Array of Inverted Amos Antennas for 2.4 GHz

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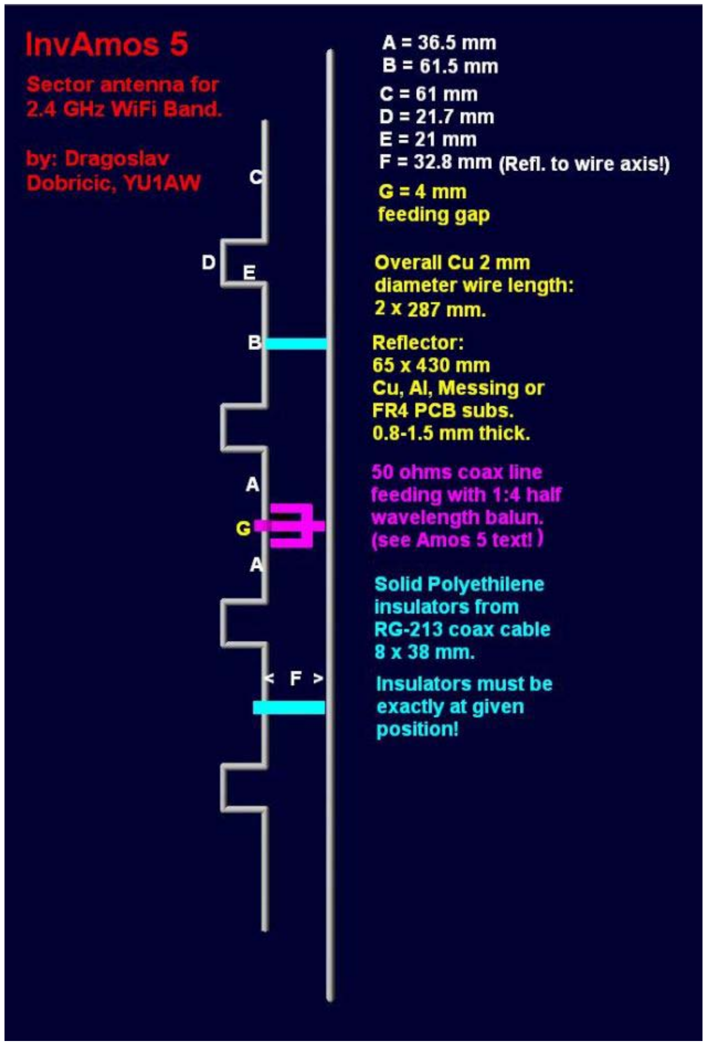
Introduction

In one of my previous articles about Amos antenna **[1]** I described how it is possible to build WLAN antenna with semicircular horizontal diagram of radiation using Franklin's antenna in front of a narrow reflector surface. In that article I described how it is possible to decrease, or almost completely eliminate, undesired radiation of the short circuit at the end of phasing lines in order to get a clean pattern unspoiled by these parasitic radiations. By placing the reflector near the short circuited end of the two wire line, it was achieved that the wire that short circuited the two wire lines acts with the close reflector as a transmission line, with an impedance of about 150 Ohms. In that way, its parasitic radiation is considerably reduced. In addition, it was possible to increase the length of that wire to achieve the desired distance between wires and needed value of characteristic impedance of two-wire line.
After successful construction of the Amos antenna, I was curious to see what would happen if I tried to take advantage of the short circuits at the end of the phasing lines radiation and get higher gain from the antenna. Instead of suppressing this parasitic radiation by converting the short circuit wires at the end of phasing lines in transmission line with help of reflector vicinity, I decided to try to take advantage of this parasitic radiation as a constructive part of my new antenna.
By rotating the radiator 180 deg. and with additional optimization of dipoles and phasing lines dimensions I got an antenna with higher gain and a narrower horizontal diagram. It is obvious that this undesired parasitic radiation now became a constructive part of the antenna's overall radiation and with its properly phased currents and fields improved the Amos antenna in a way that increases gain and narrows the horizontal diagram. In fact, the horizontal diagram became narrower but not too much and the antenna preserved all good characteristics of the Amos antenna. The Inverted Amos antenna is very useful as a sector antenna if you need a narrower horizontal angle of coverage than Amos antenna has.

