Coaxial Cable Feeder Influence on Yagi Antenna

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Introduction

So far, in several previous articles **[1, 2, 3]**, we investigated how boom radius and its distance from antenna elements influences performance of six different 2 m Yagi antennas which are very similar in all characteristics except in Q factor values **[4, 5]**.

Besides the conducting boom as an inevitable part of the antenna, there are also other supporting structures which can influence antenna performances. In a previous article we saw that the boom or other similar conductive structure influences extend to quite large distances from antenna elements. However, there is another inevitable part of an antenna system, antenna feeder, which can influence antenna work, especially because feeding cable has to be very close to antenna and connected to it. Its closeness as a connection to the antenna, the way it is connected to a driven element and the path over which it travels down to the transceiver makes it an important factor that can produce a serious impact on antenna performances.

Using computer simulations, we investigated how a fixed radius coaxial cable feeder that runs to a dipole under various angles and from various directions in regard to antenna elements influences of Yagi antenna parameters. The problem of achieving minimum interaction between antenna and its feeder is very interesting and important so we will try to shed more light on this problem.

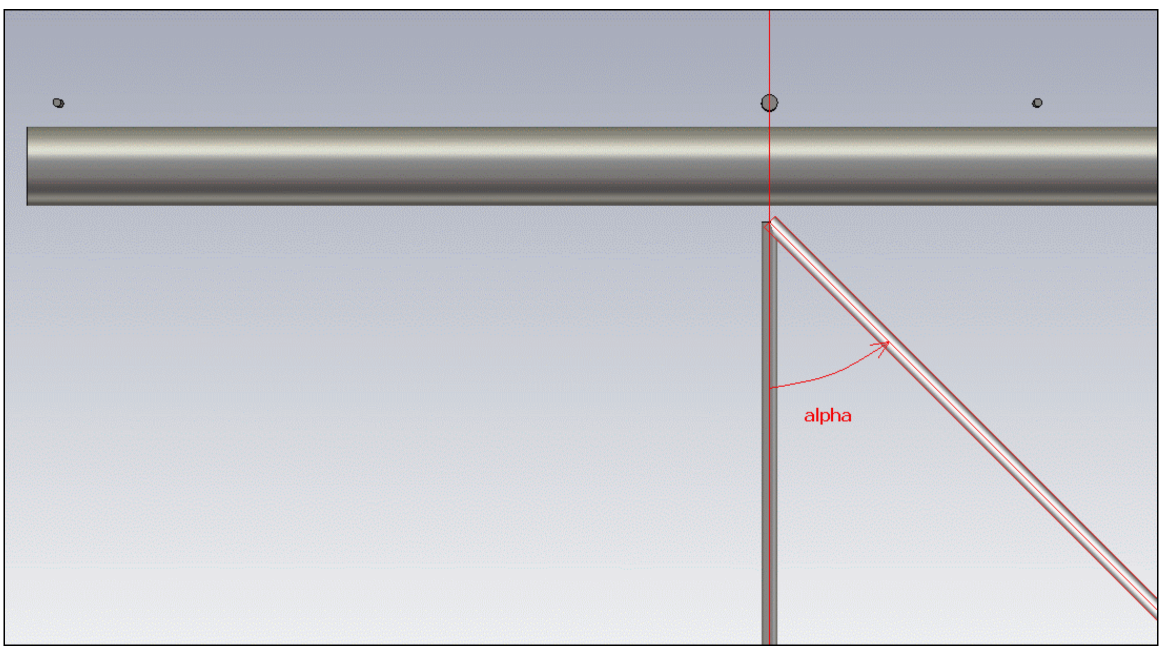
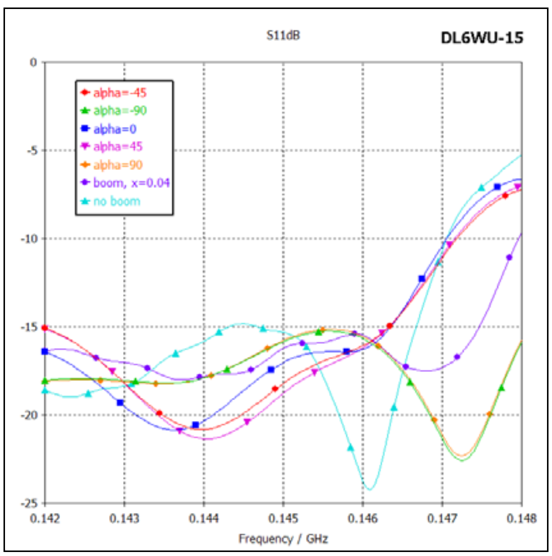
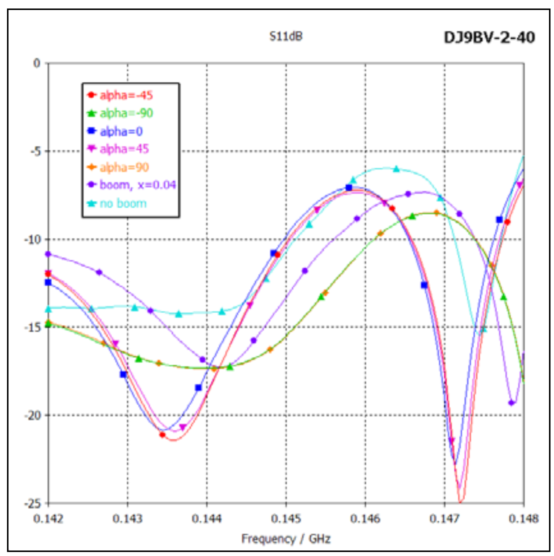


