Non-Foster Fast-Wave Transmission Line Report

Template: see website for instructions

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*Abstract*— *See the website for all of the detailed requirements.* ***Project reports may not exceed 3-page limit***. The project web-page information overrides any information contained in this template. The source of every item copied into the report must be cited. All figures must be clear and legible as would be submitted for IEEE publication. The examples in this template are not necessarily up to such clear and legible standards. You must include references in the bibliography for any formulas used. See http://thomasweldon.com/tpw/papers/tpwAps2016tunableNonFos\_e\_ppt.pdf

# Introduction

The first paragraph introduction should begin with an overall description of the “big picture” of the project topic, similar to the content in the abstract above, but stated somewhat differently and less details. bla blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

The second paragraph of the introduction should explain the organization of the rest of the paper. In the next section we describe the theory, ...blah blah. In Section III, we discuss various implementations of the whatever. The following section describes simulations/measured/whatever ... blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

# Theory

The basic non-Foster circuit element is the negative capacitor shown in Fig. 1, where the input impedance seen at the input of the op-amp is:

Zin(s)= Vin(s) / Iin(s) = ???  (1)

where the effective input capacitance is then ???. finish this sentence describing your formula. blah blah blah blah blah blah blah blah blah blah blah



Fig. 1. Schematic of negative capacitor. Include whatever is required and describe what is in this figure ... Fix all captions!!

As shown in Fig. 2, the paper uses three negative capacitors to load 6 sections of transmission line of length ??? meters each, effectively reducing the capacitance, and increasing the transmission line group velocity vg=(L0 C0)-1/2 , where L0 C0 are the inductance per meter and capacitance per meter of the transmission line. The velocity increases because the negative capacitance effectively reduces C0.

# Simulation Results

First, say what the schematic is. In this project, we were provided with an ADS design for a fast-wave transmission line split into 6 sections, with a negative capacitance inserted between pairs of sections, as shown in Fig. 2. As shown, ports 1 and 2 are connected to the fast-wave line, so S21 shows the fast-wave behavior. Ports 3 and 4 are connected to normal transmission line of the same total length so S43 shows the normal line behavior, and similarly S65 shows the behavior of a speed-of-light vacuum line.



Fig. 2. Schematic of amplifier non-Foster loaded fast-wave transmission line simulation. Include whatever is required and describe what is in this figure blah, blah, blah ... Fix all captions!!

The first fast-wave simulation for three -4 nF loads is in Fig. 3, showing the fast-wave S21 phase in degrees??? as a function of frequency in solid blue, normal line phase S43 in solid red, and vacuum speed of light in dashed magenta. blah blah blah blah blah blah



Fig. 3. Fast-wave phase simulation for three -4 nF capacitance. The fast-wave S21 phase in degrees??? is in solid blue, the blah blah blah... describe what is in this figure... Fix all captions!!

as the . blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

The second fast-wave simulation for three -6 nF loads is in Fig. 4, showing the fast-wave S21 phase in degrees??? .... blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

blah blah blah blah blah blah blah blah blah blah blahblah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah



Fig. 4. Fast-wave phase simulation for three -6 nF capacitance. The fast-wave S21 phase in degrees??? is in solid blue, the blah blah blah... describe what is in this figure... Fix all captions!!

The third fast-wave simulation for three -8 nF loads is in Fig. 4, showing the fast-wave S21 phase in degrees??? .... blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

blah blah blah blah blah blah blah blah blah blah blah



Fig. 5. Fast-wave phase simulation for three -8 nF capacitance. The fast-wave S21 phase in degrees??? is in solid blue, the blah blah blah... describe what is in this figure... Fix all captions!!

blah blah

For each of the ADS simulations in Fig. 3 to Fig. 5, the phases in degrees were recorded at a frequency of 50 kHz, in addition to the reference phases of a normal line and vacuum. These measured phases are given in Table I.

1. Phases measured at 50 kHz

| Parameter | Phase |
| --- | --- |
| Normal Line | ??? degrees |
| Vacuum | ??? degrees |
| Three -4 nF capacitive loads | ??? degrees |
| Three -6 nF capacitive loads | ??? degrees |
| Three -8 nF capacitive loads | ??? degrees |
| Do any phases above indicate velocity faster than speed of light? | yes/no |

The number of degrees phase is inversely proportional to the phase velocity of the line, since phase in degrees = 360\*length\*f/vg, where f is frequency in Hz and line length is in meters. Less phase indicates a faster line.

Fig. 6 shows the group delay (time delay) for three -6 nF loads, showing the fast-wave S21 delay in seconds??? as a function of frequency in solid blue, normal line S43 group delay in solid red, and vacuum speed of light group delay in dashed magenta. blah blah blah blah blah blah blah



Fig. 6. Fast-wave group delay simulation for three -6 nF capacitance. The fast-wave S21 group delay in seconds??? is in solid blue. Include whatever is required and describe what is in this figure... Fix all captions!!

The measured group delays in nanoseconds at 20 kHz from Fig. 6 are shown in Table II.

1. Measured Group Delays at 20 kHz

| Parameter | Group Delay |
| --- | --- |
| Normal Line | ??? ns |
| Vacuum Line (speed of light) | ??? ns |
| Three -6 nF capacitive loads | ??? ns |
| Is the -6 nF time delay less than the time that light would travel the lenght of the cable in vacuum? | yes/no |

# Conclusion

Summarize any problems you may have encountered, or summarize what you learned from the items discussed in this paper. Dont forget to include your references, one must bea journal or conference paper. Do not use websites as references, all figures must be sourced from conference or journal papers.

##### References

*At least 1 reference must be this paper :*

http://thomasweldon.com/tpw/papers/tpwAps2016tunableNonFos\_e\_ppt.pdf

*(cite it properly as in the examples below)*

1. T.P. Weldon, J.M.C. Covington III, K.L. Smith, and R.S. Adams ``Performance of Digital Discrete-Time Implementations of Non-Foster Circuit Elements,'' *2015 IEEE Int. Sym. on Circuits and Systems*, Lisbon, Portugal, May 24-27, 2015.
2. T.P. Weldon, J.M.C. Covington III, K.L. Smith, and R.S. Adams, ``Stability Conditions for a Digital Discrete-Time Non-Foster Circuit Element,'' *2015 IEEE Int. Symposium on Antennas and Propagation*, Vancouver, BC, Canada, July 19-25, 2015.