# All-band antenna for the KX2/KXAT2


*KX2/KXAT2 with All-band inv-L antenna on SOTA HB/BE-135 Muntiggalm*

# Antenna geometry and dimensioning

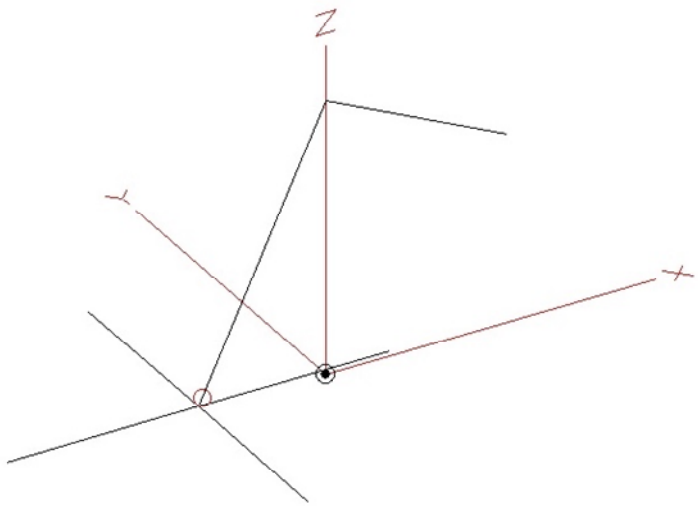


*Figure 1 Inverted-L antenna geometry: 10.90 m radiator inclined by approx. 25° (apex angle 90-110°)*

| Apex height [m] | Length oft the «vertical» radiator part [m] | *Distance oft he base to the mast [m]* |
|---|---|---|
| 5.5 | 6.0 | *(approx. 2.6)* |
| **6.0** | **6.5** | *(approx. 2.8)* |
| 6.5 | 7.0 | *(approx. 3.0)* |

*Figure 2 Dimensioning range of the 10.90 m inverted-L antenna (on flat terrain)*

# Antenna characteristics (EZNEC) : Overview

The EZNEC simulation of inverted-L antennas according to the dimensioning range listed in Figure 2 has shown that the antennas characteristics differ slightly.
Therefore the results listed in Figure 3 should be understood as approximate values only.

| **EZNEC Simulation**<br>10.90 m inverted-L antenna (apex height 6.0 m along Figure 2, 4 Radials of 4.20 m each (over average ground)<br>Results : Max. Gain [dBi] / Elevation [°] / Azimuth [°] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.6 MHz | 5.355 MHz | 7.1 MHz | 10.12 MHz | 14.1 MHz | 18.08 MHz | 21.1 MHz | 24.9 MHz | 28.1 MHz |
| -4.35/30/180 | -2.35/30/180 | -1.2/35/180 | 0.15/40/180 | 2.7/60/250 | 5.4/45/90 | 4.9/35/85 | 4.0/25/85 | 3.2/20/80 |

*Figure 3  EZNEC results for the 10.90 m inverted-L antenna (apex height 6.0 m)*

EZNEC wire definition

» Radiator length 10.90 m, wire diam. 0.6 mm (copper strand), PVC insulation thickness 0.35 mm
» Radial length 4x 4.20 m, wire diam. 0.9 mm (copper strand), PVC insulation thickness 0.55 mm