Fig.1 Yagi antenna with coaxial cable feeder and definition of approach angle alpha

Simulation conditions

All six Yagi antennas were simulated under the same conditions. Yagi antennas were first simulated without conductive a boom and without a coaxial cable feeder as a reference for comparison because it is a common manner antennas are often simulated in NEC programs. Later, a 50 mm diameter conductive round tube boom was added. The boom was placed below the elements so that the distance ***x*** between the boom axis and elements axis was 40 mm. It is a quite good representation of a Yagi antenna simulation with elements insulated from a boom and mounted on the boom using plastic insulators with very low dielectric permittivity and a fixed 15 mm height of element axis above the boom's most top surface. Finally, a Yagi antenna with the same boom and elements set horizontally was fed by fixed diameter coaxial cable leading from the bottom vertically up to driven element. The coaxial cable is under a right angle to the boom and to the elements axis and lying in a vertical plane of antenna symmetry. The coaxial feeder is of 10 mm diameter, 3 m long and ends in the vicinity of the boom's most bottom surface, but doesn't touch it (Fig.1). Both ends of the outer conductor of the coaxial cable are left unconnected, i.e., they are electrically "floating." RF source was placed and connected to dipole arms at the dipole center insulation gap.





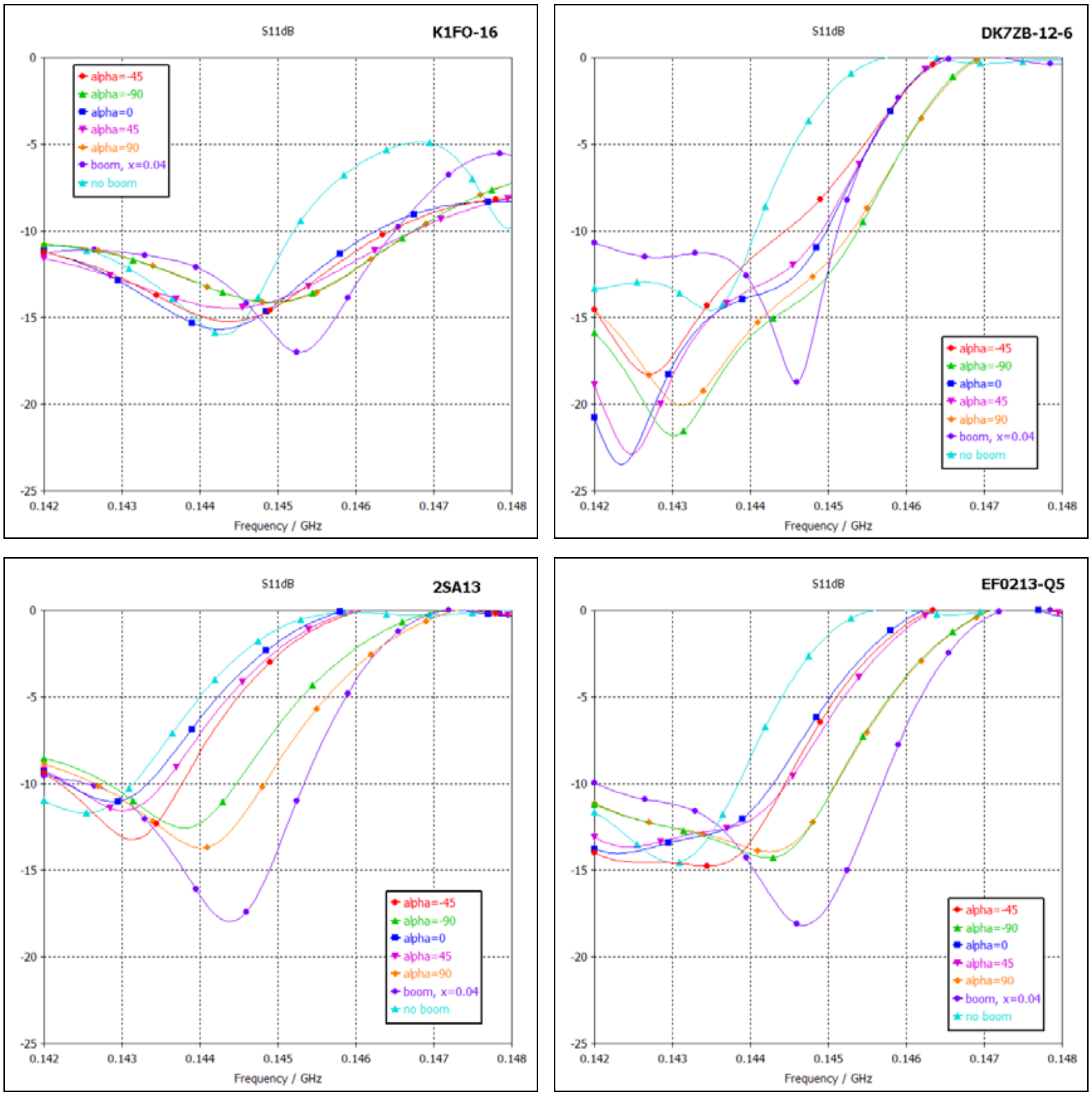


Fig.2 Input return loss for all six antennas in dependence on cable approach angle alpha

