On the extending bandwidth of electrically small antenna using negative impedance converter

Katarzyna Jagodzińska
Department of Electronics and Computer Science, Koszalin University of Technology, Koszalin, Poland,
katarzyna.jagodzinska@ie.tu.koszalin.pl

***Abstract*—This paper deals with extending bandwidth of electrically small antenna using negative impedance converter that acts as a negative reactance.**

Using the idea of negative impedance converter an active reactance circuit is proposed to cancel the imaginary part of electrically small antenna impedance and thus matched antenna to the transmitter over a wide band. Furthermore, design and measurement results of active reactance circuit are presented and discussed in details.

***Kewords*—electrically small antenna, non-Foster element,negative impedance converter, impedance matching.**

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INTRODUCTION

- ESA are very popular class of antennas because of their compact size and variety of application
- ESA suffers from highly reactive input impedance that affects bandwidth, therefore it needs network impedance matching
- To achieve broad bandwidth in desire frequency range an active matching circuits are used instead of passive circuits
- Active matching circuits are based on Non-Foster elements such as elements with negative capacitance or negative inductance. Negative elements can be realized in practice using NICs (negative impedance converters)
- NIC is usually assumed as an active two-port device where the input impedance Z_{in}, seen at IN, is the negative (scaled) of the corresponding passive load, Z_L, at OUT (see fig.1.)

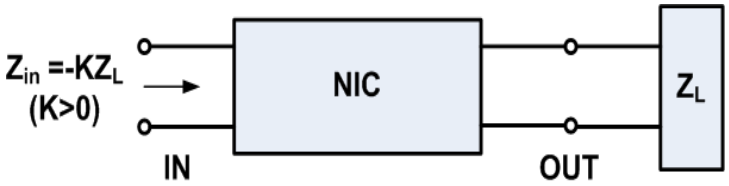

Fig.1. NIC scheme

- NICs can be realized via a combination of active devices (amplifiers) and lumped loads (capacitors and inductors)
- The idea of using Non-Foster matching is simple and based on the reduction of the reactive part of antenna input impedance by connecting the antenna terminals to active matching circuit that consists of converters.

GOALS OF WORK

- Design, build and test an active reactance circuit (ARC) using idea of NICs
- Objective of the ARC is to match the ESA impedance to the transmitter over a wide band
- Proposed ARC should be simpler than the other NICs found in literature

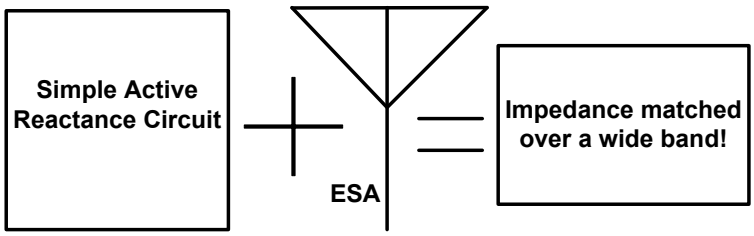

Fig.2. Goal of work

ACTIVE MATCHING DESIGN

• **ESA DESCRIPTION**

Tested antenna consists of four wire segments connected in series (see fig.3a.) Segments lengths (except for the first segment) are equal. The first antenna segment is half the length of other segments due to ground plane. Total length of the antenna structure is 0.25 m, each segment (except for the first one) has a length of a 0.125 m. The operating frequency is 600MHz while input impedance Z_{in} = 21-j105.

• **ARC DESCRIPTION**

Designed ARC acts as a negative capacitor and it is shown in the fig.3b. It is a single-stage amplifier, operating in emitter follower configuration. It is loaded with antenna impedance. Between power supply and amplifier is a constant-voltage regulator which stabilizes the voltage in the range from 9 V to 30 V, giving at the output 6 V and neutralizing any disruption generated by the power supplies. Resistors R1 and R4 act as a voltage divider. Resistor R3 acts as a polarity system of the transistor, is responsible for setting the quiescent current of the transistor and acts as the emitter current limiter. It is also a part of transistor load. Capacitor C1 is responsible for separating the DC component from the output of the amplifier.

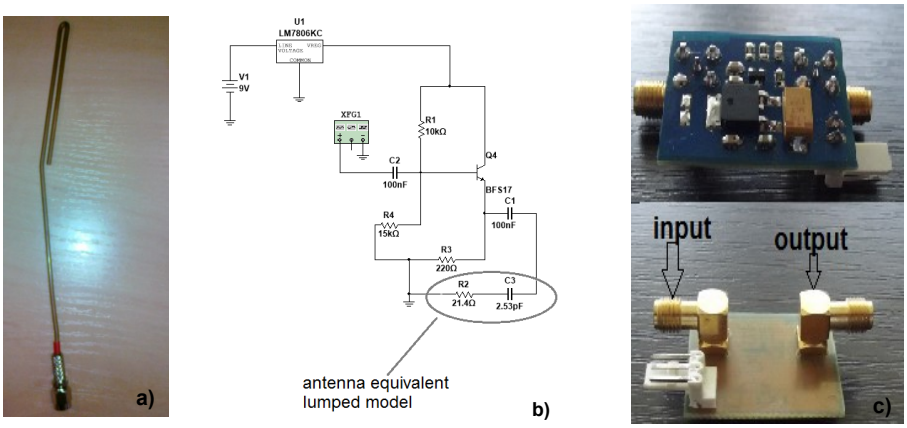

Fig.3. ARC design: a) ESA used in the investigation, b) ARC scheme, c) ARC prototype

