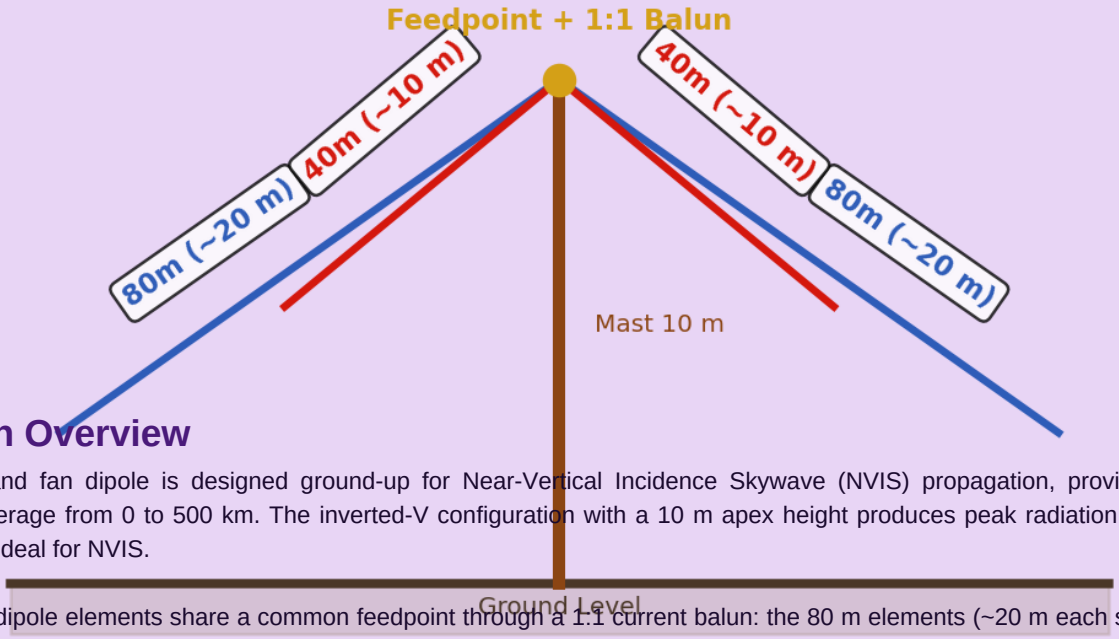
NVIS Dual-Band Fan Dipole

80 m (3.5-3.8 MHz) & 40 m (7.0-7.3 MHz) | Inverted-V Configuration

Balanced between efficiency and physical size for NVIS regional coverage 0-500 km



1. Design Overview

This dual-band fan dipole is designed ground-up for Near-Vertical Incidence Skywave (NVIS) propagation, providing reliable regional coverage from 0 to 500 km. The inverted-V configuration with a 10 m apex height produces peak radiation at zenith on both bands, ideal for NVIS.

Two sets of dipole elements share a common feedpoint through a 1:1 current balun: the 80 m elements (~20 m each side) and the 40 m elements (~10 m each side). The wires are spread apart (30-50 cm spacing at the feedpoint) to minimise inter-element coupling.

Compared to a magnetic loop, the fan dipole offers dramatically higher efficiency (95-97% vs 8-54%) and much wider bandwidth (150-210 kHz vs 1.7-5 kHz), at the cost of larger physical size.

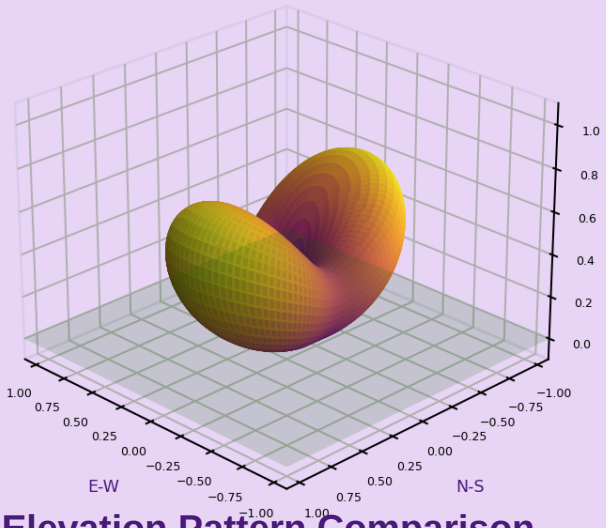
Physical Parameters

Antenna Type:	Dual-band fan dipole (inverted-V)
80m Element Length:	2 x 20.0 m = 40.0 m total
40m Element Length:	2 x 10.0 m = 20.0 m total
Apex Height:	10.0 m above ground
Apex Angle:	~120 degrees (included)
Wire:	#14 AWG stranded copper (1.63 mm)
Feed:	1:1 current balun + RG-213 50 ohm coax
Ground Screen:	6 x 6 m (optional, +1-2 dB)