This represents simulation of Yagi antenna fed with coaxial cable over very good 1:1 Balun which represents very high impedance to common mode currents flowing on outer surface of the coaxial cable. This setup gives good opportunity to investigate coaxial cable influence on Yagi antenna only due to induced currents which flow on the cable's outer surface as a consequence of the antenna's near field. It was expected that any influence between the antenna and coaxial cable lying exactly in the plane of antenna symmetry would be minimal due to induced current cancelation at the outer surface of the coaxial cable's outer conductor. The length of coaxial cable was limited solely by the computer's computation demands. Simulation conditions are very similar to a practical situation when one single antenna is mounted on the top of a very tall and slim pole. This simulation should give the answer to the question what would be the best way to guide a feeding coaxial cable in regard to the pole, antenna boom and other possible support structures. Is it better to guide a coaxial cable through the air following the shortest path, or tighten near metal boom and pole? Is it better to guide a coaxial cable from driven element forward or backward in relative to the antenna? Is the best cable position with minimal impact to antenna performance the same for all antenna designs? How is the cable position and how severe is the related deterioration of performance correlated to antenna Q factor? We would like to try to give answers to all these questions. Let us see what simulation results show.

As in previous articles, for this task the antenna simulation software based on FIT method has been used, instead of usual MoM based software which has been found inadequate due to a few unacceptable program limitations **[3].** The coaxial cable influence has been monitored on the following antenna parameters in dependence on angle ***alpha*** between the beginnings of the vertical position versus alternative way to position the coaxial cable (Fig.1):

