Coaxial Cable Feeder Influence on Yagi Antenna - Part 2

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Introduction

In the first part of this article **[1]** we presented the results of investigation how coaxial cable antenna feeder influences antenna performances in situation when minimum interaction between antenna and cable is achieved. Investigations were conducted by computer simulations of six antennas under same conditions.

Results show high degree of dependence on cable approaching angle *alpha* to antenna driven element. This happened although approaching angle *alpha* was always kept lying in the antenna symmetry plane in order to maintain minimum interaction between cable and antenna.

Coaxial cable was set in a way that it is not electrically connected to antenna in order to model antenna feeding through ideal 1:1 BalUn which represents infinite impedance to common mode currents. Only currents induced by the antenna RF field were considered. We were using infinite common mode impedance and cable position lying in the antenna symmetry plane intentionally in order to get results of minimum possible interaction and influence. Even under these idealized conditions and in the absence of any other environmental effect, results show considerable antenna performance degradation for some antennas, prevalently for those with higher Q factors.

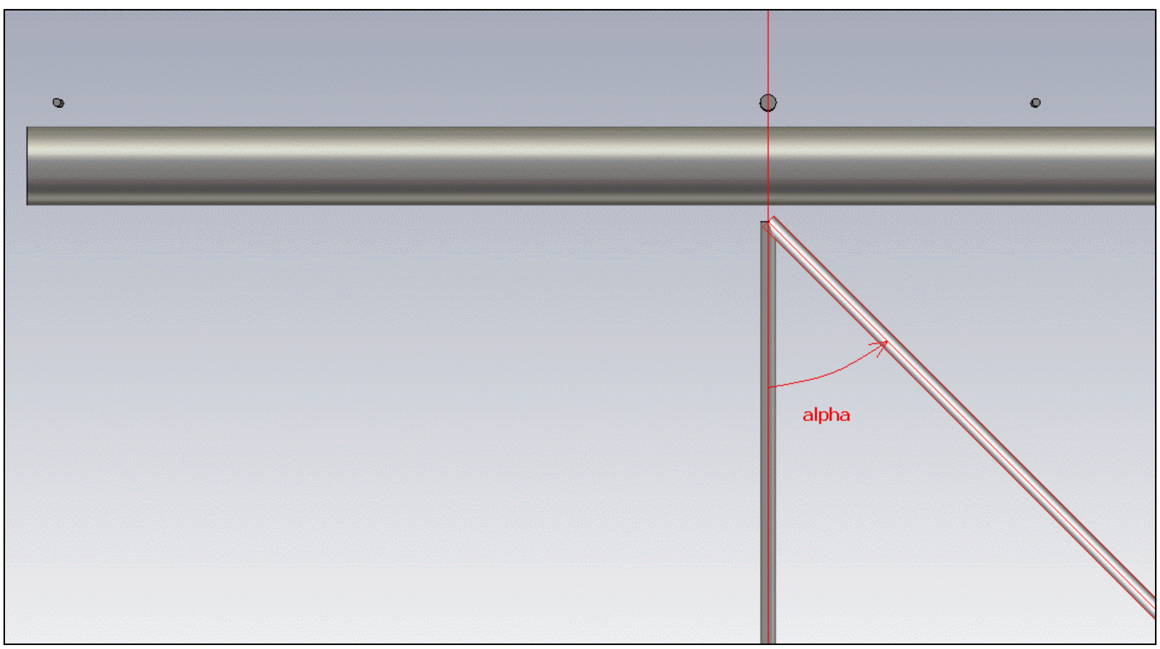

***Fig.1 Yagi antenna with coaxial cable feeder and definition of approach angle* alpha**

By using a real balun, or feeding the antenna without a balun and guiding cable that is not always lying in antenna symmetry plane, we can expect much higher degree of performances influence and degradation.