• **ARC PROTOTYPE**

Prototype of an active matching circuit is made on a single sided printed circuit board with SMD elements and NPN bipolar transistor BFS17. Network analyzer is connected to the input of the ARC while tested antenna is plugged to the output.

MEASUREMENT RESULTS

• MEASUREMENT SETUP

In order to do measurement properly the measurement setup was taken. It is shown in Fig. 4. It consists of network analyzer, copper ground plane and tested antenna connected to the ground. The two-port ARC circuit is connected with antenna and tested using Agilent E5071C network analyzer. Measured parameters were standing wave ratio (VSWR) and input impedance (Zin).

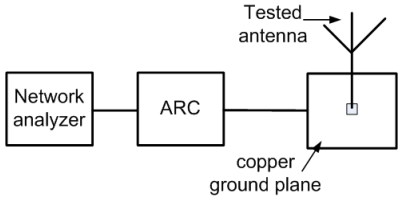

Fig.4. Block diagram of measurement setup

• VSWR AND INPUT IMPEDANCE MEASUREMENT WITHOUT ARC

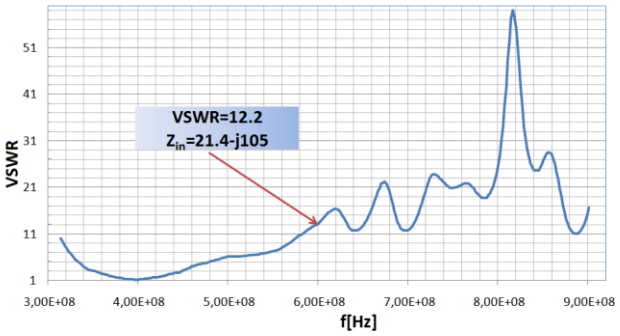

Fig.5.Measured VSWR and Z_{in} without matching

• VSWR AND INPUT IMPEDANCE MEASUREMENT WITH ARC

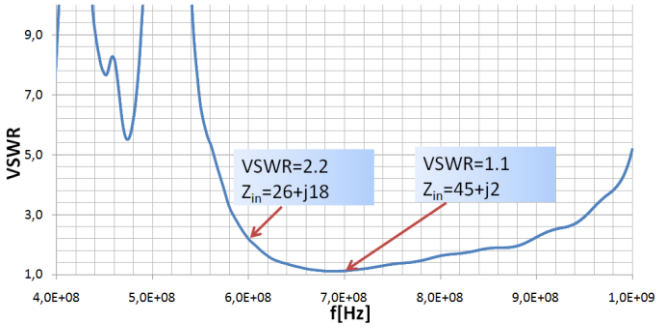

Fig.6.Measured VSWR and Z_{in} with ARC

• BANDWIDTH DETERMINATION

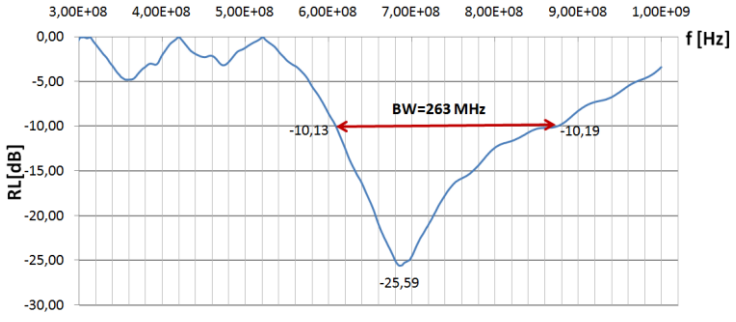

Fig.7.Bandwith determination for ARC

SUMMARY

- This paper presented researches on extending bandwidth of electrically small antenna. To extend it, an active reactance circuit (ARC) based on the non-Foster impedance concept was proposed
- Using ARC that acts as a negative impedance converter (NIC) a large portion of the reactance of an electrically small antenna was reduced (see fig.6.)
- VSWR values have significantly been improved (see fig.6.)
- A broadband antenna was obtained: BW=263MHz for RL=-10dB (see fig.7.)
- Proposed active matching circuit is simple in comparison to other solutions found in the literature and can be used in place of mounting the antenna and supplied from a central supply system
- All goals of work have been completed