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

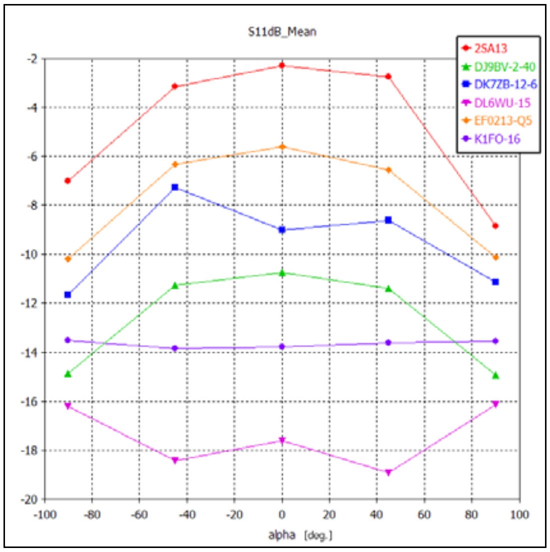


Fig.3 Input return loss mean value in 144…146 MHz band

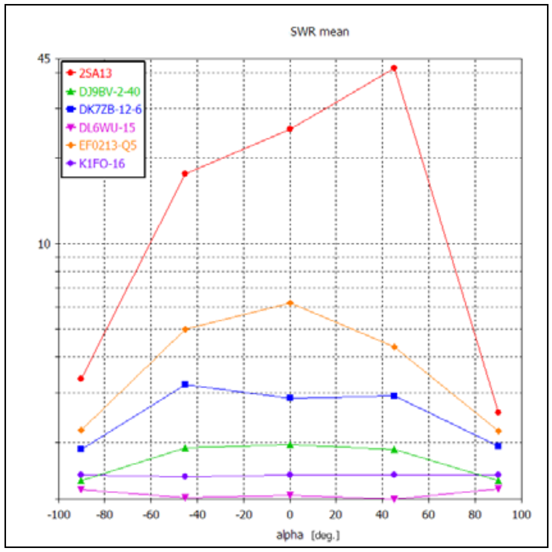


Fig.4 Antenna SWR mean value in 144…146 MHz band

Influence on input return loss and SWR

Some degree of coaxial cable influence on antenna input return loss and SWR was expected. Conducted simulations gave clear confirmation that presence and position of coaxial cable feeder produce considerable change of antenna input impedance. (Fig. 2) From presented diagrams on Fig. 3 and 4 it is obvious that for a majority of antennas, and especially those with higher Q, for cable positions under angle alpha = +/- 90 degrees, i.e., the cable is not located parallel to the driver element, but parallel and close to the boom, SWR and input return loss mean values are the best. There is small difference in performance degradation with cable leading from the rear (alpha = -90 deg.) and from the front side of the antenna (alpha = 90 deg.) in favor to the latter.

A bit surprising is the result that vertical cable, i.e. alpha = 0 or 180 degrees produces the most influence on impedances of almost all higher Q antennas. It seems that along with the increasing of antenna Q simultaneously increases input SWR mean value of antenna if the coaxial cable is led vertically, i.e. alpha = 0 or 180 deg.

Influence on broadband directivity and Q factor

Antenna broadband directivity curves were being shifted in frequency due to coaxial cable influence similarly as due to conductive boom or moist influence **[4, 5]**. Higher Q antennas have narrower broadband directivity curves and higher sensitivity to environmental impacts. As a result of directivity curves frequency shift they have a considerably higher variation of antenna directivity mean value within the amateur band. Cable influence on antenna broadband directivity is in accordance with influences on SWR. The least degradation for higher Q antennas is when the cable runs parallel to the boom (alpha = +/- 90 deg.) and in close vicinity to it. However, for lower Q antennas any position of cable is almost the same and these antennas suffer almost no influence of cable presence and its position (Fig. 5).

Change of antenna Q factor mean value with various cable positions also follow the same rule as for SWR and antenna directivity. Antennas with higher Q factor suffer a much bigger Q factor increase due to cable presence and position than antennas with lower Q factor (Fig. 6). This is very similar to change of antenna Q factor due to moist influence as we already found and reported in past articles **[4, 5]**.