Influence of cable which is not lying in antenna symmetry plane

In practice, very often coaxial cable is not lying in the symmetry plane even when a single antenna or vertically stacked antenna array is used. In situations when we use a horizontally stacked antenna array, it is simply not possible to have the cable lying in the vertical plane of antenna symmetry.

We conducted investigations how coaxial cable influences antenna performance when it is not lying in symmetry plane as it is usually used for feeding two horizontally stacked antennas or four antennas stacked two over two, or due to any other reason depending on mechanical support construction demands. In this situation, cable cannot lie in the antenna symmetry plane, and it is approaching a Yagi antenna's driver element under angle *beta* which is lying in the plane perpendicular to the antenna symmetry plane. With combinations of various values for angles *alpha* and *beta*, we can set the coaxial cable in different positions in respect to the Yagi antenna's position. In such case, cancelations of some effects could be present in a lesser degree and we could expect more influence than in a situation when the cable is lying exactly in the antenna symmetry plane (beta = 0 deg).

In this investigation we will examine how the coaxial cable feeder influences antenna performance when it approaches a single Yagi antenna's active dipole element from various directions which are not lying in antenna vertical plane of symmetry.

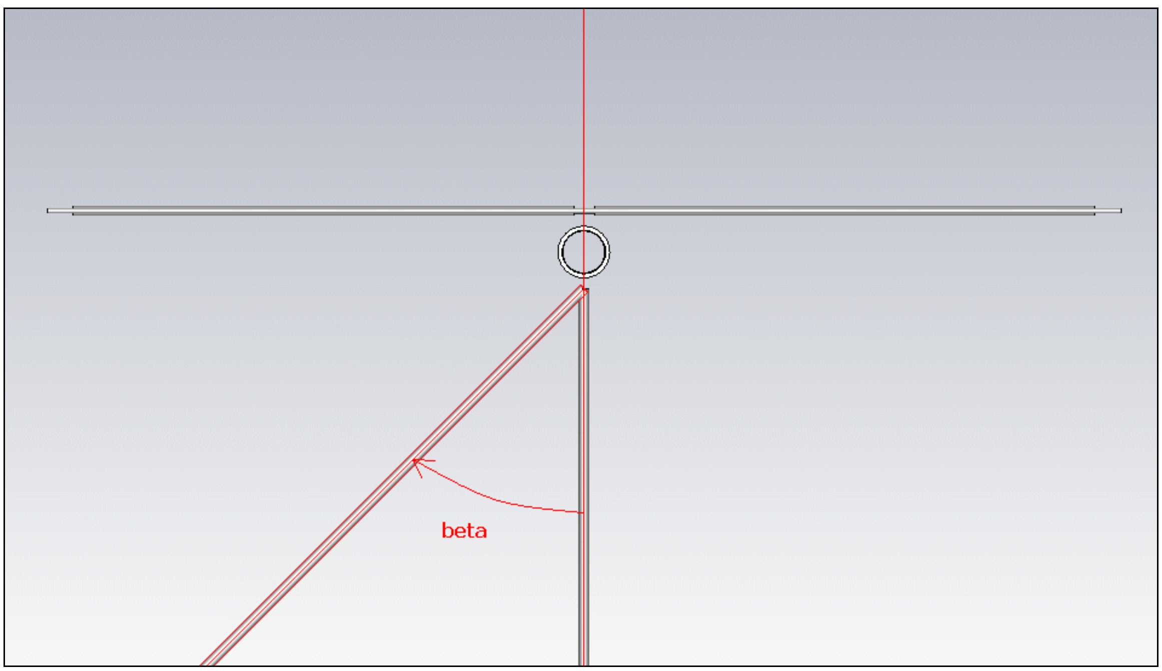

Fig.2 Yagi antenna with coaxial cable feeder and definition of approach angle **beta**

Simulation conditions

All six Yagi antennas were simulated under the same conditions. A 50 mm diameter conductive round tube boom was placed below the elements so that the distance between the boom axis and elements axis was 40 mm. It represents a Yagi antenna simulation with elements insulated from a boom and mounted on the boom using plastic insulators with very low dielectric permittivity and with fixed 15 mm height of element axis above the boom's most top surface. A Yagi antenna with elements set in the horizontal plane was fed by a fixed diameter coaxial cable that was coming from the bottom vertically up to the driven element.

