# IMPROVEMENT OF PARAMETERS OF BROADBAND ANTENNA STRUCTURES

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**Abstract**

*Different broadband antennas are well known for a long time, e.g. Vivaldi structures, double ridged horn antennas, log-spiral, helical antennas, elliptical dipoles etc. New parameters of the design for using of broadband antennas in new measurement systems (e.g. EMC) and services and ideas how to reach them, demands, and design of a new parts of antenna structures are described. All antennas of improved parameters here listed were developed and tested at the Czech Technical University and National Security Authority in Prague.*

**Keywords**

broadband antennas, Vivaldi structure, double ridged horn (DRH) antenna, log – spiral antenna

## Introduction

For the design of better broadband radiating structures is important to know, what “broadband criteria” we really need for the final use. The good matching, flat gain (sometimes even sufficiently high gain) are well known, but really to reach them in a broadband concept was/is not too easy. New standards of complicated measurements in “metallic areas” (e.g. EMC) and in a “near radiating field” are used. New criteria of antennas for special tests of shielding efficiency measurement, electromagnetic radiating emissions and immunity are demanded as well as of antennas for UWB systems.

## List of some broadband antenna problems/parameters for a special use

- **Shielding of relatively (electrically) small enclosures testing (**MIL-STD 285, IEEE 299). Good and stable matching in different positions close to the other objects is necessary. Antenna is often very near to the metallic walls, including the direction of main lobe, sometimes is inside the enclosure under the test too (Fig. 1).
- **Electromagnetic immunity tests**. We need high power antennas with directive behavior, good and stable matching versus near position to the large (metallic) devices under the test (e.g. cars). High levels of electrical intensity for testing and good transmission of electromagnetic pulses are needed. Broadband antenna phase characteristics are asked.
- **Electromagnetic radiation tests.** Near distance testing by standard is given. Measurement needs the conductive (30 MHz – 1 GHz) or absorbing floor (above 1 GHz, not standard). The stability of the shape and symmetry of radiation pattern is necessary, including polarization (Fig.1).

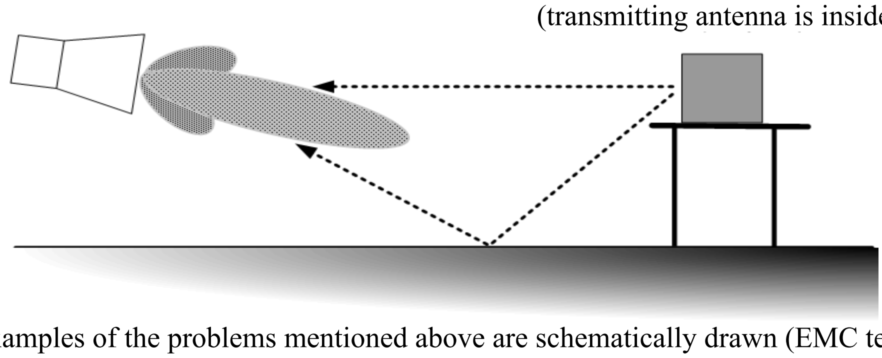


Fig. 1. Examples of the problems mentioned above are schematically drawn (EMC testing)

- **UWB systems**. These systems directly transmit narrow pulses and one of the critical parts of such systems is the antennas influence on the transmitted pulse. Demand on the antenna is to have a minimal distortion on the Gaussian pulse.

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Some of examples mentioned above show, that we need more then the old well known broadband concept. Some of the demands are connected with a new level of quality – e.g. better matching criteria of the whole class of broadband antennas, some of them need to search for the best radiating structures (e.g. antennas working in the presence of the other objects, close to the metallic walls etc.). Some of them need new methods and attitudes to the modeling and design (e.g. antenna for UWB communication systems with the low distortion of pulse, antennas with a proper broadband phase characteristics).

**Broadband strategy and tested parameters**

The main task is to find a proper antenna structure and design it from the point of view of particular application. Here it means to define the parameters which can generally and sensitively evaluate the structure from the point of the items mentioned above. To use the input impedance of the structure seems to be best attitude (including all input and mutual impedances of the structure, stronger and week couplings). To find a final improvement needs to split the radiating structure in substructures, analyze individual parts separately, to find the critical point, optimize the substructure and then the whole structure itself.