Inverted Amos antenna construction

The inverted version of Amos antenna is built in the same way as the Amos antenna explained in my previous article **[1]**. Everything said about Amos antenna construction could be said also for Inverted Amos, except of different dimensions for dipoles, phasing lines and reflector. These new dimensions for single Inverted Amos antenna with 5 dipoles are given in the illustrations below. Feeding and the 1:4 half wavelength coax cable BalUn construction is the same as for Amos antenna because of the same input impedance of antenna of about 200 Ohms. The gain of Inverted Amos antenna also depends on number of vertically stacked dipoles.
In that article **[2]** I wanted to show that it is possible to use parasitic phasing line radiation as a constructive addition to improve overall antenna performance. It is possible to achieve this without sacrificing other good performance features of the initial antenna except narrowing horizontal diagram of radiation. The new antenna has all of the good

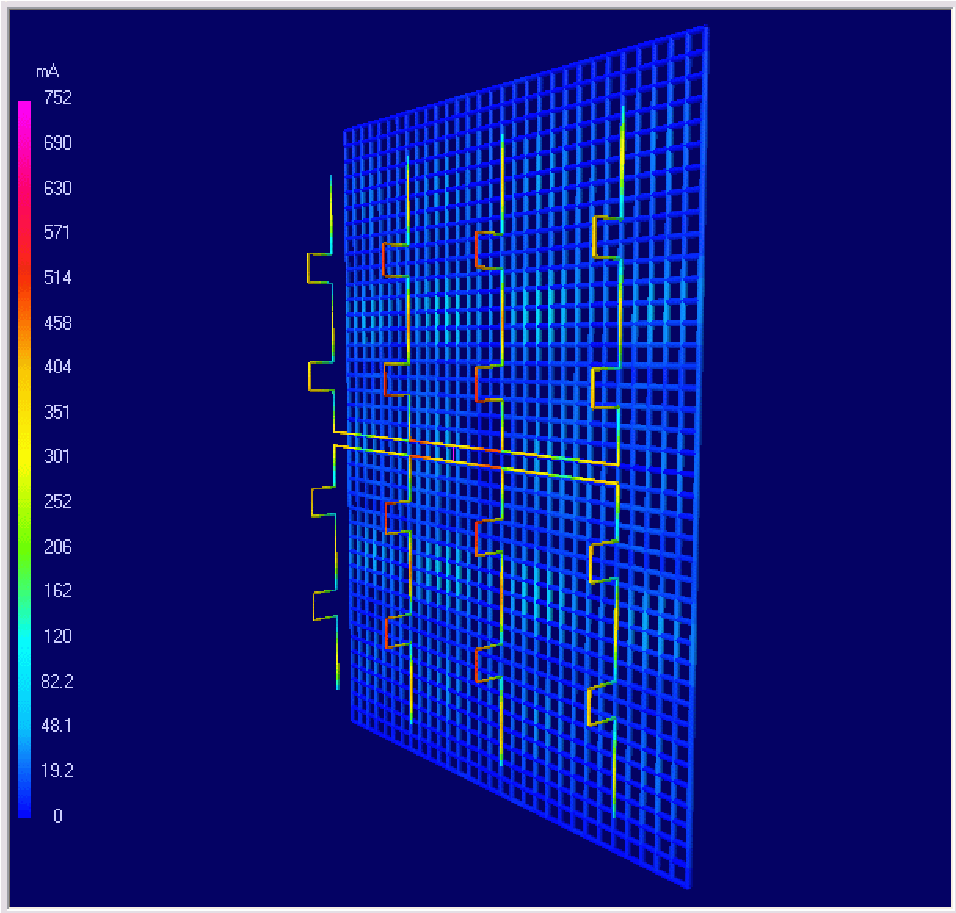
performance of the Amos antenna, but with higher gain and a narrower horizontal diagram of radiation.