At the beginning, the coaxial cable is under a right angle to the boom and to the elements axis and lying in the vertical plane of antenna symmetry. This is a starting reference position. Then the cable direction angles are defined as in Fig. 1 and 2. Angle *alpha* is the same as it was defined in previous article and it is lying in the symmetry plane of the antenna. Another angle *beta* is added which is lying in the plane perpendicular to the boom axis. By setting various values for these two angles it was possible to change the cable position in any direction.

Coaxial feeder is of 10 mm diameter, 3 m long and it ends in the vicinity of boom's most bottom surface, but doesn't touch it (Fig.1 and 2). Both ends of outer conductor of the coaxial cable are left unconnected, i.e., they are electrically "floating." The RF source was placed and connected to the dipole arms at the dipole center insulation gap. The length of coaxial cable was limited solely by the computer's computational demands.

This represents a simulation of a Yagi antenna fed with coaxial cable over ideal 1:1 balun which represents infinite impedance to common mode currents flowing on the outer surface of the coaxial cable. This setup gives a good opportunity to investigate coaxial cable influence on the Yagi antenna only due to induced currents which flow on a cable's outer surface as a consequence of an antenna's near field.

In the previous article, we saw that any influence between the antenna and coaxial cable that was lying exactly in the plane of antenna symmetry were minimal due to induced currents cancelation at the outer surface of the coaxial cable's outer conductor. But with introduction of angle *beta,* it was possible to place the cable out of the antenna symmetry plane and see how big the influence would be.

Simulation conditions were very similar to a practical situation when a single antenna is mounted on the top of a very tall and slim pole, but where the coaxial cable is approaching the antenna from directions that are not lying in symmetry plane of antenna. This simulation together with previous one **[1]** should give an answer to the question what would be the best way to guide the feeding coaxial cable in regard to pole, antenna boom and other possible support structures, and how various antennas are sensitive to this.

For this task the antenna simulation software based on FIT method has been used once again, instead of the usual MoM based software which has already been found inadequate due to a few unacceptable program limitations **[2].** Similarly as in the previous article, coaxial cable influence has been monitored on the following antenna parameters in dependence on angles *alpha* and *beta* between the starting vertical position and some next new position of the coaxial cable (Fig.1 and 2):

1. Mean value of antenna input return loss (S11) in 144…146 MHz band
2. Mean value of broadband directivity in 144…146 MHz band
3. Mean value of antenna Q factor in 144…146 MHz band
4. Antenna directivity pattern in E and H planes at frequency 144.5 MHz

