

# **Practical Issues of Using Negative Impedance Circuits as an Antenna Matching Element**

by

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# Contents

Contents .....	i
Abstract .....	iii
Statement of Originality .....	v
Acknowledgments .....	vii
Thesis Conventions .....	ix
List of Figures .....	xi
List of Tables .....	xiii
1 Introduction and Motivation .....	2
1.1 Introduction .....	2
1.1.1 Limitations of small antennas .....	2
1.1.2 Other potential methods .....	3
1.2 Motivation .....	4
1.2.1 Broadband matching network .....	4
1.3 Thesis Overview .....	7
2 Negative Impedance Converters .....	10
2.1 Introduction .....	10
2.2 Linear analysis .....	10
2.2.1 NIC Realisation .....	11
2.2.2 Analysis with and without parasitic capacitance .....	17
2.3 Matching Performance Using a Simple Negating Capacitor .....	22
2.4 Three element negation network .....	26
2.5 Chapter summary .....	30
3 Stability concerns .....	32
3.1 Introduction .....	32
3.2 NIC characteristic .....	32
3.3 Stability Analysis .....	34
3.4 Circuit Modification .....	42
3.5 Chapter Summary .....	56
4 Effects of Non-idealities .....	58
4.1 Transistor Mismatch and $H_{fe}$ Variations .....	58
4.2 Temperature Variations .....	62
4.3 Supply Voltage Variations .....	63
4.4 Sensitivity Analysis .....	66
4.5 Chapter Summary .....	70
5 Noise Considerations .....	72
5.1 Introduction .....	72
5.2 Internal noise .....	72
5.3 External noise .....	76
5.4 Chapter summary .....	82
6 Non-linear Analysis .....	86
6.1 Introduction .....	86
6.2 Intermodulation Distortion and Numerical Modelling .....	87
6.3 Broadcast Stations .....	96
6.4 Theoretical or Expected IMD Noise Levels .....	98
6.5 Comparison with External Noise .....	99
6.6 Chapter summary .....	101
7 Conclusion .....	104

7.1 Results and Conclusions..... 104  
Appendix A ..... 109  
Appendix B ..... 111  
References ..... 113

# Abstract

In the design of antenna systems, it is well known that there are trade-offs between bandwidth and size. As the size of an antenna reduces, in proportion to wavelength, there is a reduction in bandwidth. Wavelength at HF is of the order of tens of meters and so practical HF antennas either have narrow bandwidth or are very large in size. This conclusion holds when passive matching circuits are used, but it is possible that active circuits could provide improved bandwidth. Negative Impedance Converters (NICs) are active circuits that provide a promising avenue for achieving a high bandwidth with electrically small HF antennas. This thesis focuses on tackling the practical issues of using NIC based matching networks for HF reception.

The work presented in this thesis contributes to the research on NICs as HF matching networks in several ways: (i) the interaction of the environment with the non-linearity in the NIC circuit; (ii) a comparison between the external and internal noise effects; and (iii) the stability of the NICs when operated as matching circuits at HF frequencies.

In this thesis, a brief introduction is presented to the previous work to reduce the size of antennas. This includes a short summary on the development of the NIC and its application as a matching network. The thesis then continues with a theoretical analysis of the NIC and its application as an antenna matching circuit.

The thesis also provides an investigation on various practical issues namely the stability of the circuit, device variations, noise and the effects of non-linearity. It was found that device variations, noise and non-linearity did not pose a serious problem. Stability, however, was found to be an important issue and that the NIC circuit had to be carefully loaded to maintain stability. This research is a contribution towards the use of NICs in HF receive systems and could help bring to fruition the dream of small sized HF antennas with high bandwidth. In particular, HF radios for domestic purposes could benefit from such a research outcome.



# Statement of Originality

I, Fu Tian Wong, certify that this work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published written by another person, except where due reference has been made in the text.

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Date





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For my friends who have seen my ups and downs, encouraged and prayed for me throughout this journey, thank you very much. I thank my family for their unconditional love, support and prayers. This research could not have been completed without them. I would like to thank God for providing me with wisdom and help from all the people listed above, and many others whom have been a great support in many ways.

*Fu Tian Wong (June 2010)*



# Thesis Conventions

## Typesetting

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This thesis is typeset using Microsoft Word 2007.  
The fonts used in this thesis are Times New Roman and Arial.