# Antenna characteristics (EZNEC) : Horizontal radiation on 80-30 m

***>>> Slices at max. radiation (gain, azimuth and elevation according to Figure 3)***

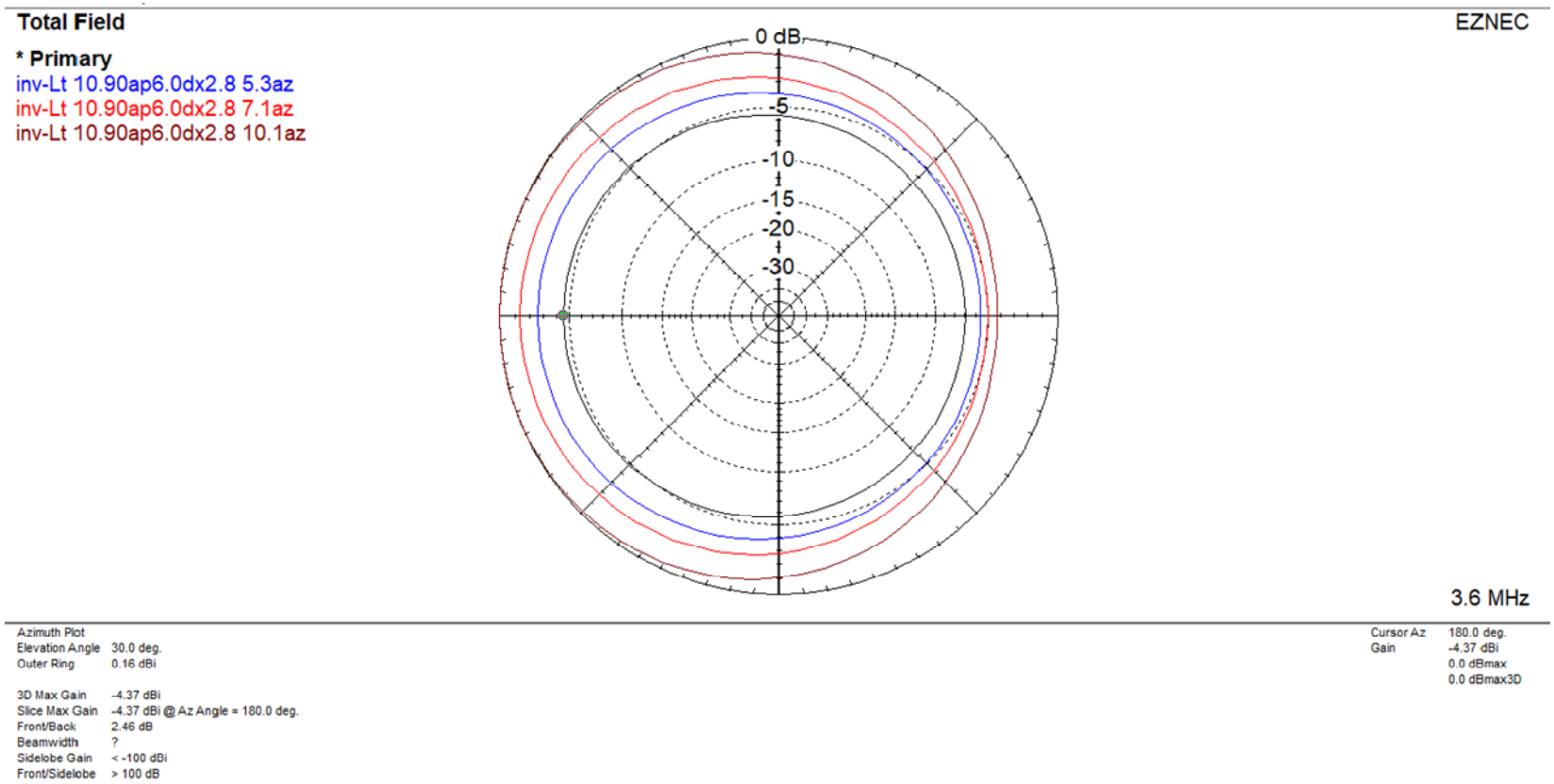


*Figure 4 Horizontal radiation (at maximum) on 80-30 m*

# Antenna characteristics (EZNEC) : Horizontal radiation on 20-10 m

***>>> Slices at max. radiation (gain, azimuth and elevation according to Figure 3)***

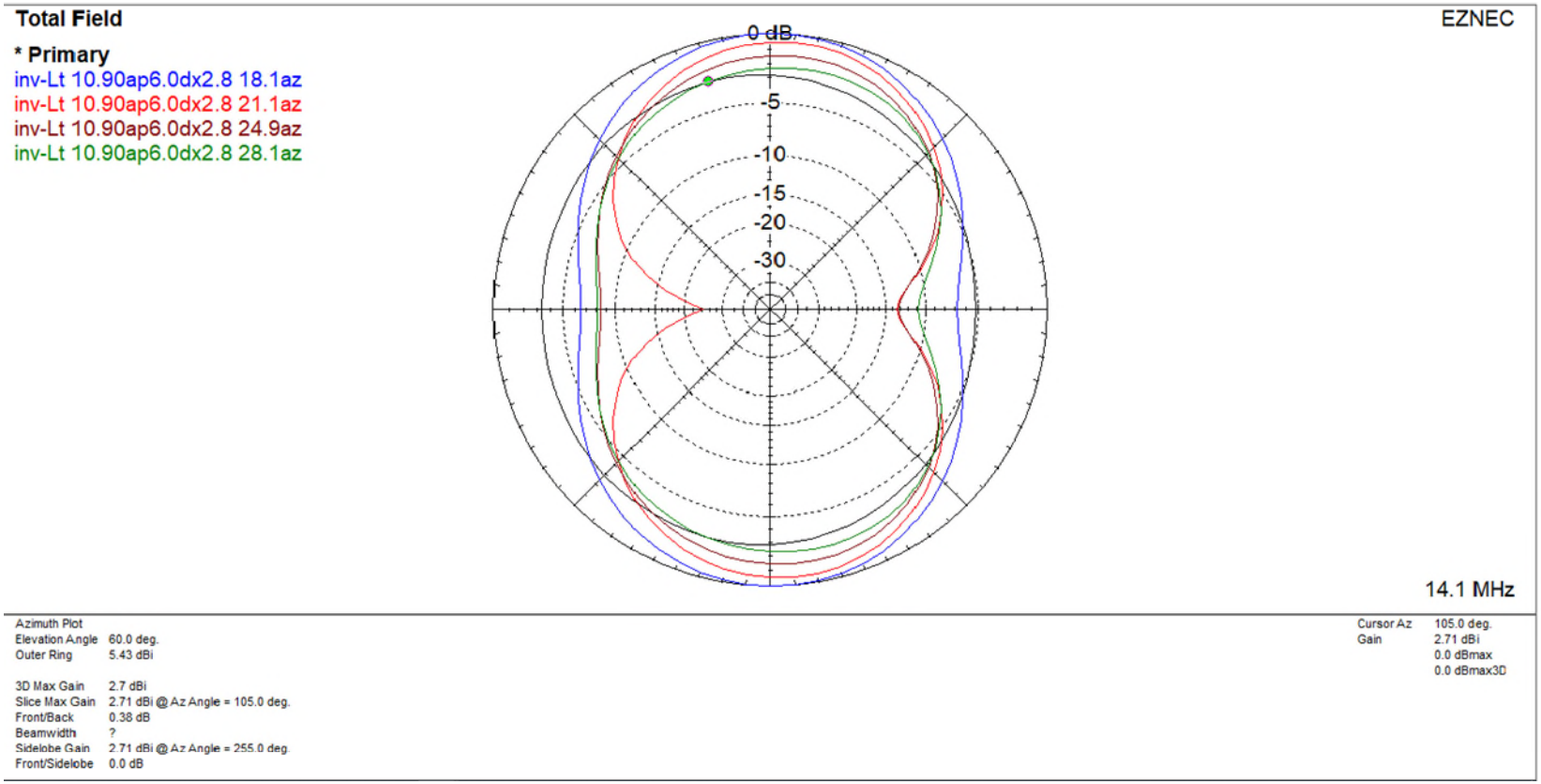