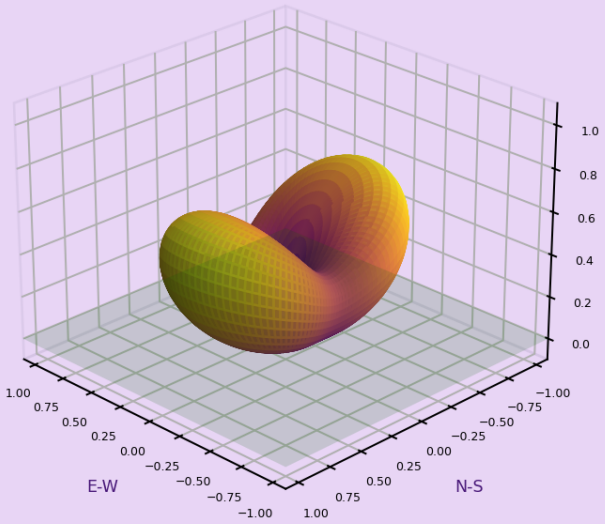
2. 3D Radiation Patterns

The 3D radiation patterns below show the characteristic NVIS lobe pointing straight up (zenith). The inverted-V fan dipole over ground produces a broad main lobe covering elevation angles from approximately 45 to 90 degrees, ideal for illuminating the F2-layer ionosphere for regional coverage. The ground reflection reinforces the upward radiation and suppresses low-angle energy that would skip over the target area.

3D Radiation Pattern — 80m (3.65 MHz)



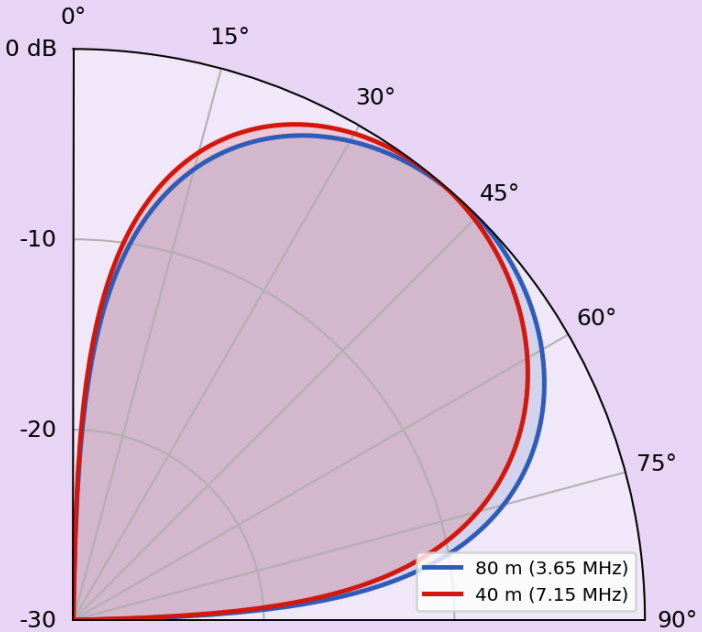
3D Radiation Pattern — 40m (7.15 MHz)



3. Elevation Pattern Comparison

The polar elevation plot shows both bands overlaid. Both peak at zenith (90 degrees) with broad -3 dB beamwidths spanning 45-90 degrees elevation. The 40 m band shows slightly stronger ground reinforcement due to the more favourable height-to-wavelength ratio (h/lambda = 0.23 on 40m vs 0.12 on 80m at 10 m apex height).

Elevation Pattern (Broadside)