## Referencing

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The referencing and citation style adopted in this thesis are based on the Institute of Electrical and Electronics Engineers (IEEE) Transaction style.  
For electronic references, the last accessed date is shown at the end of a reference.

## Units

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The units used in this thesis are based on the International System of Units (SI units).

## Prefixes

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In this thesis, the commonly used numerical prefixes to the SI units are “p” (pico;  $10^{-12}$ ), “n” (nano;  $10^{-9}$ ), “ $\mu$ ” (micro;  $10^{-6}$ ), “m” (milli;  $10^{-3}$ ), “k” (kilo;  $10^3$ ), “M” (mega;  $10^6$ ) and “G” (giga;  $10^9$ ).

## Spelling

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The Australian English spelling is adopted throughout this thesis



# List of Figures

Figure 1 : Non-Foster circuit reactance cancellation .....	5
Figure 2 : Time harmonic analysis of antenna system. Antenna represented by a series RC component and a voltage source.....	10
Figure 3 : (a) Basic NIC circuit as proposed by Sussman-Fort [20] (b) Bipolar Junction Transistor equivalent circuit.....	11
Figure 4 : Small signal analysis (excluding $r_{\pi}$ ) .....	12
Figure 5 : Small signal analysis (including $r_{\pi}$ ).....	14
Figure 6 : Small signal analysis (Including parasitic capacitance).....	18
Figure 7 : A BJT implementation of the negative ‘capacitor’ .....	24
Figure 8 : Simulation results of a 2 meter dipole by 4NEC2+ program .....	25
Figure 9 : Equivalent capacitor representing the antenna's reactance (Using a first order approximation).....	25
Figure 10 : Equivalent resistor representing the antenna's resistor (Using a first order approximation).....	25
Figure 11 : Simple three element network to represent antenna's reactance across 3-20MHz .....	27
Figure 12 : The reactance of the three element network (blue curve) reasonably resembles the reactance of the antenna (red curve) .....	29
Figure 13 : NIC's two ports terminated by $Z_{L1}$ and $Z_{L2}$ . One port will be Open Circuit Stable while the other will be Short Circuit Stable (adopted from [24]). .....	33
Figure 14 : Circuit setup for Rollet Factor simulation .....	35
Figure 15 : Rollet Factor simulation result .....	35
Figure 16 : Reflection coefficient (S11) as seen from the receiver.....	36
Figure 17 : Circuit setup for antenna port reflection coefficient (S11) simulation.....	37
Figure 18 : Reflection coefficient (S11) as seen from the antenna.....	38
Figure 19 : Circuit setup for transistor base reflection coefficient (S11) simulation.....	39
Figure 20 : Reflection coefficient (S11) as seen the receiver side transistor's base and the antenna side transistor base respectively.....	40
Figure 21 :(a) Transient Analysis and (b) Fourier Series of the voltage at the receiver (labelled $V_{out}$ in the circuit) .....	41
Figure 22 : Modified NIC circuit .....	43
Figure 23 : Reflection coefficient (S11) as seen from the receiver (a) and antenna (b) respectively .....	44
Figure 24 : Reflection coefficient (S11) as seen the receiver side transistor's base (a) and the antenna side transistor base (b) respectively .....	45
Figure 25 : Transient Analysis (a) and its Fourier Series (b) of the voltage at the receiver.....	46
Figure 26 : Transient Analysis circuit setup .....	47
Figure 27 : Transient Analysis (a) and its Fourier Series (b) of the voltage at the receiver.....	48
Figure 28 : Imaginary part of the input impedance of the NIC with 1:1 transformer....	49
Figure 29 : Reactance curve of an ideal negative 27pF capacitor.....	50
Figure 30 : Imaginary part of the input impedance of the NIC with a transformer as seen from the receiver .....	50
Figure 31 : Real part of the input impedance of the NIC as seen from the receiver.....	51
Figure 32 : Circuit setup for stability sensitivity due to receiver load .....	52