*Figure 5 Horizontal radiation (at maximum) on 20-10 m*

# Antenna characteristics (EZNEC) : Vertical radiation on 80-30 m

***>>> Slices at max. radiation (gain, azimuth and elevation according to Figure 3)***

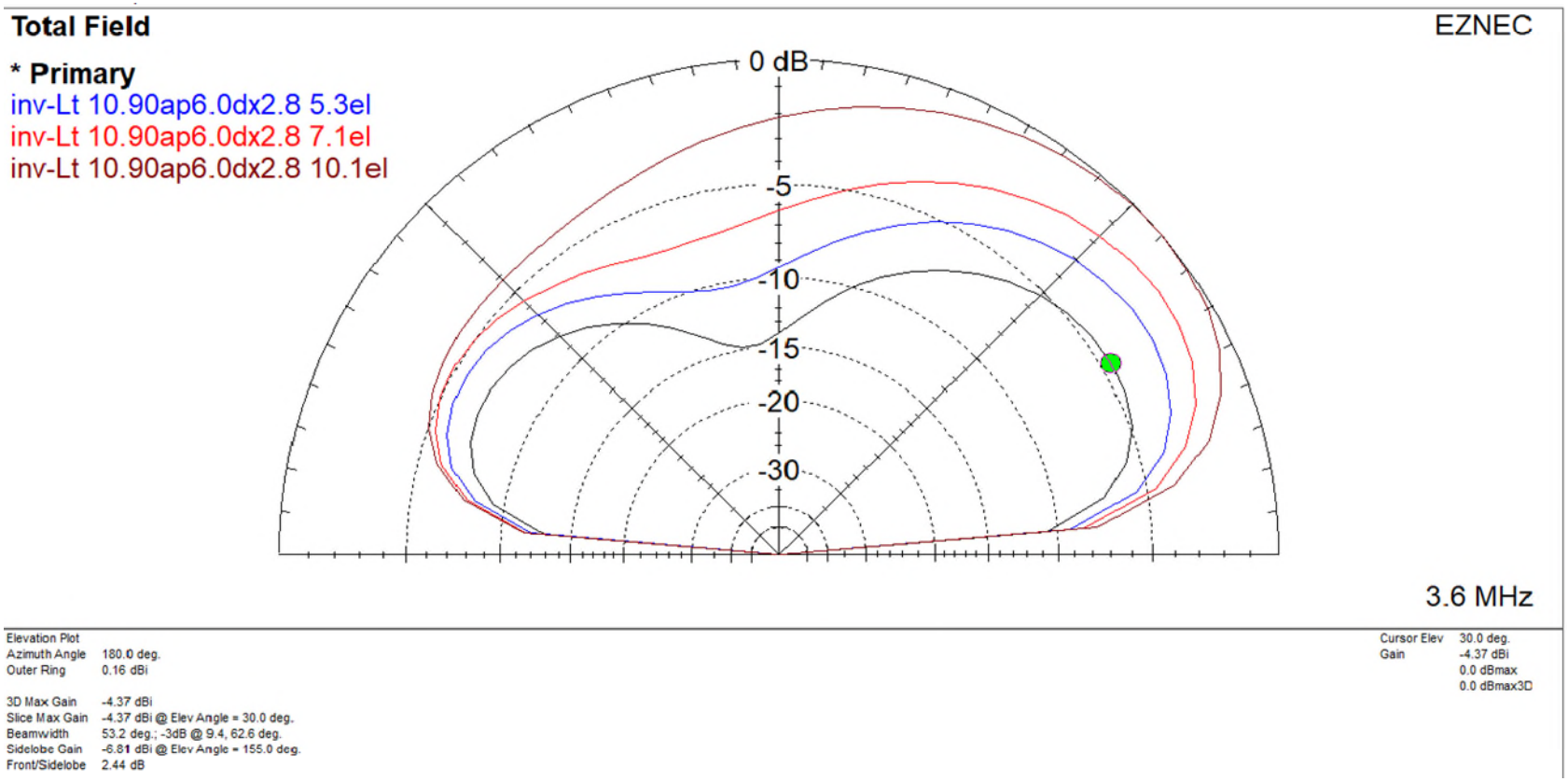


*Figure 6 Vertical radiation (at maximum) on 80-30 m*

# Antenna characteristics (EZNEC) : Vertical radiation on 20-10 m

***>>> Slices at max. radiation (gain, azimuth and elevation according to Figure 3)***

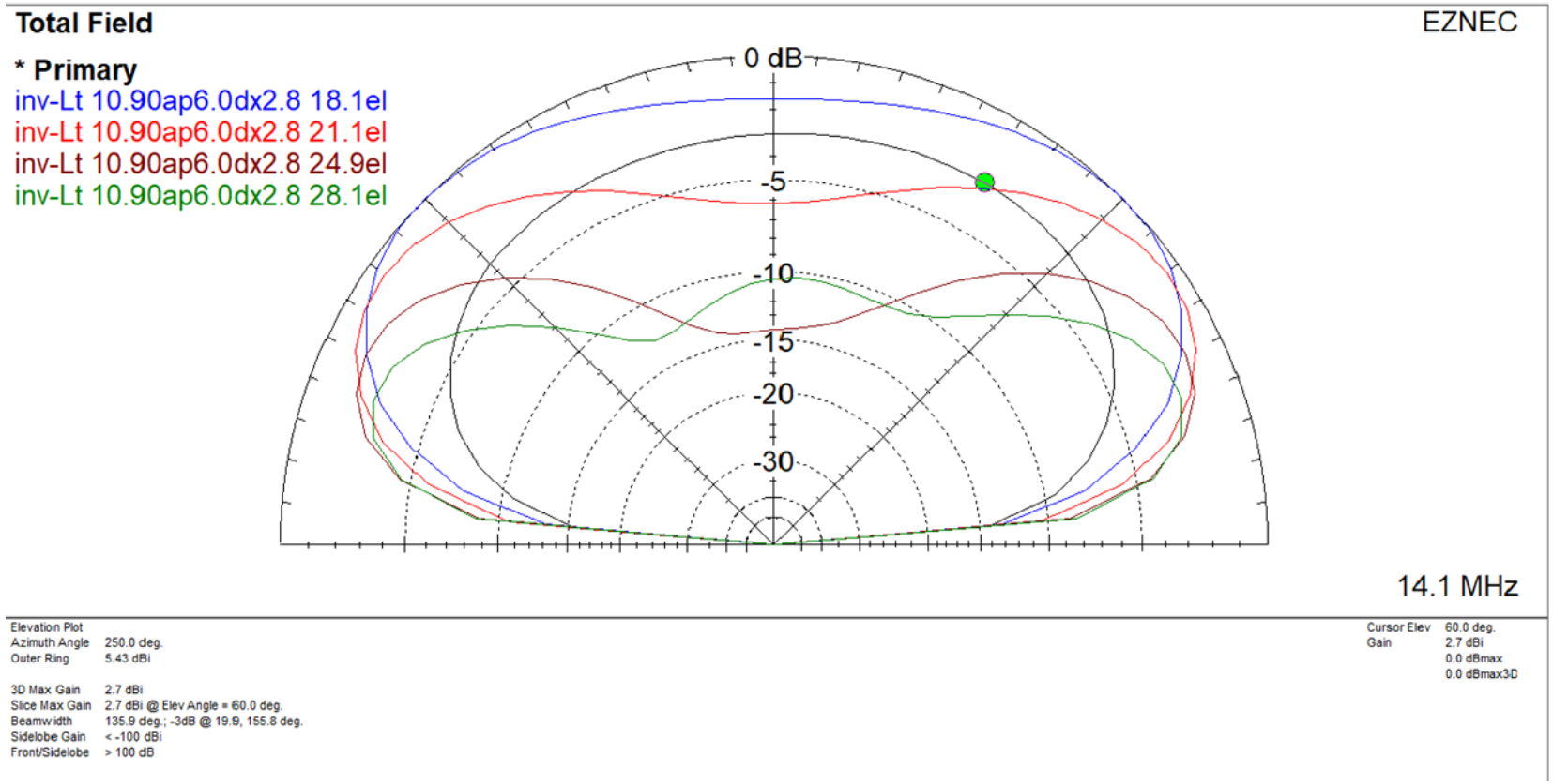


*Figure 7 Vertical radiation (at maximum) on 20-10 m*

# Realization: Antenna radiator

- Radiator length: 10.90 m
- Wire strand: Radox 125 (0.25 mm2, 19 x 0.13 mm copper, conductor diam. 0.6 mm)
- Attachment of the radiator to the mast with rubber ring or sleeve (Figure 8)
- Isolator and guy rope: Stroft ABR 0.60 mm Monofil Polyamide thread

*Note*
*Wire strands with another length/diameter ratio or different conductor properties have a different velocity factor and therefore can not be exchanged 1:1 with respect to their length.*
*Therefore, electrically thinner antenna conductors would have to be cut by up to about 10 cm longer and electrically thicker accordingly shorter. Criterion: Perfect matching of the 12 m band (measured over 2 extreme soils).*