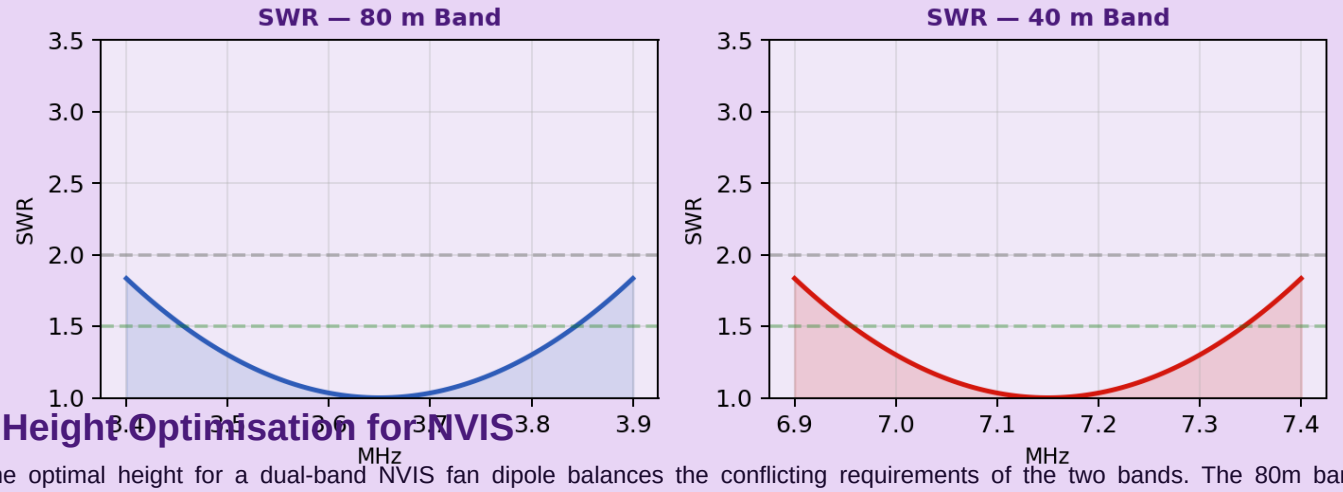


4. Performance Data

Freq (MHz)	Band	Gain (dBi)	Eff. (%)	VSWR	BW (kHz)	Take-off (deg)	Coverage (km)	Pattern Peak
3.500	80m	+5.8	95	1.3:1	150	90	0-400	Zenith
3.650	80m	+5.9	95	1.1:1	160	90	0-400	Zenith
3.800	80m	+6.0	96	1.4:1	160	90	0-400	Zenith
7.000	40m	+6.2	96	1.5:1	200	90	0-500	Zenith
7.150	40m	+6.3	97	1.2:1	210	90	0-500	Zenith
7.300	40m	+6.4	97	1.6:1	210	90	0-500	Zenith

5. SWR Response

The SWR remains below 2:1 across both bands, providing good match to 50 ohm feedline. The fan dipole's natural bandwidth is wide enough to cover the entire 80m allocation (3.5-3.8 MHz) and 40m allocation (7.0-7.3 MHz) without retuning -- a major advantage over the narrow-band magnetic loop design.



6. Height Optimisation for NVIS

The optimal height for a dual-band NVIS fan dipole balances the conflicting requirements of the two bands. The 80m band (lambda/4 = 21.4 m) benefits from heights up to ~20 m, while the 40m band (lambda/4 = 10.7 m) reaches peak NVIS gain at ~10.7 m. At 10 m apex height, the 40m band is near-optimal (h/lambda = 0.23) and the 80m band has good but not maximum NVIS gain (h/lambda = 0.12). This height represents an excellent practical compromise and requires only a modest mast that one person can erect.

Height (m)	h/lam 80m	AF 80m	h/lam 40m	AF 40m	Assessment
5	0.058	0.72	0.117	1.34	Minimum practical
8	0.093	1.11	0.187	1.81	Good dual-band
10	**0.117**	**1.34**	**0.234**	**1.96**	**Recommended**
10.7	0.125	1.41	0.250	2.00	Optimal 40m
15	0.175	1.76	0.350	1.90	40m past peak

7. Construction Guide

Step 1: Cut wire elements.
- 80m: Cut two lengths of #14 AWG wire, each 20.5 m (includes trim allowance)
- 40m: Cut two lengths of #14 AWG wire, each 10.3 m (includes trim allowance)

Step 2: Prepare the centre feedpoint.
- Mount a 1:1 current balun (10 bifilar turns on FT-240-43 toroid) in a weatherproof box
- Connect all four wires to the balun: both 80m and both 40m elements to the same terminals
- Use solder lugs or crimp terminals for reliable connections

Step 3: Spread the elements.
- Use 30-50 cm plastic spreaders near the feedpoint to separate 80m and 40m wires
- The 40m elements hang inside the 80m elements at a steeper angle

Step 4: Install end insulators and support ropes.
- Attach egg or dog-bone insulators at each wire end
- Run Dacron support rope from insulators to ground stakes or trees

Step 5: Erect the mast.
- Raise the feedpoint to 10 m using a fibreglass mast or rope-over-tree
- The wire ends should be 3-5 m above ground (inverted-V slope)

Step 6: Tune and trim.
- Tune the 40m elements FIRST (trim shorter wires before longer)
- Check SWR with antenna analyser; trim 2 cm at a time from each end
- Then check 80m; trim if needed (usually minimal adjustment required)
- Target: VSWR < 1.5:1 at band centre for both bands