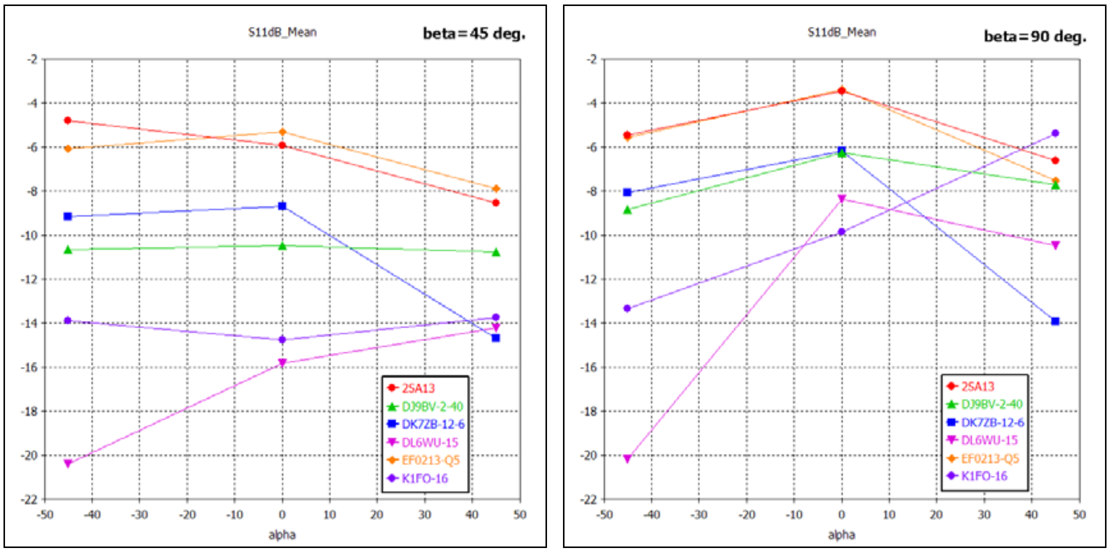

***Fig.3 Input return loss mean value in 144…146 MHz band for different cable approaching angles* alpha *and* beta**

Influence on input return loss

Some higher degree of coaxial cable influence on antenna input return loss and SWR was expected because of the cable position that does not produce the minimum of interaction between antenna and cable as in previous article **[1]**. Conducted simulations gave clear confirmation that the presence and position of coaxial cable feeder that is out of antenna symmetry plane produces more considerable change of antenna input impedance and thus the input return loss mean value, especially for beta = 90 deg. (Fig. 3).

From presented diagrams on Fig. 3, it is obvious that for all antennas, except the K1FO antenna, for cable positions under angles alpha = 0 and beta = 90 degrees, i.e., when the cable is leading to the antenna parallel and close to driver element, input return loss mean values are the worst. For K1FO antenna the worst case is when the cable leads from front side under alpha = 45 deg. and parallel with antenna elements plane, i.e., beta = 90 deg.

Generally, under beta = 45 deg., lower Q factor antennas remained with similar or little worse degradation than in the previous article where a minimum of interaction has been achieved. Higher Q factor antennas suffered high degradation but paradoxically little less than in the previous article. With beta = 90 deg. all antennas suffered much higher degradation of input return loss, except the 2SA13 antenna which had a little higher degradation with starting vertical position of the cable (alpha = 0 and beta= 0), as can be seen in previous article **[1].**

It is also very interesting that input return loss value of all antennas for cable approaching from rear side under alpha = -45 deg. stays almost unchangeable for both *beta* angle values.