We studied different broadband principles and structures in details – e.g. Vivaldi, double ridged rectangular, and spiral structure. Generally speaking, the structure can be split into: the output discontinuity between the structure and free space, broadband transforming part of the structure, and input discontinuity between feeder and radiating structure. First two we optimized, but the final improvement was not so much promising compare to the optimization of the feeder point. From that follows that simple modeling between the frequency bands is not continuously possible because of limited number of input geometrical structure – connectors. This part is most important for the broadband concept from point of view of impedance and geometrical (symmetry) matching. Both matching (transformations) are important to get broadband characteristics for radiation pattern, gain, reflections, noise in the system etc.

**Improvements and obtained results**

**Double Ridged Horn (DRH)**

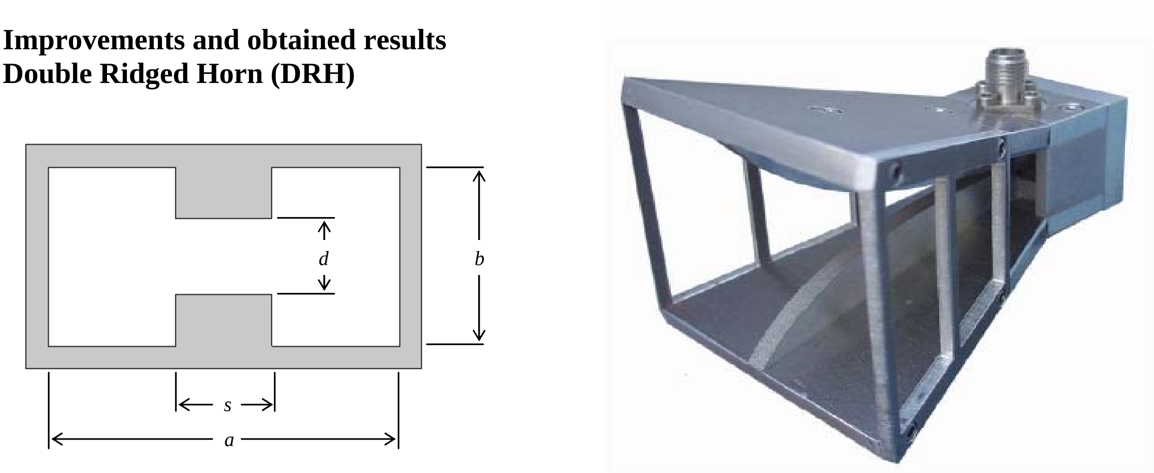


Fig. 2 Double ridged (DR) waveguide and improved DR horn antenna (example 4 – 40 GHz)

The study of double ridged waveguide modes for nonstandard dimensions was used [1]. Absence of $TE_{30}$ mode or mode degeneration or higher mode skips in front of the $TE_{30}$ mode were observed. The new usable ridged waveguide bandwidth was then defined as the ratio of $TE_{10}$ to $TE_{X1}$ mode cutoff wavelength, the $TE_{X1}$ mode is the first higher mode that has maximum intensity between ridges. The curves of the $TE_{X1}$ mode were numerically calculated and compared with curves analytically solved by [2]. Fig. 3. It was discovered that new numerical solution differs from the old analytical one.

