SASP Homework Assignment No. 2 (HWA2)

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0.1 Wave Digital Filter (WDF) scheme

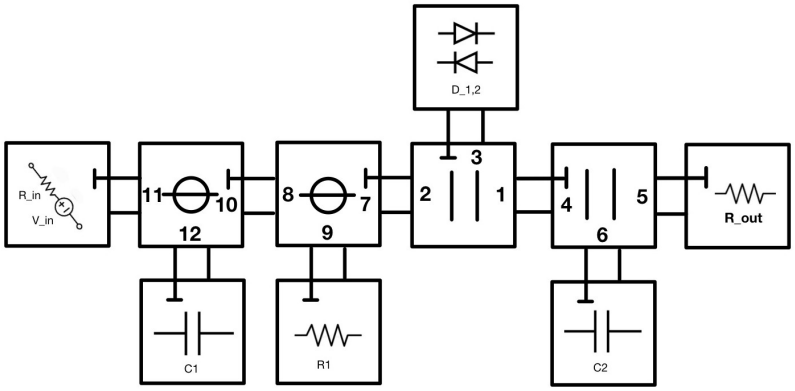

Figure 1. WDF scheme

As required by the WDF modelling algorithm, we placed at the top of our schema as root of the tree the non-linear component, namely the antiparallel diodes. Starting from there we structured the tree using junctions (or better call them **adaptors**) with a maximum of three ports, in order to create a binary tree. Will now be listed below all the free parameter of our WDF scheme with the correct setting to make each port of the system **reflection-free**. Let's start from the linear one-port elements.

- Linear resistive voltage generator:

$$Z_{11} = R_{in}$$

- 1st capacitor (to AC coupling the input voltage source):

$$Z_{12} = \frac{T_s}{2C_1}[1]$$

- 2nd capacitor (in parallel to the diodes to filter out higher frequencies):

$$Z_6 = \frac{T_s}{2C_2}[1]$$

- Resistance (to limit the amount of current into the diodes):

$$Z_9 = R_1$$

- Ouput resistance (potentiometer controlling the output volume):

$$Z_5 = R_{out}$$

Now let's pass to the topological junctions. As said before we chose to use adaptors with a maximum of three ports connected, and so we ended up with two series adaptors and two parallel adaptors:

[1]To discretize dynamic elements it has been used the bilinear transform or Tustin's method:

$$s = \frac{2}{T} \cdot \frac{1 - z^{-1}}{1 + z^{-1}}$$

- 1st series adaptor (to compensate input voltage source and the 1st capacitor):

$$Z_{10} = Z_{11} + Z_{12}$$

- 2nd series adaptor (to compensate the resistance):

$$Z_7 = Z_8 + Z_9$$

- 1st parallel adaptor (to adapt the diodes with the rest of the circuit):

$$Z_3 = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

- 2nd parallel adaptor (to compensate the output resistance and the 2nd capacitor):

$$Z_4 = \frac{Z_5 Z_6}{Z_5 + Z_6}$$

Finally it comes the setting of the free-parameters to connect the four adaptors together

- Connecting 1st series adaptor with the 2nd one

$$Z_8 = Z_{10}$$

- Connecting 2nd series adaptor with the 1st parallel one

$$Z_2 = Z_7$$

- Connecting 1st paralles adaptor with the 2nd one

$$Z_1 = Z_4$$

0.2 Plots of the results

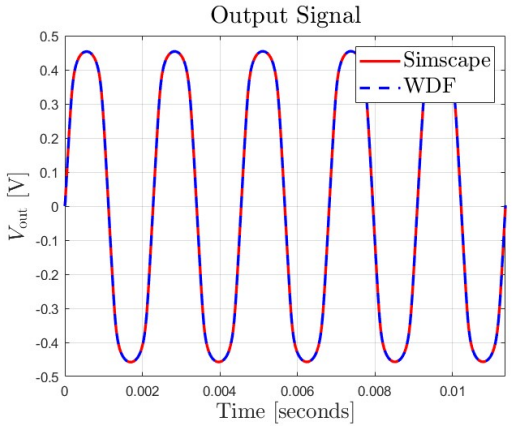

Figure 2. Plot of the output signal compared with the ground-truth provided as reference. As it is possible to see, the 2 signal are almost perfectly superimposed.

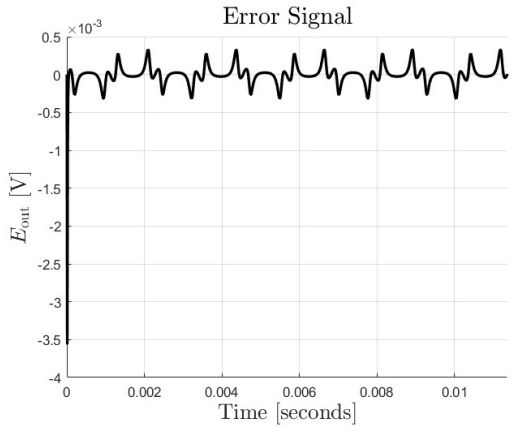

Figure 3. Plot of the error signal, namely the difference between our output signal and the ground-truth provided as reference. In this plot is shown the evolution of the error over time but considering a mean value, the overall Mean Square Error is equal to 2.0941e-07.

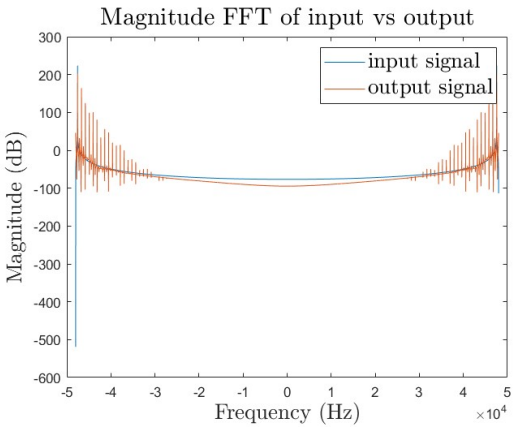

Figure 4. Plot of the spectrum of the input signal compared with the one of the output. From this plot it's clearly noticeable the effect of the distortion since there are new harmonic components on the output signal.