Dimensions and construction of single Inverted Amos-5 antenna

Array of four Inverted Amos antennas

In the cases when we do not need very wide beam in horizontal plane we can stack more antennas broadside and get higher gain and narrower horizontal angle of radiation.
If we use four antennas in front of common reflector we can get 6 dB theoretical increase of gain compared with the single antenna gain and about four times narrower horizontal diagram.
Two wires transmission line is used to provide feeding of each collinear antenna and impedance transformation to the center point where 1:4 half wavelength coaxial cable BalUn transforms equivalent impedance of 200 ohms to 50 ohms impedance of coaxial cable feeder.



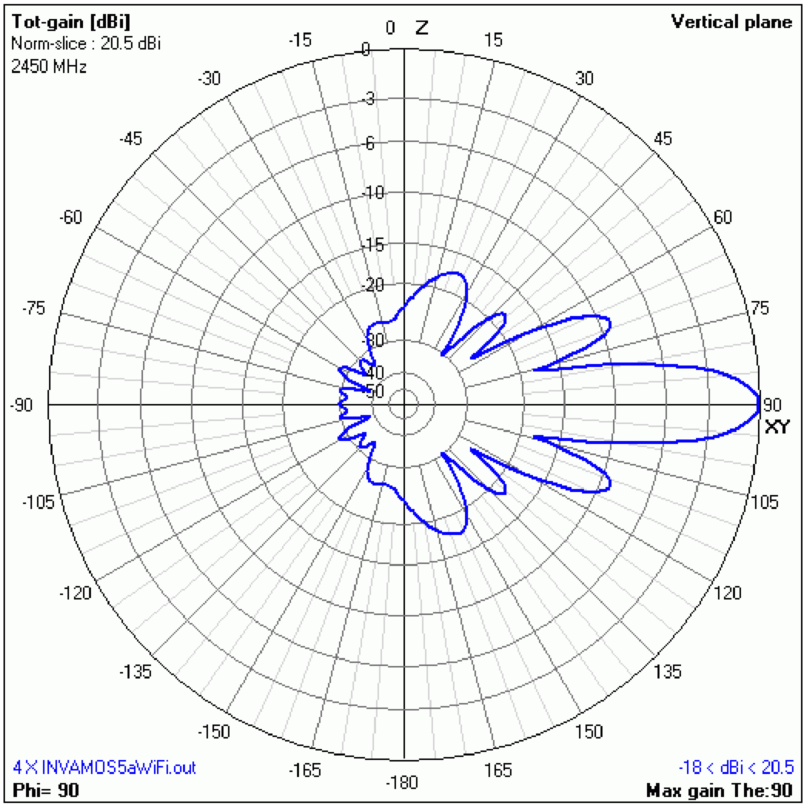
Construction of array of four Inverted Amos-5 antennas and currents that flow in antenna elements with RF power of 100 W

It would be convenient if the stacking distance between individual antennas was half of a wavelength. In that case two antennas on the left and two on the right from the center would be connected parallel and their equivalent impedances would be 100 ohms. With 200 ohms quarter wavelength lines they would be easily transformed to 400 ohms. Left and right antenna pair connected together would give equivalent feeding point impedance of 200 ohms.