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

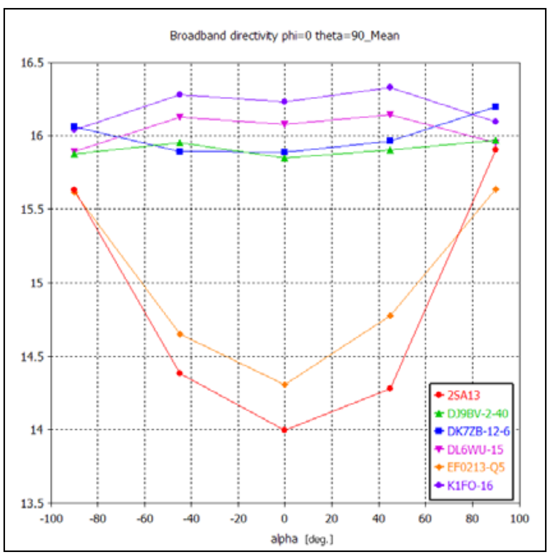


Fig.5 Broadband directivity mean value in 144…146 MHz band

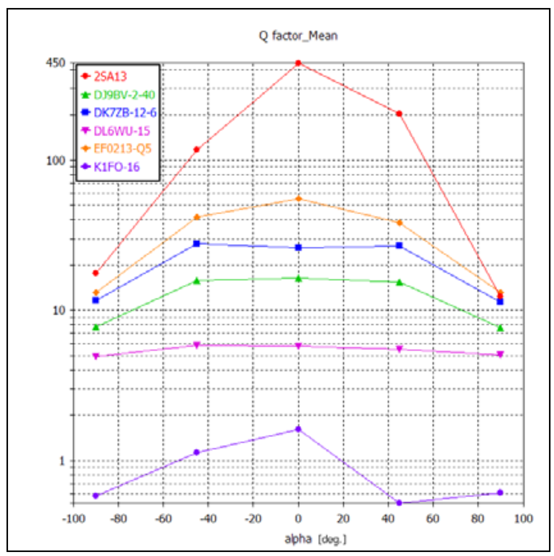
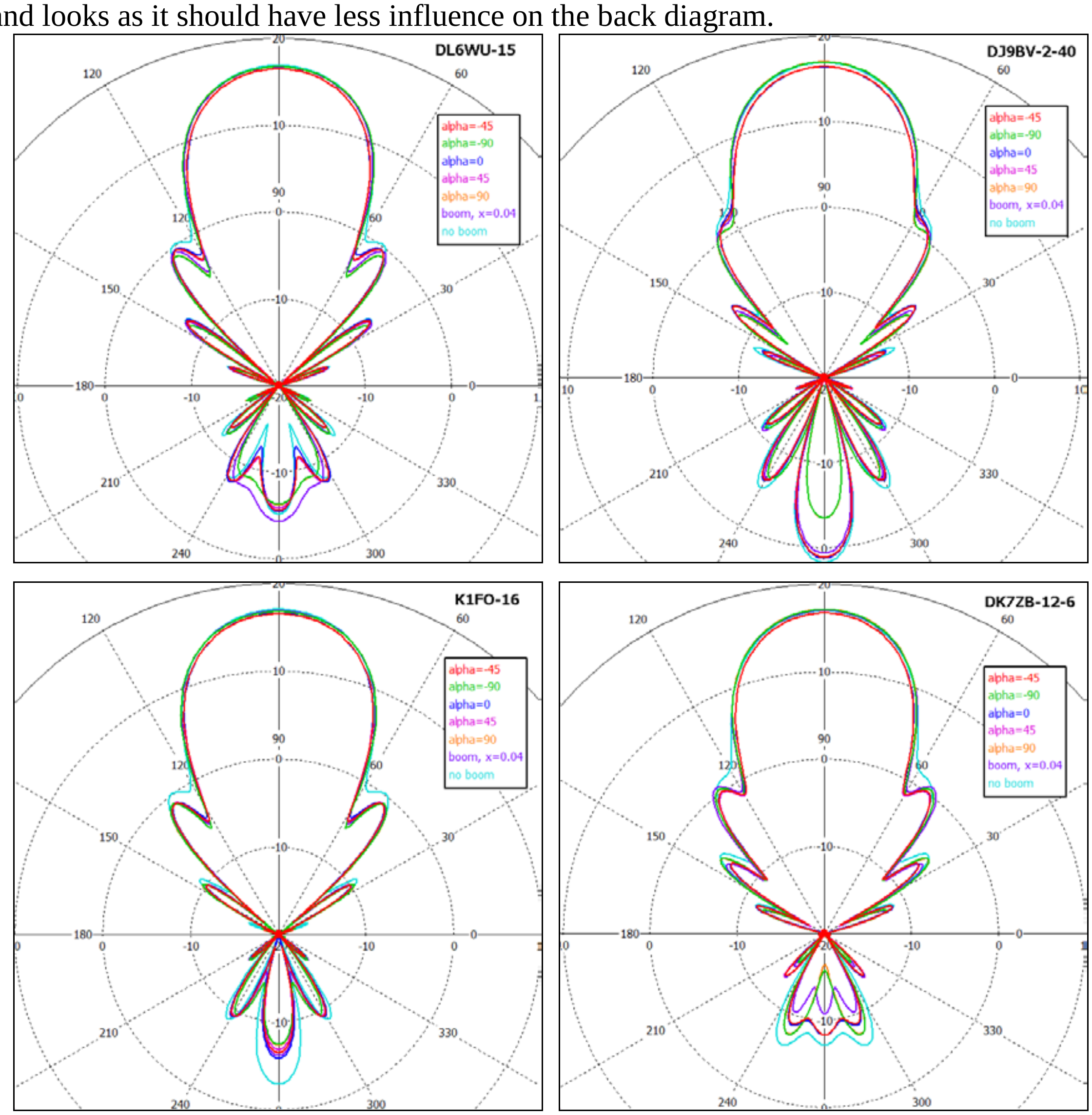