Figure 33 : Reflection coefficient as seen from antenna with varying receiver load (Rx)	53
Figure 34 : Reflection coefficient as seen from the base of the antenna-side transistor with varying receiver load (Rx)	53
Figure 35 : Source Follower Circuit Design (note: $V_{buff} = 7.0$ V)	54
Figure 36 : Real part of the input impedance of the overall NIC circuit	55
Figure 37 : (a) Reactance (without buffer circuit) and (b) stability, when both transistor betas are varied	59
Figure 38 : (a) Reactance (without buffer circuit) and (b) stability, when only the antenna side transistor is varied	60
Figure 39 : (a) Reactance (without buffer circuit) and (b) stability, when only the receiver side transistor is varied	61
Figure 40 : (a) Reactance (without buffer circuit) and (b) stability when temperature is varied for military applications	63
Figure 41 : (a) Reactance (without buffer circuit) and (b) stability when the voltage source at the collectors are varied	64
Figure 42 : (a) Reactance (without buffer circuit) and (b) stability when the voltage source at the bases are varied	65
Figure 43 : Sensitivity Analysis for the NIC circuit	67
Figure 44 : Reactance (without buffer circuit) sensitivity analysis across 0.1 to 40 MHz	67
Figure 45 : Reactance sensitivity analysis across (a) 3-10 MHz , (b) 10-12 MHz and (c) 12-40 MHz respectively	68
Figure 46 : Sensitivity of the reflection coefficient as seen from antenna across 0.1 to 40 MHz.	69
Figure 47 : ADS circuit to analyse internal noise	74
Figure 48 : Noise Figure of the NIC circuit	75
Figure 49 : Minimum Noise Figure of the NIC circuit	75
Figure 50 : Noise voltage at the output of the NIC circuit due to internal noise	76
Figure 51 : Median values for man-made noise power (adopted from [41])	78
Figure 52 : Noise voltage at the receiver end of the NIC due to environmental noise in rural areas	81
Figure 53 : Noise voltage at the receiver end of the NIC due to environmental noise in the cities	82
Figure 54 : Noise voltage at the receiver end of the NIC circuit due to environmental noise and internal noise.	82
Figure 55 : NIC two tone harmonic balance analysis	88
Figure 56 : $V_{out}$ spectrum arising from input frequencies of 15.17 MHz and 15.72 MHz	89
Figure 57 : Surface plots for MATLAB's least squares quadratic fit to the coefficients of (a) $\alpha_1^2$ and (b) $\alpha_1^0$ (as described in Equation 6.3).	92
Figure 58 : Surface plots for MATLAB's least squares quadratic fit to the coefficients of (a) $2w_2$ (i.e. $a_4$ ) and (b) $w_2-w_1$ (i.e. $a_6$ ) (as described in Equation 6.1).	93
Figure 59 : Surface plots for MATLAB's least squares quadratic fit to the coefficients of (a) $w_2+w_1$ (i.e. $a_5$ ) and (b) $3w_1$ (i.e. $a_7$ ) (as described in Equation 6.1).	94
Figure 60 : Surface plots for MATLAB's least squares quadratic fit to the coefficients of (a) $2w_1+w_2$ (i.e. $a_9$ ) and (b) $2w_1-w_2$ (i.e. $a_{10}$ ) (as described in Equation 6.1).	95

# List of Tables

Table 1: Input Impedance (Real and Imaginary) and the Voltage Standing Wave Ratio (VSWR) of the NIC output as obtained using ADS .....	26
Table 2 : Antenna reactance as represented by an equivalent capacitor .....	27
Table 3 : Reactance of three element network .....	28
Table 4 : VSWR and impedance characteristics of a three element negated NIC circuit .....	29
Table 5: Signal level at receiver given a fixed input voltage level .....	55
Table 6: Temperature durability range according to the context of application .....	62
Table 7: Man Made Noise according to location. A noise figure of 39.5 dB (bolded) was used for a electric field calculation in Equation 5.7.....	79
Table 8: Least squares quadratic fit for first 6 coefficients (c.f. Equation 6.1; The relationship between coefficients $a_n$ and $b_n$ is described by Equation 6.2) .....	90
Table 9: Least squares quadratic fit for next 6 coefficients (c.f. Equation 6.1; The relationship between coefficients $a_n$ and $b_n$ is described by Equation 6.2) .....	91
Table 10: MRF949's IMD modelled and simulated performance when the 15.17MHz signal at 0.00652V interacts with the 15.72MHz signal at 0.00255V).....	91
Table 11: Typical shortwave broadcast stations' signals, as received in Adelaide, Australia. ....	96
Table 12: Highest $2w1-w2$ or $2w2-w1$ components due to the different two tone combinations. (The highest value was bolded).....	99
Table 13: Comparison between IMD levels with environmental noise in rural areas and cities. ....	100
Table 14: Transistor IMD performance comparison. The $2w1-w2$ component represents the most significant IMD problem (as bolded). ....	100
Table 15: MRF949 Die Gummel Poon Parameters .....	111