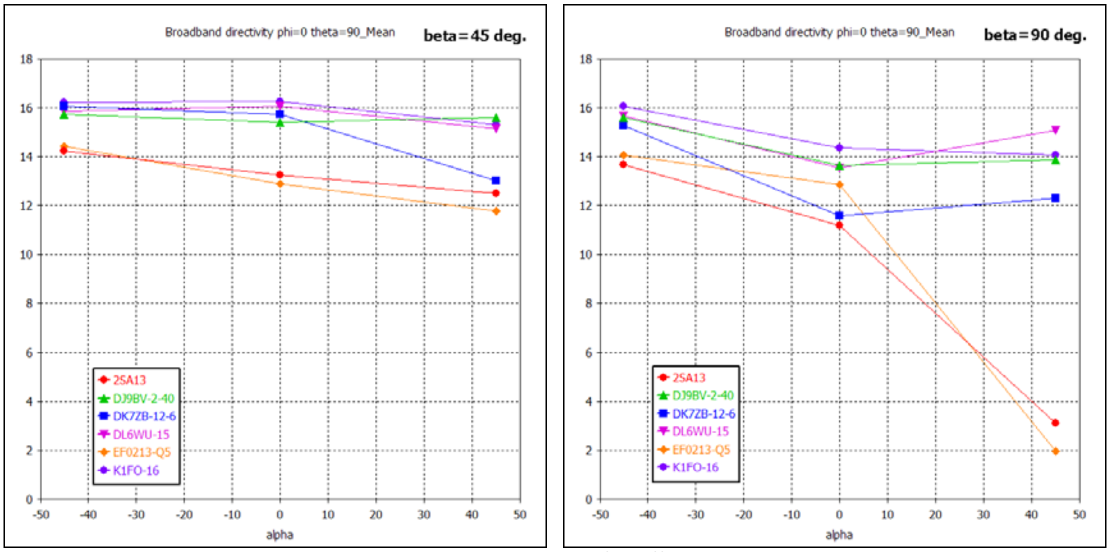

***Fig.4 Broadband directivity mean value in 144…146 MHz band for different cable approaching angles* alpha *and* beta**

Influence on broadband directivity

As we mentioned in previous article **[1]**, antenna broadband directivity curves are being shifted in the frequency domain due to coaxial cable influence similarly as due to a conductive boom or moist influence **[3, 4]**. Higher Q antennas have narrower broadband directivity curves and, due to higher sensitivity to environmental impacts, their directivity curves shift more. As a result, they have considerably higher variation of antenna directivity mean value within the amateur band.

Generally, cable influence on antenna broadband directivity mean value is higher than in previous article and that is in accordance with influences on input return loss mean value. The least degradation for all and especially for higher Q antennas is when the cable comes from the rear side of antenna (alpha = -45 deg.).

However, for lower Q antennas any position of cable under beta = 45 deg. is almost the same and these antennas suffer very small influence of cable presence in its position similarly as in previous article.

Presented diagrams on Fig. 4 clearly show much lower sensitivity and directivity degradation of lower Q factor antennas under all cable approach angles. This is especially visible under conditions when the cable is lying in the same plane as antenna (beta = 90 deg.) which can severely degrade directivity of high Q antennas.

Here it is also noticeable that broadband directivity mean value of all antennas for a cable approaching from the rear side under alpha = -45 deg. stays almost unchanged for both *beta* angle values, similarly as for input return loss value.