Fig.6 Antenna Q factor mean value in 144…146 MHz band

Influence on antenna directivity pattern

Radiation diagrams in the E plane for all six antennas with dependence on the cable's approaching angle *alpha* are given on Fig. 7. Besides this, for comparison purposes, there are also diagrams for the same antennas with a 50 mm diameter conductive boom at distance x = 0.04 m between the boom and element axis, but without coaxial cable. The same antennas without coaxial cable and without a conductive boom, i.e., antennas built on nonconductive boom, are also given for comparison. Radiation diagrams in the H plane are given on Fig. 8.

As can be seen from presented radiation diagrams, antennas with lower Q factor are less disturbed by presence of coaxial cable and its various positions due to their lower sensitivity to environmental influences **[4, 5]**. The most noticeable influence is on the magnitude and angular position of the first pair of side lobes and on the back lobe. Similar behavior was found when we investigated conductive boom influence on antenna radiation pattern**.** On these antenna patterns we can see that cable influence on Yagi antenna back lobe appears quite counter intuitive. Namely, when cable approaches driven element from rear side parallel to boom (alpha = -90 deg.), it in a way, “extends” conductive boom in rear direction. This results with less back lobe magnitude than in a situation when cable leads vertically, i.e. perpendicular to boom (alpha = 0 or 180 deg.) and looks as it should have less influence on the back diagram.