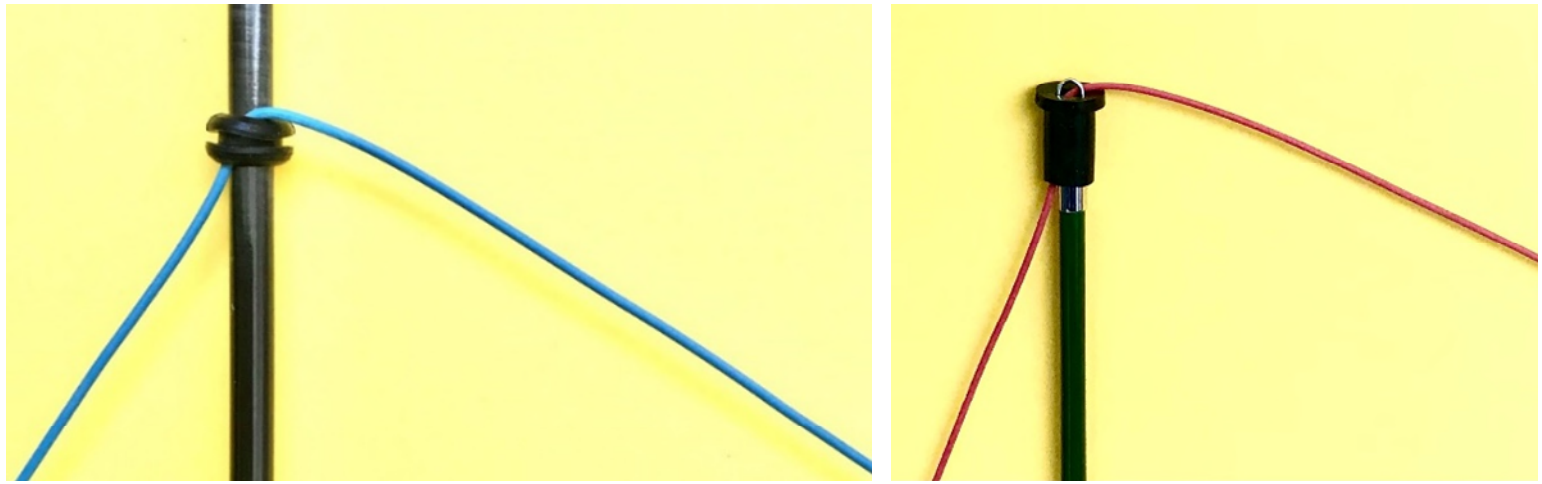

*Figure 8 Fastening the antenna on the mast by rubber ring/grommet*

# Realization: Radials (non-resonant)

» Radial length 4.20 m, 4 pieces of equal length
» Wire strand: RADOX-125 (0.5 mm2, 19x0.18 mm copper, conductor diam. 0.9 mm)
Note: The radial ends must be isolated (Figure 9), e.g. turn the ends and shrink with shrink tubing with inner melt adhesive

*Figure 9 Radials (set of 4) with insulated ends*

# Realization: Impedance matching aids

An inverted-L antenna according to the dimensioning range listed in Figure 2 has a resonance frequency of about 7150 +/- 100 kHz. The frequency varies slightly, not only because of the different arrangements, but also due to different conductivity and reflectivity of the ground (conductivity poor to very good).

The KXAT2 is capable to find a perfect match (SWR 1) for an appropriately arranged antenna by majority on all bands except 80, 60 and 20 m.

To support the KXAT2 in the above-mentioned exceptional cases, KX2 external fixed tuned matching aids are used. These are housed in a small housing, which is flanged to the KX2 by means of 2 BNC angular pieces.
The 2 angular pieces («gooseneck») make it possible to swivel the matching box in 2 planes, what allows to follow the orientation of the radiator direction (Figure 12).

The short relative antenna length of 10.90 m on the 80 and 60 m band is electrically extended to about a quarter wavelength each by loading coils. The 20 m band is matched by a fixed tuned LC matching circuit (Figure 10).

| Band [m] | Core | Inductivity [uH] @ 1 kHz | Number of turns / wire diam. [mm] | Capacity [pF] |
|---|---|---|---|---|
| 80 | T-130-2 | 30 | 51 / 0.75 (AWG21) | - |
| 60 | T-80-2 | 8.8 | 37 / 0.63 (AWG22) | - |
| 20 | T-68-6 | 5.36 | 32 / 0.63 (AWG22) | 21 (RG178 B/U) |