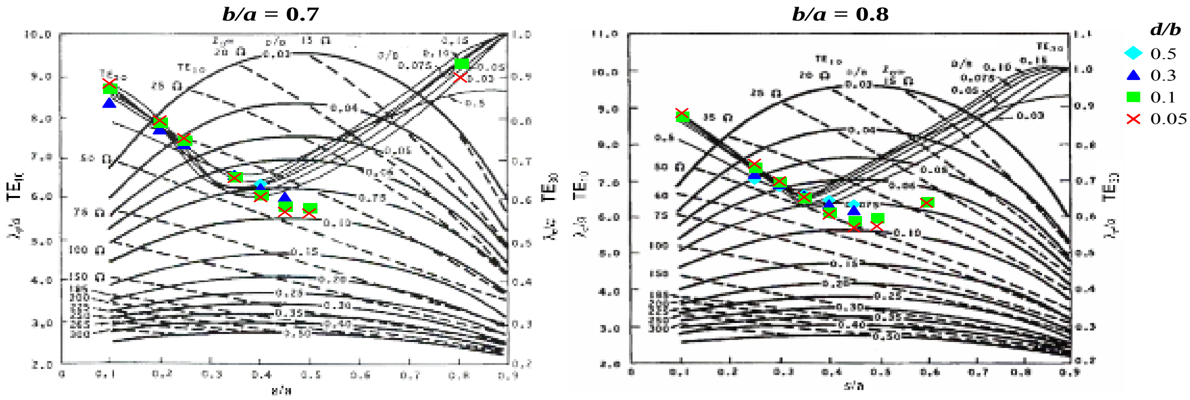


Fig. 3. Comparison of $TE_{30}$ mode cutoff wavelengths newly calculated by CST Microwave Studio (dotted lines) and old calculation by [2]. Disagreement were observed (for dimensions see Fig. 2.).

Based on these results, new connector – waveguide transmission and double ridged structure were designed and optimized with the whole antenna. Results of measurement are in Fig. 4.

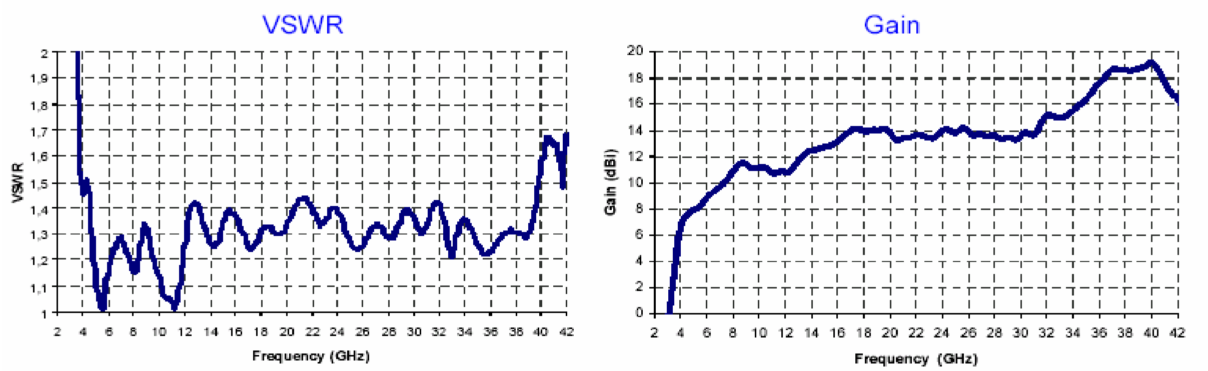


Fig. 4 Example of VSWR and gain of optimized double ridged antenna for 4 – 40 GHz, VSWR ≤1.6 (≤ 2 for 3.8 – 42 GHz) – more characteristics including radiation patterns and other DRH antennas starting from 180 MHz are on www.rfspin.cz

**Log-spiral antenna**

The broadband impedance transformer was designed in a microstrip structure to transform nonsymmetrical 50 Ω to symmetrical 62 Ω and to a symmetrical 150 Ω. The whole structure is placed inside cover with polyamid carbon absorbers. Results are in Fig. 5