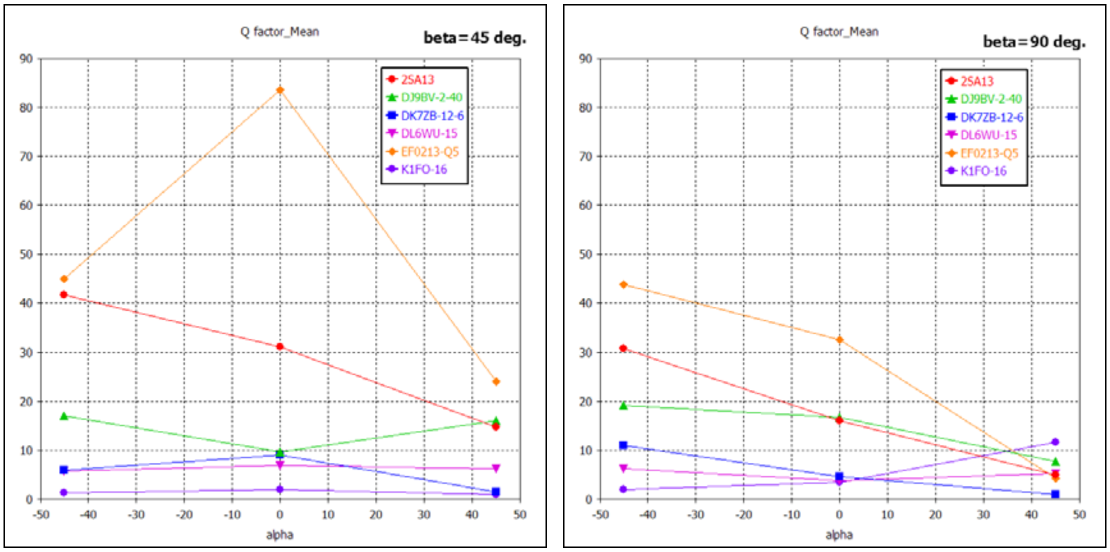

***Fig.5 Antenna Q factor mean value in 144…146 MHz band for different cable approaching angles* alpha *and* beta**

Influence on antenna Q factor

Change of antenna Q factor mean value with various cable positions also follow the same rule as for input return loss and broadband antenna directivity. Antennas with a higher Q factor suffer a much bigger Q factor change due to cable presence and position than antennas with lower Q factor (Fig. 5). This is very similar to change of antenna Q factor due to moist influence as we already found and reported in past articles **[3, 4]**.

But here it is also noticeable that coaxial cable becomes a significant part of the antenna's radiating structure. Besides the severe changing of radiation pattern, cable radiation also changes antenna input impedance and considerably increases radiation and loss resistance. All these factors together change the Q factor of the antenna.

Influence on antenna directivity pattern

Radiation diagrams in E and H planes for all six antennas with dependence on cable approaching angle *alpha* and *beta* are given on Fig. 6. and Fig. 7.

Due to significant coaxial cable influence and radiation, antenna radiation diagrams in both planes are considerably distorted. Cable approaching the antenna from the back side under alpha = -45 deg. generally shows the least distortion. But it is obvious that every antenna has some cable position which is its "Achilles' heel." On the other hand, intensity of antenna diagram disturbance is very much dependent on antenna design.

As can be seen from presented radiation diagrams, antennas with lower Q factor are usually less disturbed by presence of coaxial cable and its various positions due to their lower sensitivity to environmental influences.

