

Antenna Build

RTL-SDR Signal Processing & Antenna Systems Project

↳ Receive System

↳ Antenna Subsystem

Engineer: Luke Woszyn

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1. Objective

The objective of this activity was to design and construct a simple, predictable receive antenna to support initial bring-up and verification of an RTL-SDR-based RF receive system. The antenna was required to:

- Operate in the FM broadcast band ($\approx 88-108\text{ MHz}$)
- Exhibit well-understood radiation characteristics
- Be mechanically simple and reproducible
- Support qualitative and quantitative signal characterization

A half-wave dipole was selected to meet these requirements.

2. Antenna Selection and Design Rationale

A half-wave dipole was chosen because it provides:

- Predictable resonance behavior
- Broad bandwidth suitable for FM reception
- Clear polarization and orientation sensibility
- Minimal components requirements

This makes it appropriate for early-stage system verification prior to optimization or matching.

3. Design Calculations

Target center frequency:

$$f_0 = 100 \text{ MHz}$$

Free-space wavelength:

$$\lambda = \frac{c}{f_0} = \frac{3 \times 10^8 \text{ m/s}}{100 \times 10^6 \text{ s}^{-1}} = 3.0 \text{ m}$$

Half-wave dipole length (with shortening factor):

$$L \approx 0.95 \cdot \frac{\lambda}{2} = 1.425 \text{ m}$$

Resulting element per leg:

$$L = 0.7125 \text{ m} \approx 71.5 \text{ cm} \approx 28.1 \text{ in}$$

Elements were cut slightly long ($\pm 1 \text{ in}$) to allow for later trimming if required.

4. Materials

- 18 AWG two-conductor speaker wire
- 48 in wooden dowel (mechanical support)
- Electrical tape (zip ties in 12/22/25 revision)
- Wire cutters/strippers
- Measuring tape

No soldering or impedance matching components were used for the initial build.

5. Mechanical Construction

The speaker wire was split into two identical conductors to form the dipole elements (labeled Element A and Element B).

Each element was cut to the calculated length.

Due to the dowel length (48 in) being shorter than the total dipole span, the antenna was implemented with symmetric wire overhang:

- Feedpoint centered on the dowel
- Each element taped along the dowel for ~ 24 in. (Zip tied in revision)
- Remaining ~ 4 in of each element left unsupported. (5 inches in revision)

This overhang was assumed to have negligible impact on receive only operation.

Elements were mounted collinearly and horizontally to form a standard half-wave dipole.

6. Feedpoint Implementation

The feedpoint was formed by stripping approximately 10-12mm of insulation from one end of each element. The two conductors were maintained with a visible air gap (~ 5 mm) to prevent electrical shorting.

Key constraints:

- Elements do not touch at feedpoint.
- Mechanical support provided by tape without electrical contact
- Feedpoint geometry preserved under light handling

This configuration preserves proper dipole behavior.

7. Orientation and Installation

The antenna was installed in a horizontal orientation to match typical FM broadcast polarization.

- Dipole axis: recorded relative to room orientation (\parallel to grill ~~to living room window~~)

- Height above floor: recorded for repeatability (~ 96 in) 52 in porch
- ~~Indoor~~ environment with expected multipath effects

The configuration was frozen prior to SDR bring-up to enable consistent verification.

8. Known Limitations and Assumptions

- No balun or impedance matching network
- Unbalanced feed into SDR input
- ~~Indoor~~ ^{porch} multipath environment \rightarrow still expected due to porch environment
- Geometry-based frequency selectivity only

These limitations were accepted for initial system bring-up and documented explicitly

9. As-Built Summary

- Antenna type: Half-Wave dipole
- Target band: FM broadcast (88 ~ 108 MHz)
- Orientation: Horizontal
- Support: 48 in down with symmetric overhang
- Elements labeled and lengths matched
- Feedpoint electrically isolated

The antenna was deemed suitable for initial RF reception and system-level verification.

10. Role in System Architecture

The antenna serves as the primary RF sensing element for the RTL-SDR Receive system. Its predictable behavior enables:

- Orientation-based signal variation studies.
- Relative SNR comparison
- DSP pipeline verification
- Architecture validation prior to optimization

End of 12/20/2025 Antenna Build Log

↳ End of 12/22/2025 Revision