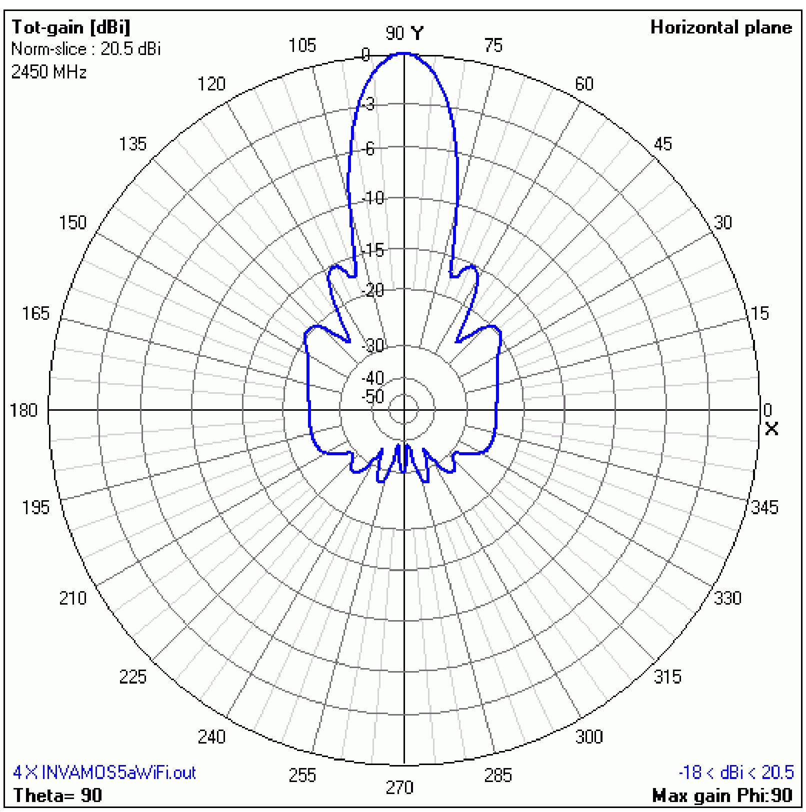
However, necessary phase inverting for proper phase of each collinear dipole done by simple twisting of two line transmission line on such high frequency can be problematic. It could be very difficult to avoid possible huge line characteristic impedance discontinuity and a lot of other parasitic effects. Half wavelength stacking distances are too small and because they are not optimal it results in low stacking gain of antenna array.

Because of that it would be necessary to increase stacking distances to 1 wavelength. However, in that case, too large stacking distances produce the problem of very high side lobes.

Stacking distances of about 0.84 wavelengths show as a good compromise between good power sharing among dipoles and impedance transformation for obtaining desired feeding point impedance. Also, it is very close to optimum stacking distances which achieve maximum stacking gain of array.



Vertical radiation diagram of array of four Inverted Amos-5 antennas



Horizontal radiation diagram of array of four Inverted Amos-5 antennas

Simulation results of antenna array

After accepting some compromises which are necessary to satisfy the limitations of the antenna simulation program and after trying a few different feeding and phasing arrangements I found results that are given on the diagrams shown.

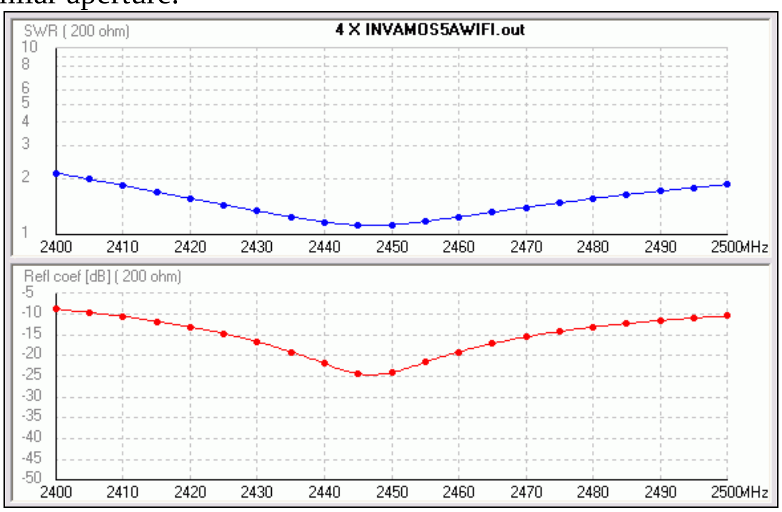
The obtained gain is about 6 dB higher related to single Inverted Amos-5 antenna which is close to theoretical value of possible stacking gain with four antennas.

The beam width for -3dB in the E plane is about 12 deg. and in the H plane is about 16 deg.