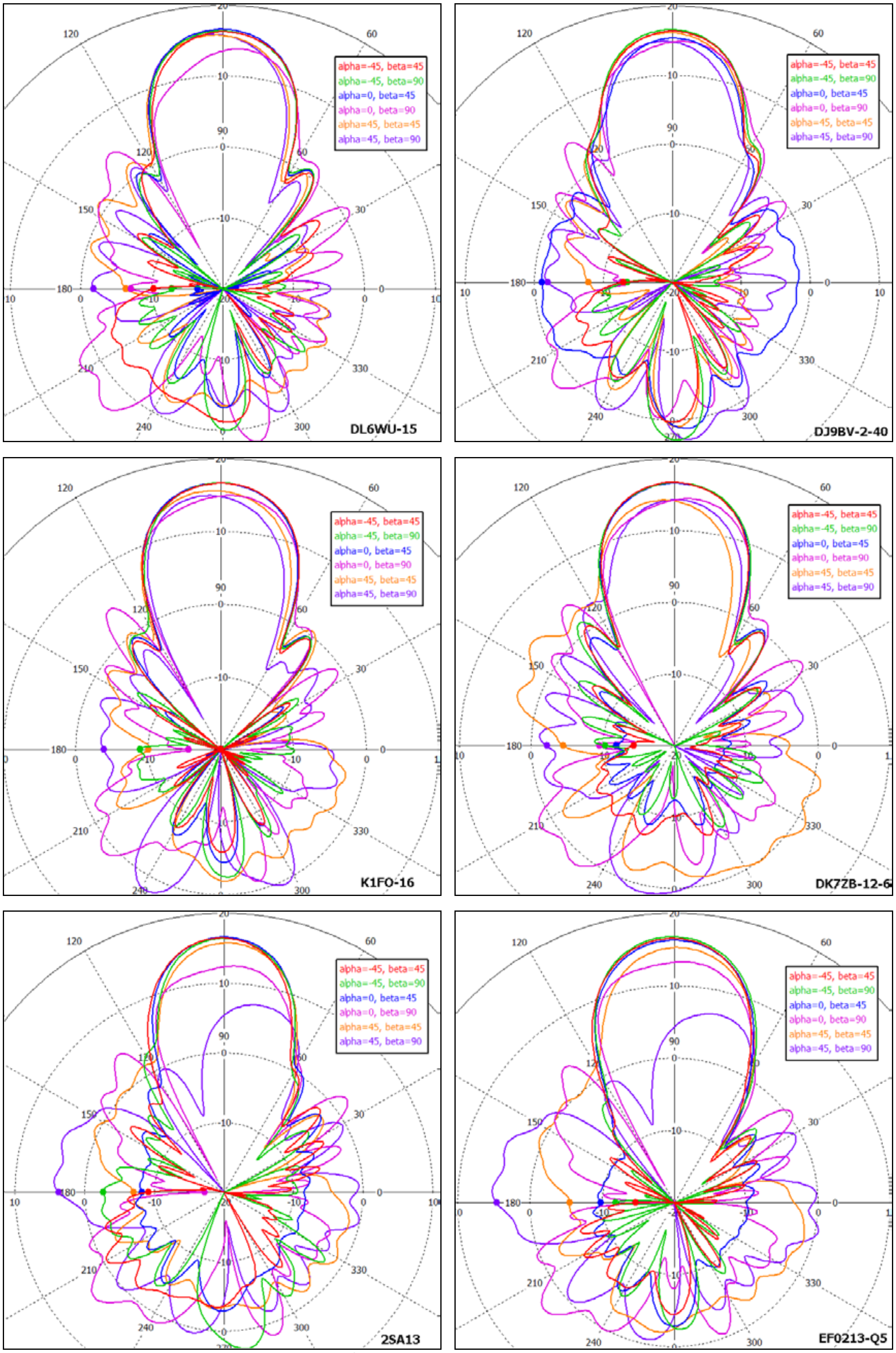

Fig.6 Radiation diagrams in E plane at 144.5 MHz for all six antennas in dependence on cable approaching angles **alpha** *and* **beta**

