_b, W_t, S_f). Plots: $|S_{11}|$, gain, Axial Ratio vs f, and the radiation patterns. Comparison of simulated and theoretical results. Written answers to all step questions in a report format

5. REFERENCES

[1] C. A. Balanis, Antenna Theory: Analysis and Design, 3rd Edition. Hoboken, NJ: Wiley-Blackwell, 2005.

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[3] H.-M. Chen, "Microstrip-fed dual-frequency Printed Triangular Monopole", Electronics Letters, Vol. 38 no. 13, 20 June 2002, pp. 619 – 620.

[4] Z. N. Chen, "Broadband planar antennas for high-speed wireless communications", Ch. 37 in Antenna Engineering Handbook, 4th ed., J. L. Volakis (Ed.), McGraw-Hill, 2007.

[5] Kin-Lu Wong and Yi-Fang Ling, "Stripline-Fed Printed Triangular Monopole", Electronics Letters, vol. 33, no. 17, 14 August 1997, pp. 1428 – 1429.