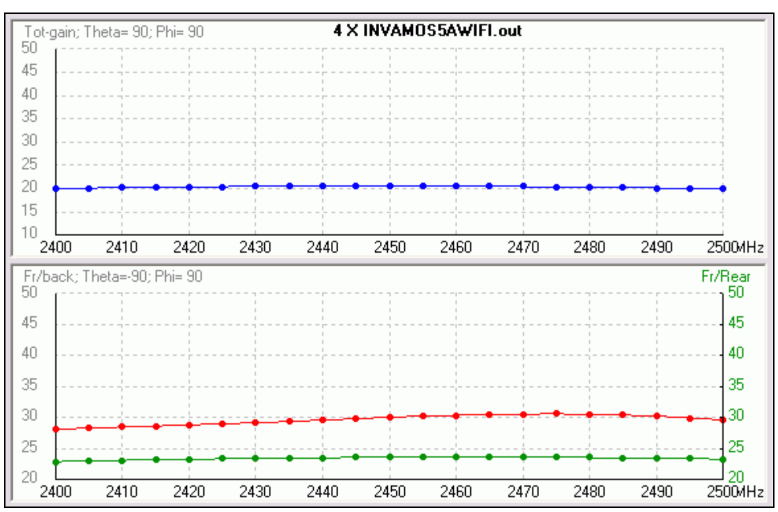
In the vertical radiation diagram, it is noticeable that the first pair of side lobes are a little higher than they should be, but they are “sacrificed” in order to preserve feeding and phasing antennas simplicity which is very important on such high frequencies.

The working frequency bandwidth is about 100 MHz for SWR=2 which is wide enough for covering the whole 2.4 GHz Wi-Fi frequency band.

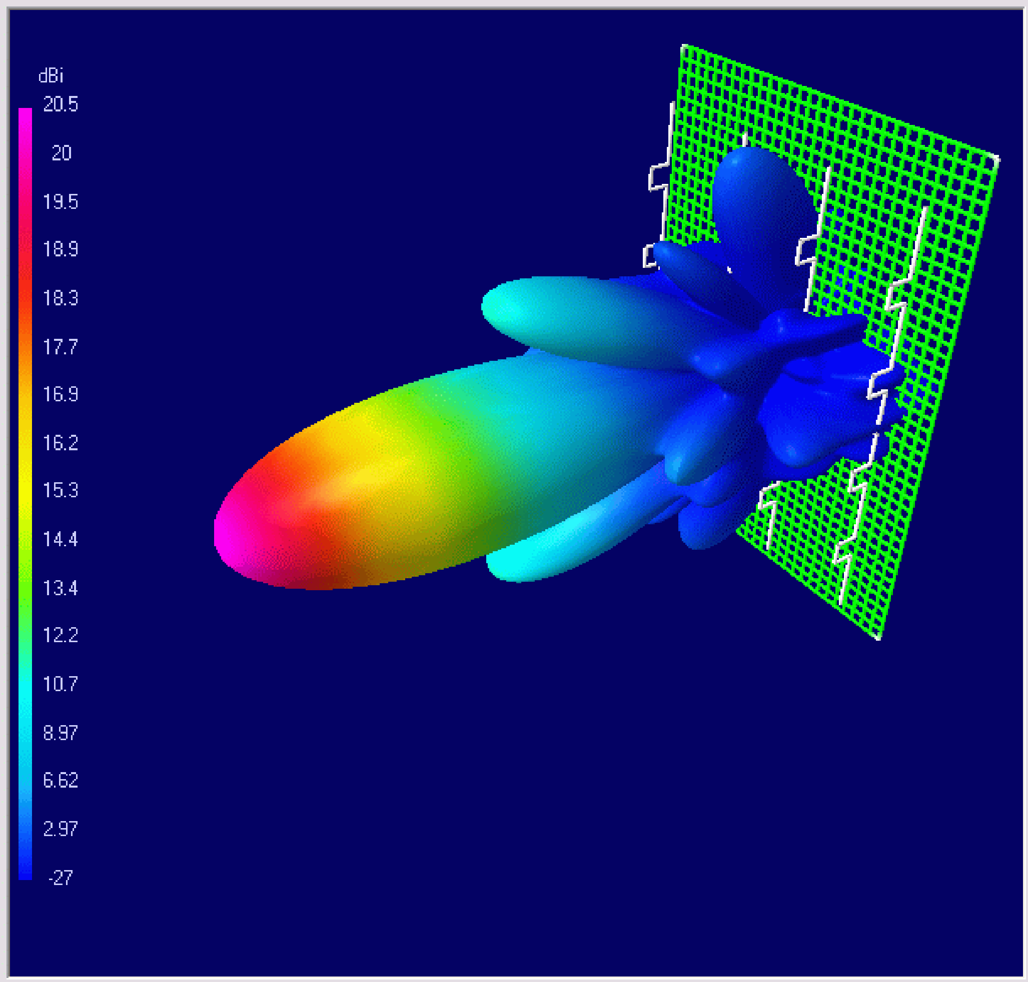
Scaling the antenna dimensions to 2.3 GHz or 1.3 GHz amateur band can give very useful wideband and high gain antenna which can be a serious competitor to parabolic antennas of similar aperture.