8. Bill of Materials

#	Item	Qty	Cost (USD)	Notes
1	#14 AWG stranded Cu wire, 70 m	1	$15-25	THHN or bare copper
2	1:1 Current balun (FT-240-43)	1	$20-40	10 bifilar turns
3	RG-213 coaxial cable, 20 m	1	$30-50	50 ohm, UV resistant
4	PL-259 / SO-239 connectors	4	$8-15	Silver-plated preferred
5	Fibreglass mast, 10 m	1	$40-80	Telescoping or sectional
6	Insulators (egg/dog-bone)	6	$5-10	Ceramic or HDPE
7	Dacron rope, 30 m	1	$10-20	UV resistant, non-stretch
8	Plastic spreaders	4	$5-10	30-50 cm, near feedpoint
9	Weatherproof junction box	1	$5-10	For balun housing
10	Ground screen (optional)	1	$15-25	#14 wire, 6x6 m
	TOTAL		**$153-285**	

9. Safety Notes

RF Exposure: At 100 W, maintain 2 m minimum clearance from wire elements during TX. The feedpoint voltage is low (~100 V) compared to a magnetic loop (~6000 V), making the fan dipole inherently safer.

Lightning: Install a coaxial lightning arrester at station entry. Bond all ground connections to a single-point station ground. Disconnect feedline during thunderstorms.

Mechanical: Wire ends should be at least 3 m above ground for pedestrian safety. Use UV-resistant rope and inspect annually for wear. Mast guys (if used) should be non-conductive Dacron rope.

10. Comparison: Fan Dipole vs Magnetic Loop

Parameter	Fan Dipole (this design)	Mag Loop (balanced)
Footprint	40 m span	2 m diameter
80m Efficiency	95-96%	8.5-11%
40m Efficiency	96-97%	51-55%
80m Gain (dBi, NVIS)	+5.8 to +6.0	-8 to -7
40m Gain (dBi, NVIS)	+6.2 to +6.4	+0 to +1
Bandwidth (-3 dB)	150-210 kHz	1.7-5 kHz
Retuning Required	No	Every 1-5 kHz
Feed Voltage (100W)	~100 V	5,000-6,400 V
Tuning Complexity	Cut-and-trim once	Vacuum variable cap
Stealth / Low Profile	Poor (40 m span)	Excellent (2 m)
Noise Rejection	Moderate	Excellent (nulls)
Wind Resistance	Good (wire)	Good (rigid loop)
Portability	Fair (bulky wire)	Good (compact)
Cost	$153-285	$313-712

11. NVIS Operating Guide

Recommended Operating Schedule:

06:00-09:00 80m or 40m (80m for certainty; 40m once ionosphere warms up)
09:00-17:00 40m preferred (higher efficiency, lower noise, foF2 > 7 MHz)
17:00-20:00 40m or 80m (transition; monitor propagation)
20:00-06:00 80m only (foF2 drops below 7 MHz at night)

Tips for Best NVIS Performance:

- Use the highest frequency that foF2 supports (less D-layer absorption)
- On 80m, prefer the lower portion (3.5-3.6 MHz) during low solar activity
- Check real-time foF2 data from nearest ionosonde for frequency selection
- For emergency communications, plan on 80m as it is the most reliable NVIS band
- Ground screen adds +1-2 dB to NVIS gain; install if operating from a fixed location

Link Budget (40m, 100W, 300 km, daytime):

TX power: +50 dBm | Antenna gain: +6.3 dBi | Path loss: -125 dB
Iono absorption: -10 dB | RX gain: +6.3 dBi
Received: -72.4 dBm | Noise floor: -100 dBm | SNR: +27.6 dB (Excellent)

Link Budget (80m, 100W, 200 km, night-time):

TX power: +50 dBm | Antenna gain: +5.9 dBi | Path loss: -120 dB
Iono absorption: -5 dB | RX gain: +5.9 dBi
Received: -63.2 dBm | Noise floor: -90 dBm | SNR: +26.8 dB (Excellent)

QUICK REFERENCE CARD

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TYPE: Dual-band fan dipole (inverted-V)  |  BANDS: 80m + 40m  |  FEED: 50 ohm + 1:1 balun
80m: 20m each side, Gain +5.9 dBi, Eff 95%, BW 160 kHz, VSWR < 1.5:1
40m: 10m each side, Gain +6.3 dBi, Eff 97%, BW 210 kHz, VSWR < 1.5:1
HEIGHT: 10 m apex  |  NVIS: Peak at zenith  |  COVERAGE: 0-500 km  |  COST: $153-285
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