RF & SDR Primer — New Zealand Edition

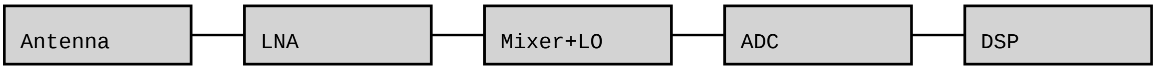
A concise, illustrated guide to RF, SDR hardware, antennas, DSP, and NZ law.

Generated for fren — HackRF-centric build

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 (HackRF focus)

- HackRF One: 1–6 GHz, 8■bit, half■duplex TX/RX. Great for learning and RF playback/sweeps.
- LimeSDR (alt): 10 MHz–3.5 GHz, 12■bit, full■duplex TX/RX.
- USRP/PlutoSDR (alt): lab/embedded options if you scale up.
- Sound■card RF (no■SDR): for audio■band experiments (VLF/AF).

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 scanner antenna.
- Yagi: directional, useful VHF/UHF gain.
- Patch/Tile: flat panel at 2.4 GHz.

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) New Zealand Law & Licensing (what’s okay vs not)

Area	What’s permitted	Notes
Receive■only	Broadcast radio/TV, your own amateur signals, SRD [illegible]	Do NOT use, reproduce, or disclose private radio[illegible]
General User Radio [illegible]	433.05–434.79 MHz — [illegible] (≈25 mW) EIRP; 86[illegible]	[illegible]
Amateur Radio (Ama[illegible]	[illegible] in the GURL after ge[illegible]	[illegible]
LPFM Broadcasting	You can run a local FM station under the LPFM GU[illegible]	Max radiated power 1 watt; use permitted freqs/en[illegible]

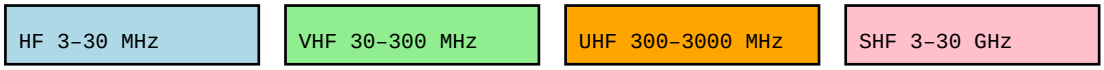
5) Gotchas and Fixes

- Overload: set gain conservatively on HackRF (use LNA/VGA judiciously).
- Clock drift: calibrate PPM for narrowband; HackRF is TCXO■upgradeable.
- Aliasing: respect Nyquist; decimate with filtering.
- RF hygiene: ferrites, grounding, and physically separating TX/RX.
- Antenna > DSP: invest in feedlines, connectors, and proper lengths.

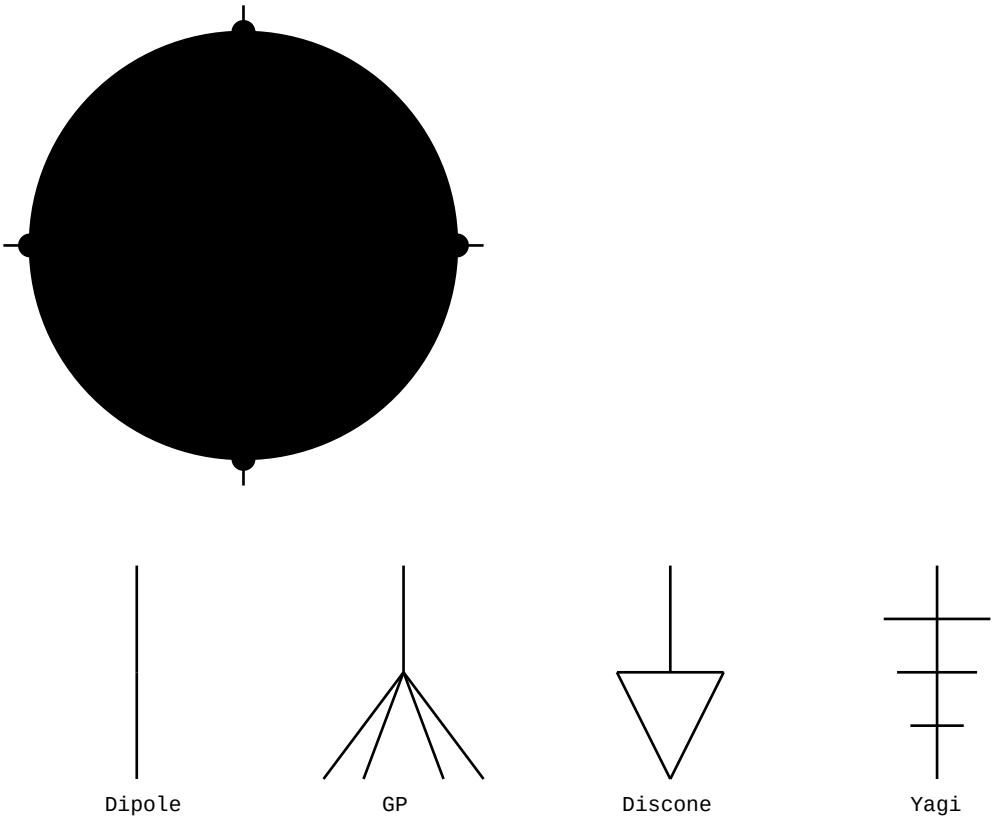
6) Quick RF Math Cheat■Sheet

- 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

- Short Range Devices GURL (2022) — NZ Gazette 2022■go3100
- Amateur Radio Operators GURL (2023) — NZ Gazette 2023■go5698
- Radiocommunications Act 1989 — s133A (Offence to disclose contents of radiocommunications)
- LPFM Broadcasting — RSM page (max radiated power 1 W)
- NZART band plans (IARU Region 3 aligned)
- PIB■21 Spectrum Usage & RSM allocation chart