SWR and Return Loss diagrams of array of four Inverted Amos-5 antennas



Gain, Front/Back and Front/Rear diagrams of array of four Inverted Amos-5 antennas



Simulation of 3D radiation diagram of four Inverted Amos-5 antennas array

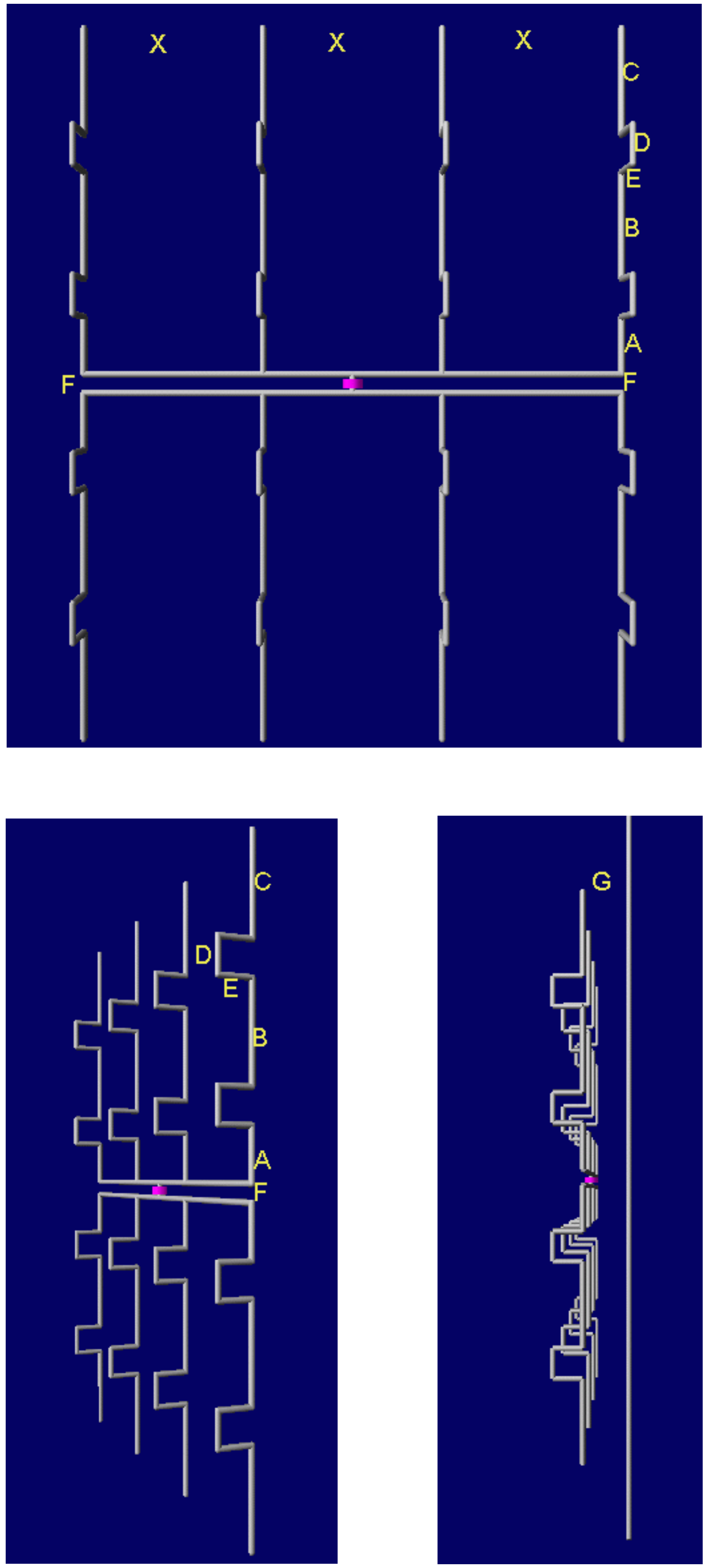
Construction of antenna array

Four Inverted Amos antennas are mounted in front of common solid reflector with dimensions of 4 x 3 wavelengths. Collinear dipoles are mounted on insulators as described in articles **[1** and **2]**. Two parallel wires transmission line feeds collinear dipoles and in the center, at the half distance from two inner antennas, the 1:4 half wavelength coaxial cable BalUn is soldered.

Good mechanical and electrical symmetry of the whole antenna is desirable and highly recommended.

Some hints and all other necessary information for antenna building are given in articles **[1** and **2]**.

Due to inserting a two-wire phasing line, it is necessary to decrease the length of the antenna dipole segment designated as "**A**" given for a single antenna!



Construction and dimensions designation of four Inverted Amos-5 antennas array

Dimensions of antenna array

Due to inserting a two-wire phasing line it is necessary to change some of the original dimensions of single Inverted Amos-5 antenna and introduce the new ones.
Here are given all dimensions of antenna both in millimeters and in wavelengths:

	mm	wavelengths	
A	33	0.27	
B	61	0.50	
C	61	0.50	
D	21.5	0.176	
E	21	0.172	
F	10.8	0.0885	
G	32.5	0.264	(from refl. surface to dipole wire axis)
X	102.5	0.840	
dw	2	0.0164	(dipole elements copper wire diameter)

Overall copper wire length: 8 x 282 mm or 8 x 2.3 wavelengths
Reflector solid metal sheet surface: 492 x 369 mm or 4 x 3 wavelengths.