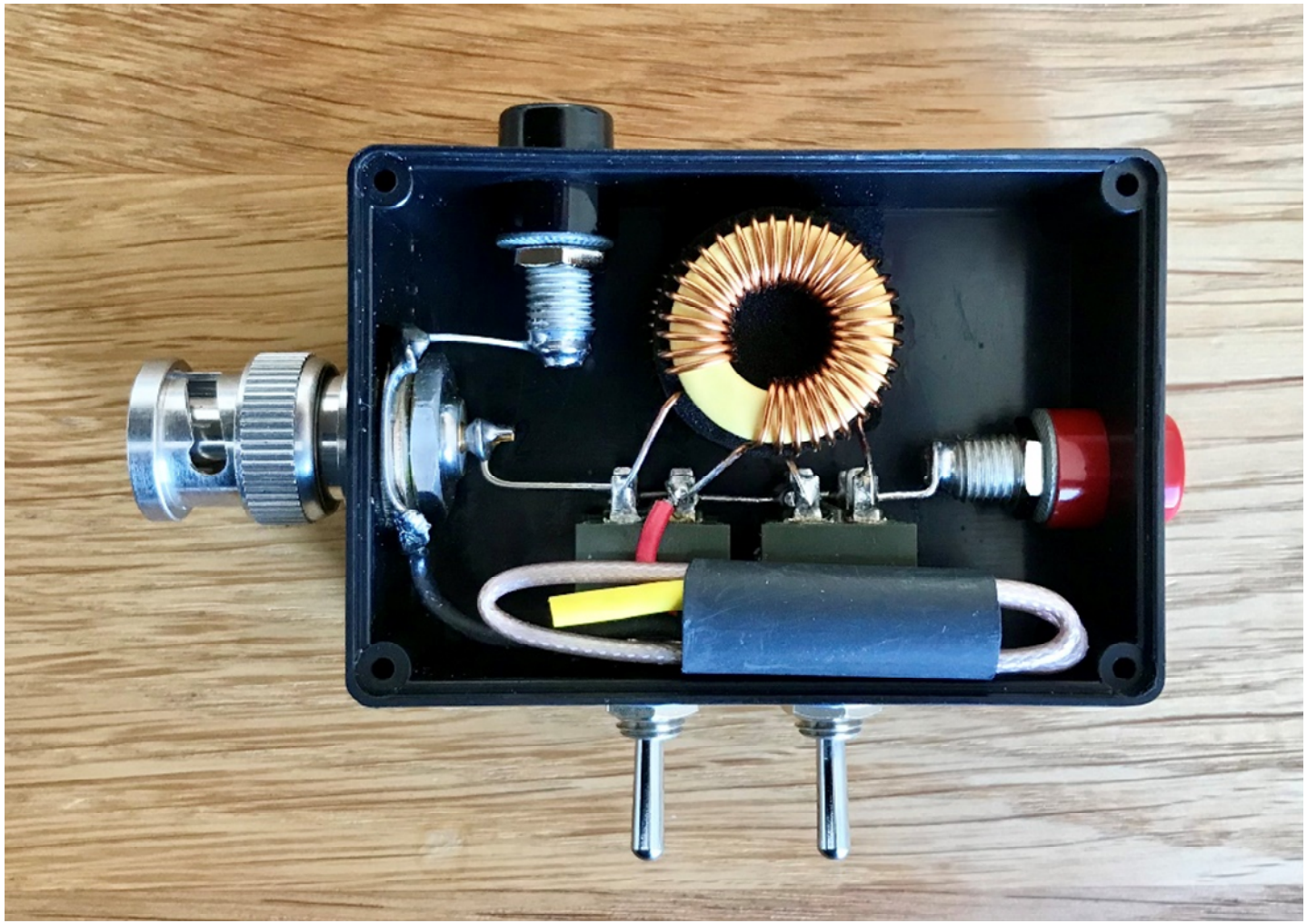

*Figure 10  Fixed tuned 20 m LC matching circuit (on top of the 60 m loading coil)*


*Figure 11 External impedance matching aids for 20, 60 and 80 m*


*Figure 12 KX2/KXAT2 with swiveling matching box for 60 and 20 m*

# Use of the inverted-L antenna: To be considered

» Inverted-L antennas belong to the family of monopole antennas and these antennas require the conductivity and reflectivity of the soil as 2nd pole (supported by the radials).

» Inverted-L antennas with non-resonant radials laid out on the ground are not suitable for operation on a tower, house roof or balcony.

» The antenna radiator must be connected directly to the antenna tuner (without a coaxial cable).

» **Avoid, if it is possible, the following situations**, because the antenna characteristics and impedance matching is impaired (frequency-dependent):

- Arrangement of the radiator **not in a straight line**, e.g. turning an antenna-half by up to 90 degrees
- Arrangement of the antenna **closer than lambda/2 of surrounding structures** (e.g., metallic signposts/summit crosses/chain-wire fences, towers, buildings, trees, high shrubs).