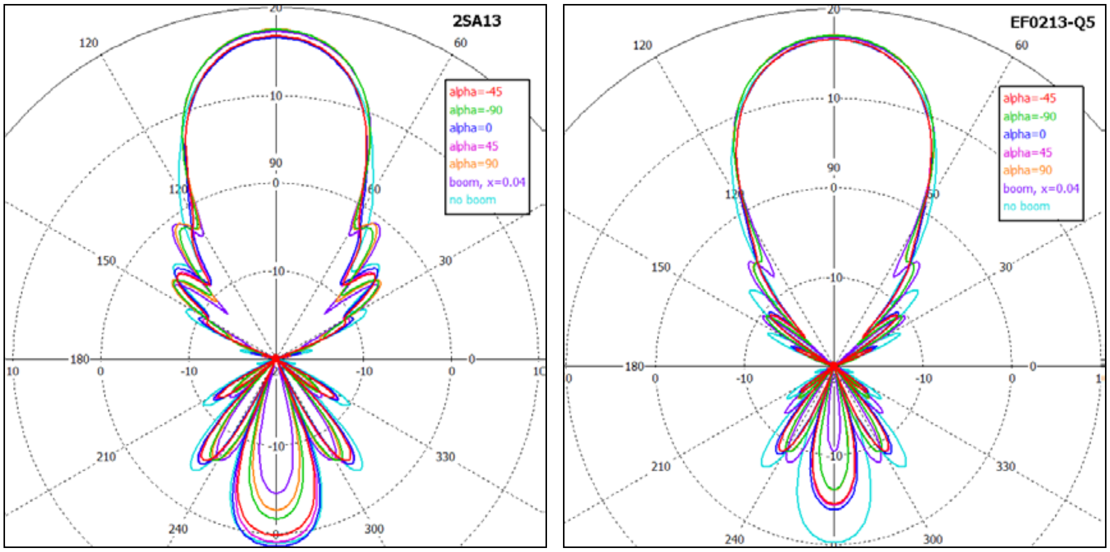
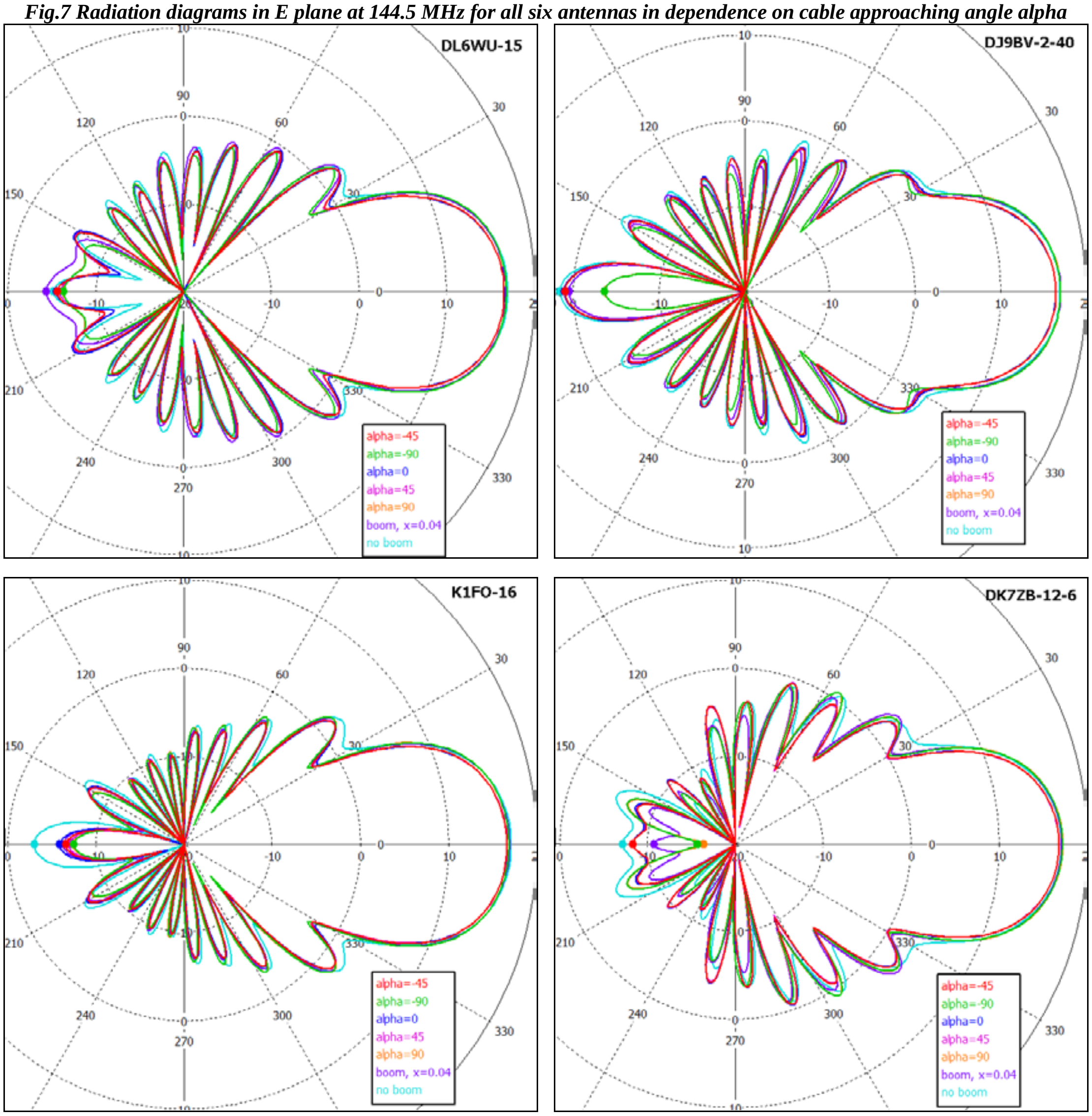


Fig.7 Radiation diagrams in E plane at 144.5 MHz for all six antennas in dependence on cable approaching angle alpha