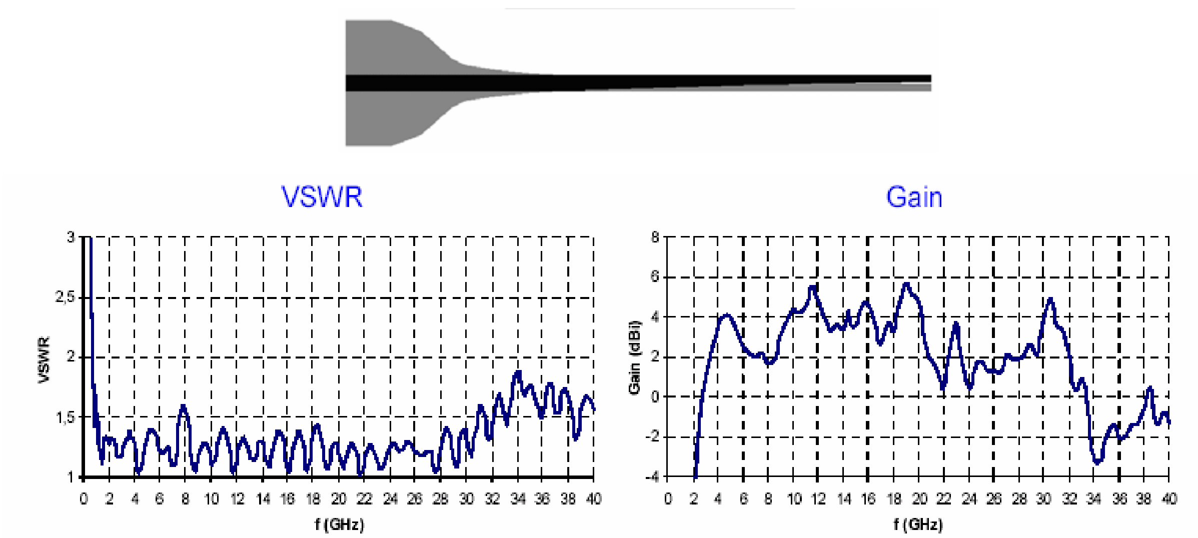


Fig. 5. Newly optimized structure of impedance and geometrical matching (symmetry) and final properties of the whole structure of log-spiral antenna (2.5– 33GHz, G≥0, VSWR ≤ 1.7)

## Vivaldi antenna with a new impedance transformer

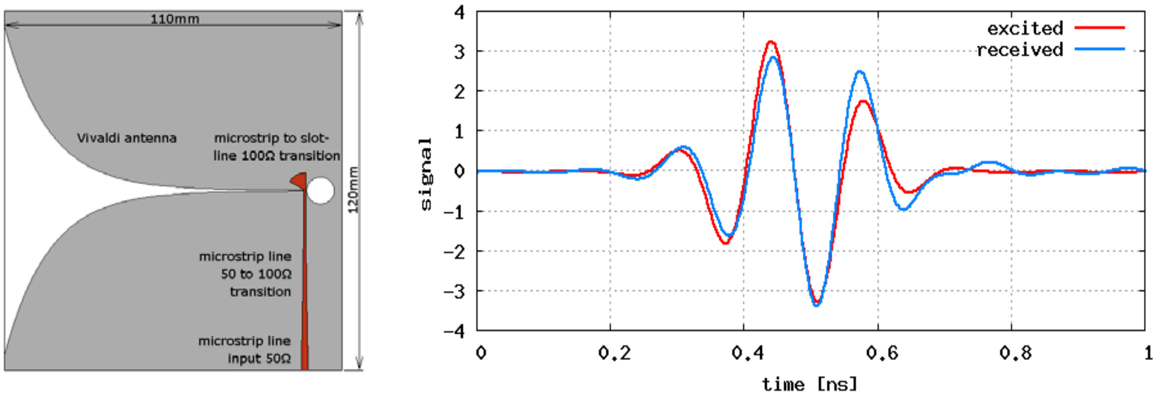


Fig. 6 New transition between microstrip and Vivaldi structure and the time input – output response

Antenna uses the microstrip - slotline transition with a microstrip radial stub (virtual broadband short). Structure is virtually shunted to the second half of the slotline metalisation while the first half serves as ground metalisation for the microstrip. Example of the antenna operates from 3.1 GHz to 10.6 GHz, (reflections below -11dB). The factor of mutual correlation function between the excited and received signals (normalized) is 0.969. The distortion from the point of view UWB system is very small – effects of some other antennas on Gaussian pulse can be seen e.g. in [5].

### Conclusion

The possibilities of improving the quality of broadband characteristic of some radiating structures were studied with agreement to the demands of new measuring systems and standards, especially EMC. Broadband characteristic and pulse "input – output" antenna transmission for the UWB systems were studied too. The influence of transition of input connector to antenna radiating structure is very strong. New design of transition structures and their optimization were conducted for different type of the broadband antennas. Some deviations between old analytical and new numerical solution were found. The use of a new input transition in all the studied antennas brings an important gain in better parameters (reflection loss, more "stable" radiation pattern from a point of view of object around the antenna, good characteristic for UWB systems). Most of the described antennas were developed (improved) at the Czech Technical University in Prague and their parameters are listed at www.rfspin.cz.

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