# Use of the Inverted-L antenna: User compass

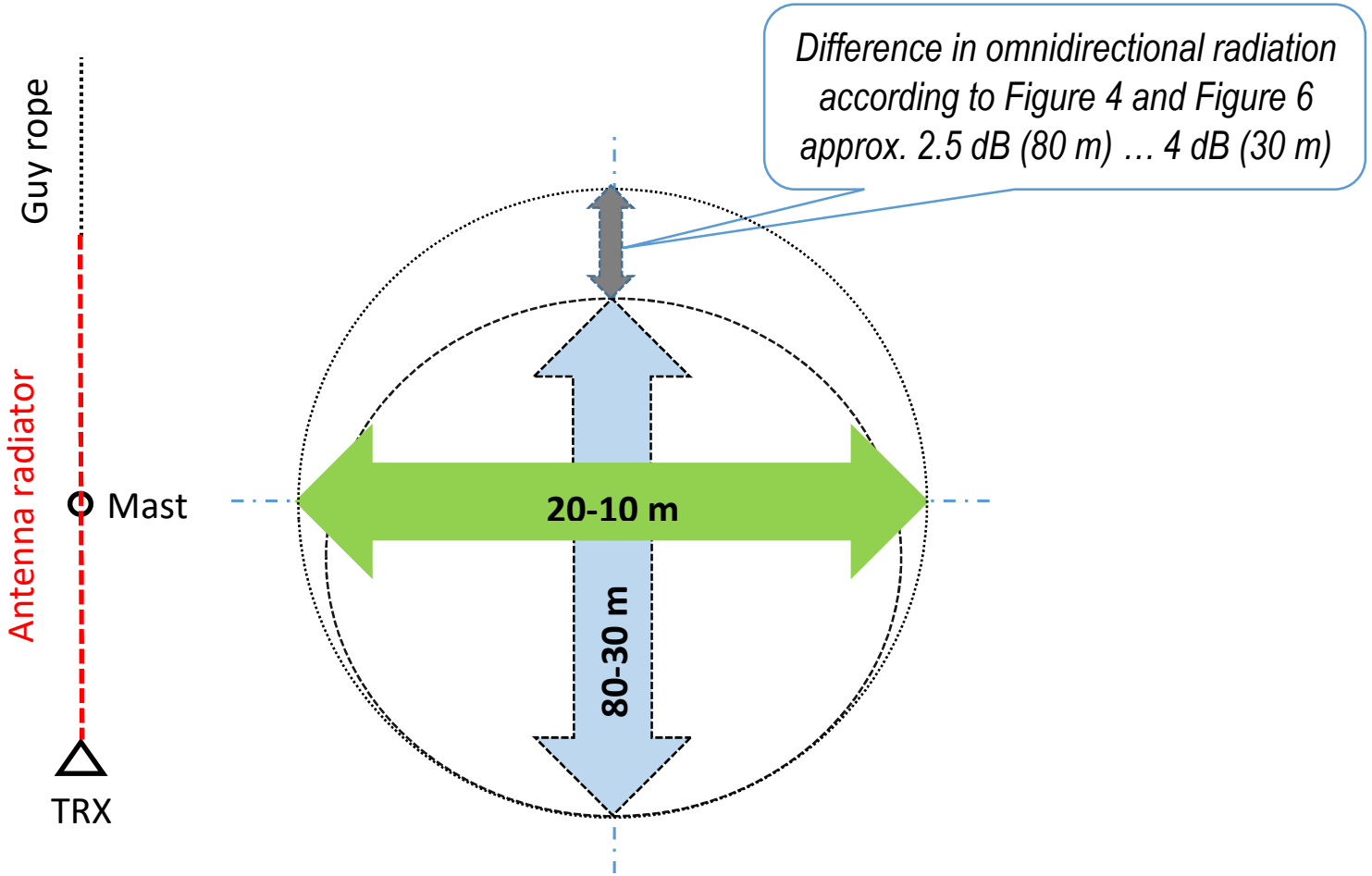


*Figure 13 Main radiation directions relative to the antenna direction (left in red)*

# Conclusion

The prototype phase, while the various inverted-L radiator lengths and matching aids were tested in practical operation, could be successfully completed after around 2 years in spring 2020.

Due to the propagation conditions prevailing during this time, the strengths of the antenna on the higher-frequency bands have not yet been really confirmed as above-average. On the bands below 14 MHz, however, the experiences made were surprisingly good, even with a transmission power of only 5 watts.

A big thank you goes to Bruno HB9CBR for his support as a tireless first-time user during these 2 years. His feedback from countless SOTA and HBFF activations was very useful in optimizing the all-band inverted-L antenna for the KX2.

With the optimized 20 m matching aid available since the beginning of 2021 (a fixed tuned LC matching circuit instead of the broadband transformer), the 10.90 m inv-L antenna can now also meet highest efficiency expectations on this interesting band.

So I hope that the present description can also encourage other antenna enthusiasts to design and self-build an antenna for individual needs.

# Attachment

## Use of the inverted-L antenna with the Elecraft KX3/KXAT3

The 10.90 m inverted-L all-band antenna with the external matching aids for 80, 60 and 20 m can also be used with the Elecraft KX3/KXAT3.

Differences between the KX2/KXAT2 and KX3/KXAT3

» Despite the almost identical dimensioning of the L and C elements of the internal antenna tuners KXAT2 and KXAT3, the KXAT3 can usually not adequately match the 10 m band (SWR >> 2).

*Suspected reason: The layout of the KXAT3 module produces a too high stray capacity with respect to the smallest C element of the LC network (10 pF). This is probably the reason that on some other bands with unproblematic impedances the matching is possible "only" to a SWR 1.1.*

» The KXAT3, however, has sufficient inductivity to easily match the 60 m band, so the external 60 m matching aid is not mandatory.

## Use of the inverted-L antenna with the Elecraft T1 Antenna Tuner

The 10.90 m inverted-L all-band antenna with the external matching aids for 80, 60 and 20 m can also be used with the Elecraft T1 antenna tuner.
The T1 is capable to find a perfect match for an appropriately arranged antenna by majority on all bands (SWR 1) and approx. SWR 1.5 for the remaining bands.