Conclusion

In this paper I tried to show that broadside stacked collinear antennas in front of common reflector can render an efficient antenna for UHF band which is often more efficient than parabolic dish of the same aperture. To prove this we can calculate the efficiency of antennas and make comparisons.
The efficiency of an aperture antennas can be calculated using their gains as follows:

$$G = E * 4 * PI * A$$
$$E = G / (4 * PI * A)$$

where
G = antenna gain in numbers (not in dB); Ga=10 log (G); G=10^ (Ga/10)
E = antenna efficiency,
A= antenna aperture in square wavelengths.

Common reflector surface of this antenna array is A = 4 * 3 = 12 wavelengths. With obtained gain of Ga = 20.5 dBi this gives

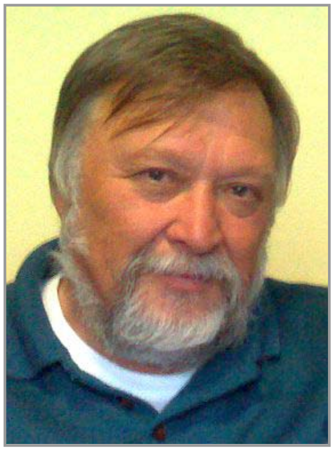
$$E = 10^{2.05} / (48 * PI) = 112.2 / 150.8 = 74\%$$

Usually very good illuminated parabolic reflectors have an efficiency which is 10-15% less. Poor illuminated reflectors have even less and rarely achieve 50%.
In this array it is also possible to insert some additional minor losses in practical realization due to parasitic effects but advantage is still obvious.
Another interesting advantage of this antenna array in relation to the parabolic dish antenna is its two-dimensionality because it is a relatively thin flat panel. Parabolic dish, especially the offset type of dish is also flat and relatively thin, but needs a large arm for holding feed in focus. **-30-**

References

1. D. Dobričić, Amos Antenna, *antenneX* Issue No. 127 – November 2007.
2. D. Dobričić, Inverted Amos Antenna, *antenneX* Issue No. 130 – February 2008.

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 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. Married and has two grown up children, a son and a daughter.