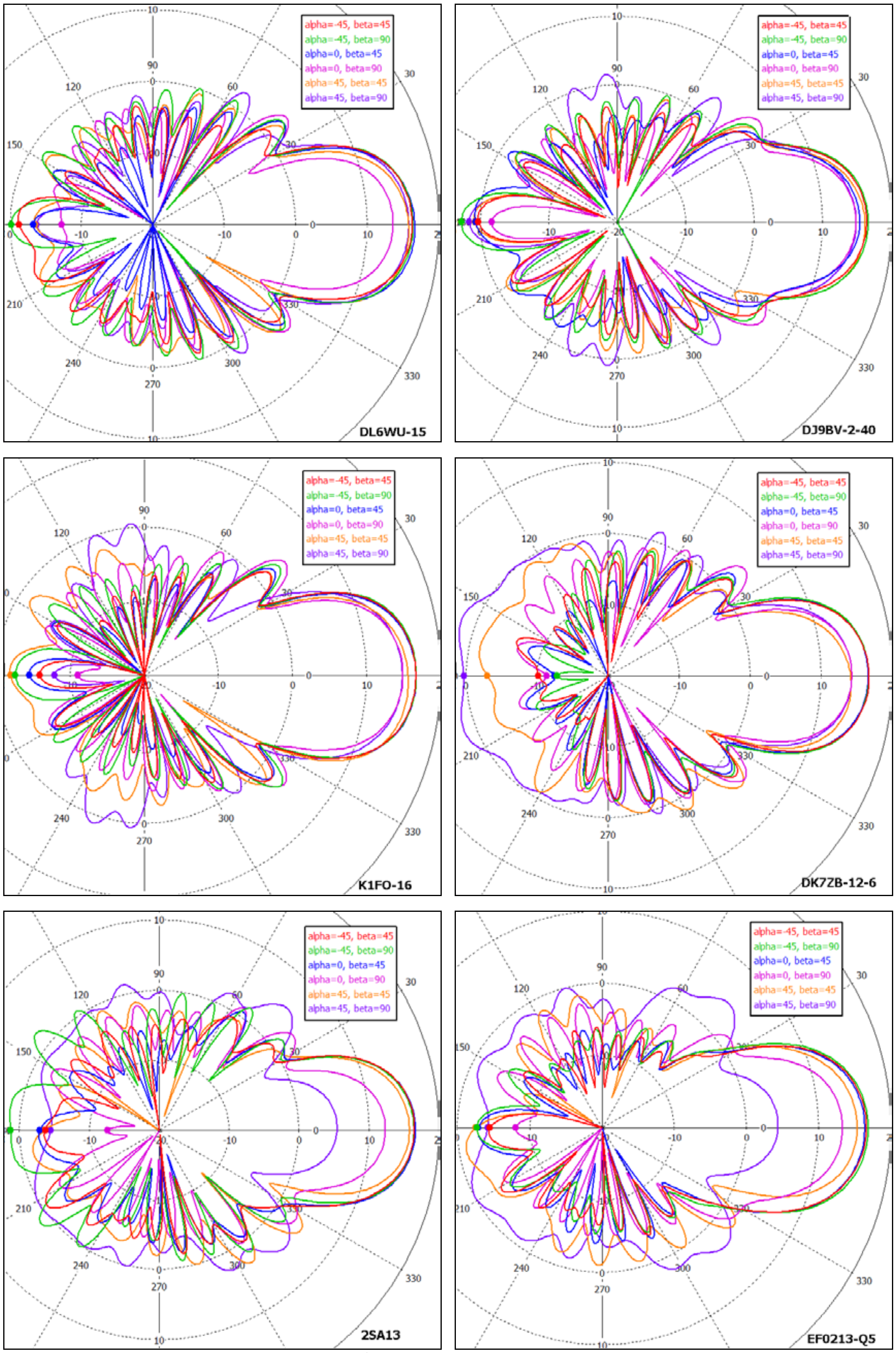

Fig.7 Radiation diagrams in H plane at 144.5 MHz for all six antennas in dependence on cable approach angles **alpha** *and* **beta**

Conclusion
In this article we presented results of an investigation of how the coaxial cable antenna feed which is not lying in antenna symmetry plane, influences antenna performance. Investigations were conducted by computer simulations of six antennas under the same conditions. Coaxial cable was set so that it represents infinite impedance to common mode currents. Only currents induced by the antenna RF near field were considered.

Results show a high degree of dependence on cable position, i.e., approaching angle *alpha* and *beta* to antenna driven element. Approaching angle *beta* was chosen so that cable was never laid in antenna symmetry plane in order to allow full interaction between cable and antenna.

The presented results can now give answers to questions asked at the beginning of previous article that are related to cable influence on a single antenna.

If we must guide coaxial cable out of the antenna's symmetry plane, then results of these simulations clearly show that it is better to guide coaxial cable from the driven element backwards (alpha = -45 deg.) in regard to the antenna. Also, we found that the best cable position with minimal impact to antenna performance is practically the same for almost all antenna designs.

These simulations unambiguously confirmed that lower Q factor antennas under all circumstances have less performances degradation.

Using a real balun, or even feeding antenna without balun as it is usually case in everyday practice, we can expect much higher degree of performance influence and degradation.

All of these effects to an antenna's most important performance obviously illustrate the antenna's probable behavior and sensitivity to environmental impacts in practical working conditions. **-30-**

References:

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BRIEF BIOGRAPHY OF THE AUTHOR

Dragoslav Dobričić, YU1AW, is a retired electronic Engineer and worked for 40 years in Radio Television Belgrade on installing, maintaining and servicing radio and television transmitters, microwave links, TV and FM repeaters and antennas. At the end of his

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For over 40 years, Dragan has published articles with different original constructions of power amplifiers, low noise preamplifiers, antennas for HF, VHF, UHF and SHF bands. He has been a licensed Ham radio since 1964. He is married with two grown up children, a son and a daughter.

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