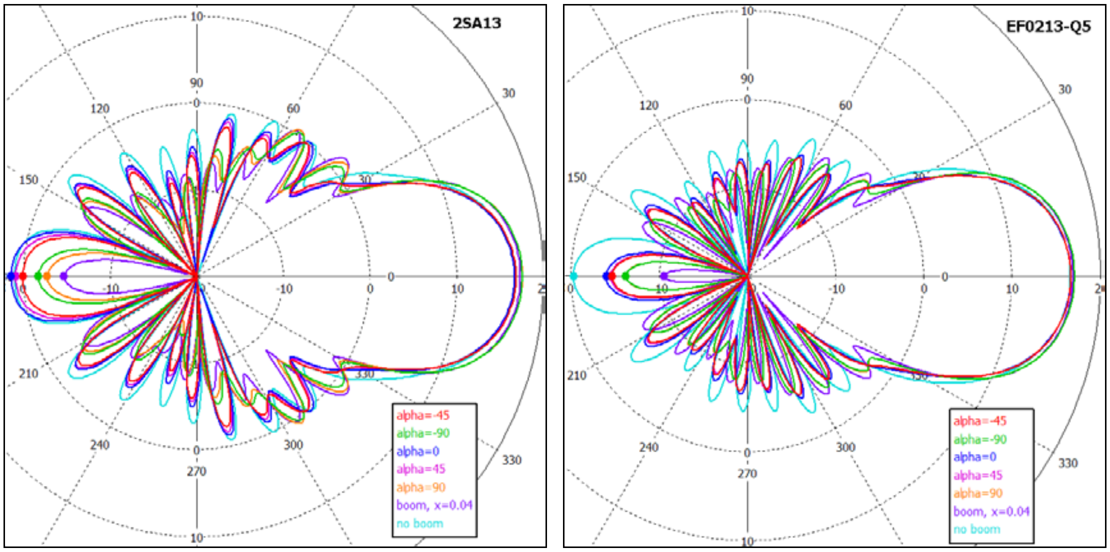


Fig.8 Radiation diagrams in H plane at 144.5 MHz for all six antennas in dependence on cable approach angle alpha

Conclusion

In this article we presented results of an investigation of how coaxial cable antenna feeder influences antenna performances. Investigations were conducted by computer simulations of six antennas under the same conditions. Coaxial cable was set so that it is not electrically connected to antenna in order to model antenna feeding through an ideal 1:1 Balun which represents infinite impedance to common mode currents. Only currents induced by the antenna RF (prevalent near) field are considered.

Results show a high degree dependence on cable position, i.e., approaching angle *alpha* to antenna driven element. Approaching angle *alpha* was always kept lying in antenna symmetry plane in order to maintain minimum interaction between cable and antenna.

We were using ideal 1:1 Balun with infinite common mode impedance and cable position always lying in the antenna symmetry plane intentionally in order to get results of minimum possible interaction and influence. Even under these idealized conditions and with absence of any other environmental effect (even a ground) results show considerable antenna performances degradation for some antennas, prevalently for those with higher Q factors.

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

On the question whether it is better to guide coaxial cable through the air following the shortest path (alpha = 45 deg) or tighly near a metal boom (alpha = 90 deg.) we can answer that is better to guide coaxial cable tightly to the boom (alpha = 90 deg.). On the question whether it is better to guide coaxial cable from driven element forward (alpha = 90 deg.) or backward (alpha = -90 deg.) in regard to a antenna we can answer that it is somewhat better to guide it forward parallel to the boom. Also, we found that the best cable position with minimal impact to antenna performance is practically the same for all antenna designs.

On the question of how the cable's position and severity of deterioration of performance are correlated to antenna Q factor, the answer is that these simulations show that antennas with higher Q factor are much more susceptible to a coaxial cable's influence and performance degradation than antennas with low and moderate Q factor value.

Using a real Balun, or even feeding antenna without a Balun and guiding cable that is not always lying in antenna symmetry plane, as it is usual in everyday practice, we can expect a much higher degree of performance influence and degradation. **-30-**

References:

1. Dragoslav Dobričić, YU1AW, **Boom Distance Influence on Yagi Antenna**, *antenneX*, August 2009, Issue No. 148.
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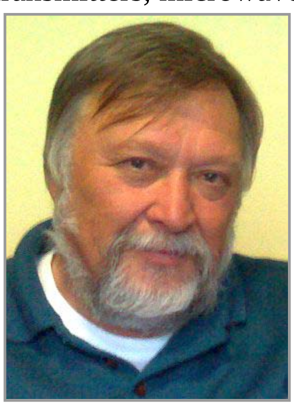
5. Dragoslav Dobričić, YU1AW, **Yagi Antenna Q factor**, *antenneX*, July 2008, Issue No. 135.

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 professional career, he mostly worked on various projects for power amplifiers, RF filters and multiplexers, communications systems and VHF and UHF antennas.



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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