RF & SDR Primer (UK Edition)

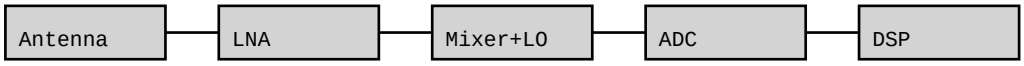
A practical illustrated guide to RF basics, SDR hardware, UK law, antennas, DSP, and more.

Generated for fren

Table of Contents

0) The 10-minute Mental Model

- Frequency ↔ Wavelength: λ = c/f. Example: 2.4 GHz → ~12.5 cm.
- Bandwidth (B): span a signal occupies. Sampling ≥ 2×B (Nyquist).
- dB/dBm: +3 dB ≈ ×2 power, +10 dB = ×10.
- Modulation: AM/FM/PM (analog), FSK/PSK/QAM/OFDM (digital).
- IQ samples: every modulation maps into movements on the I/Q plane.



1) SDR Hardware Map

- RTL-SDR: cheap, RX only (500 kHz–1.7 GHz).
- Airspy: better dynamic range.
- HackRF One: TX/RX, 1–6 GHz, but 8-bit only.
- LimeSDR Mini v2: TX/RX 10 MHz–3.5 GHz, 12-bit.
- USRP: lab grade, flexible, expensive.

2) Antennas You'll Actually Build

- λ/2 dipole: two elements, each 0.234·(c/f MHz).
- Quarter-wave ground-plane: one vertical, four sloping radials.
- Discone: wideband, great for scanning.
- Yagi: directional, gain for VHF/UHF.
- Patch: flat, 2.4 GHz Wi-Fi.

3) DSP You'll Touch

- Filters: low-pass, band-pass.
- AM demod: magnitude of IQ.
- FM demod: differentiate phase.
- FSK demod: frequency discriminator.
- PSK/QAM: Costas loop, constellation.

4) UK Law and Licensing

Area	What's legal?	What's not
Receive-only	Broadcast radio/TV, your own amateur signals	Intercepting private/emergency/business comms
Licence-exempt	433 MHz (10 mW ERP), 868 MHz LoRa (25 mW ERP), Wi-Fi/BLE (100 mW EIRP)	Higher power/Extended channels on PMR446
Amateur Radio	Operate within licence terms (Foundation/Intermediate/Full), keep records	Transmitting outside allocated bands/power limits

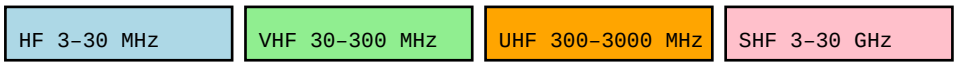
5) Gotchas and Fixes

- Overload: too much gain, adds intermod.
- Clock drift: RTL dongles need PPM correction.
- Aliasing: respect Nyquist, decimate properly.
- Ground loops: isolate power/audio.
- Antennas > DSP: better antenna beats software tricks.

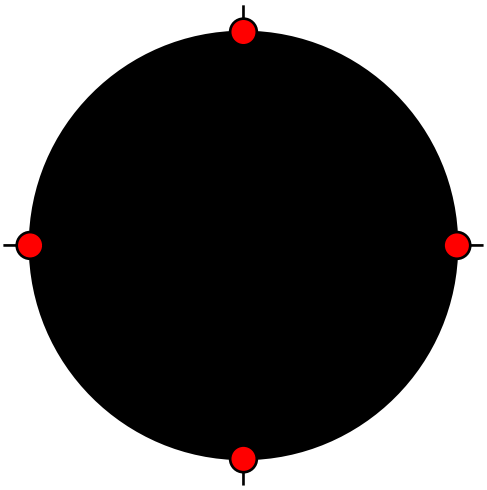
6) Quick RF Math Cheat-Sheet

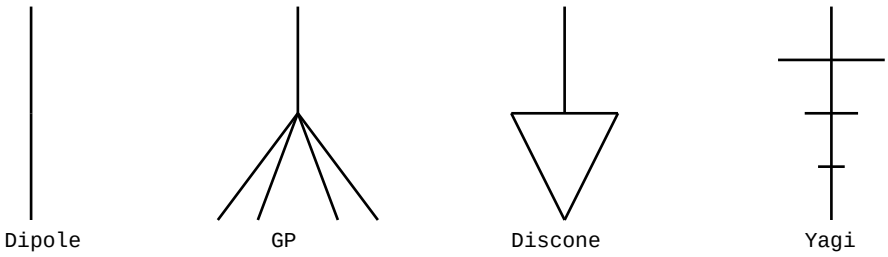
- FSPL(dB) = 32.44 + 20·log10(d_km) + 20·log10(f_MHz)
- Thermal noise (dBm) = -174 + 10·log10(B_Hz) + NF_dB
- EIRP(dBm) = TX(dBm) + Gain(dBi) – Loss(dB)
- ERP(dBW) = TX(dBW) + Gain(dBd) – Loss(dB)

7) Spectrum Placemat Diagram



8) Diagrams: IQ & Antennas





9) References & Links

- Ofcom IR2030 Licence-exempt SRD tables
- UK Amateur Radio Licence Terms & Conditions
- RSGB (Radio Society of Great Britain)
- rtl-sdr.com tutorials
- GNU Radio, GQRX, SDR# software