How to simulate SFDR/IMD3 vs F_{in}

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Data converters 2 – DAC design

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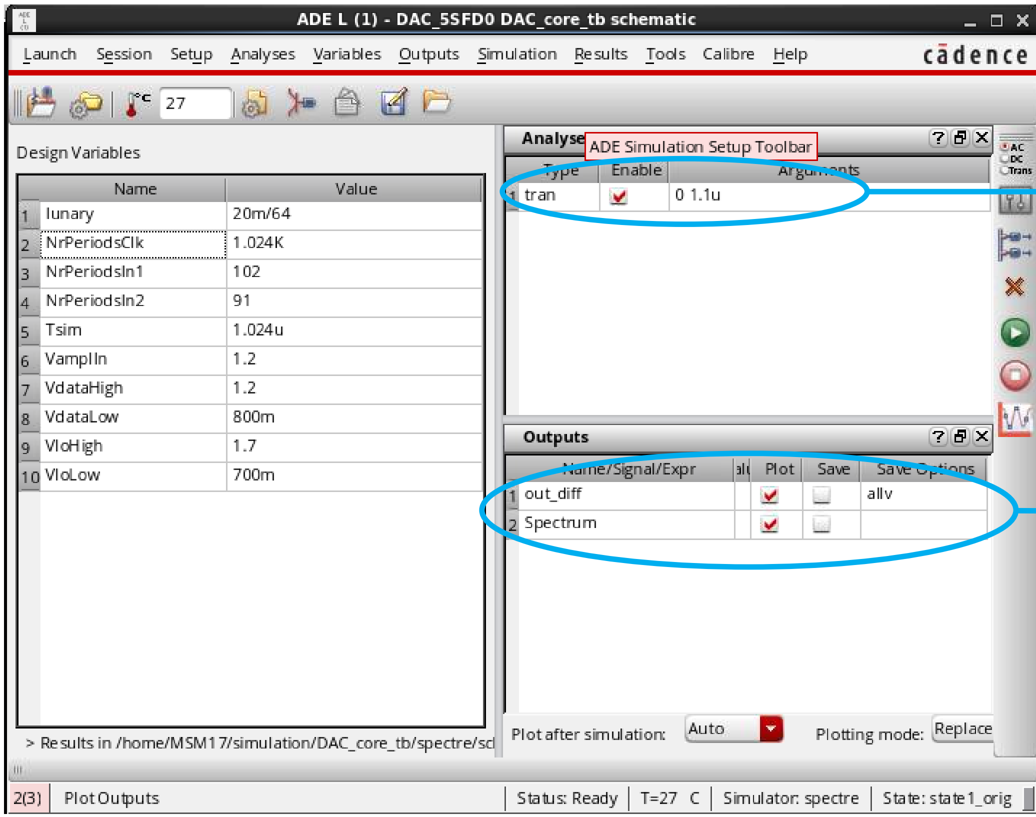
Where innovation starts

Step 1 : Explanation of the existing test bench



Type of simulation(e.g. tran, DC)

Outputs : can be signals or even expressions from calculator (e.g. Spectrum is obtained from calculator)

→ How to setup the FFT (Spectrum) will be shown in the later steps

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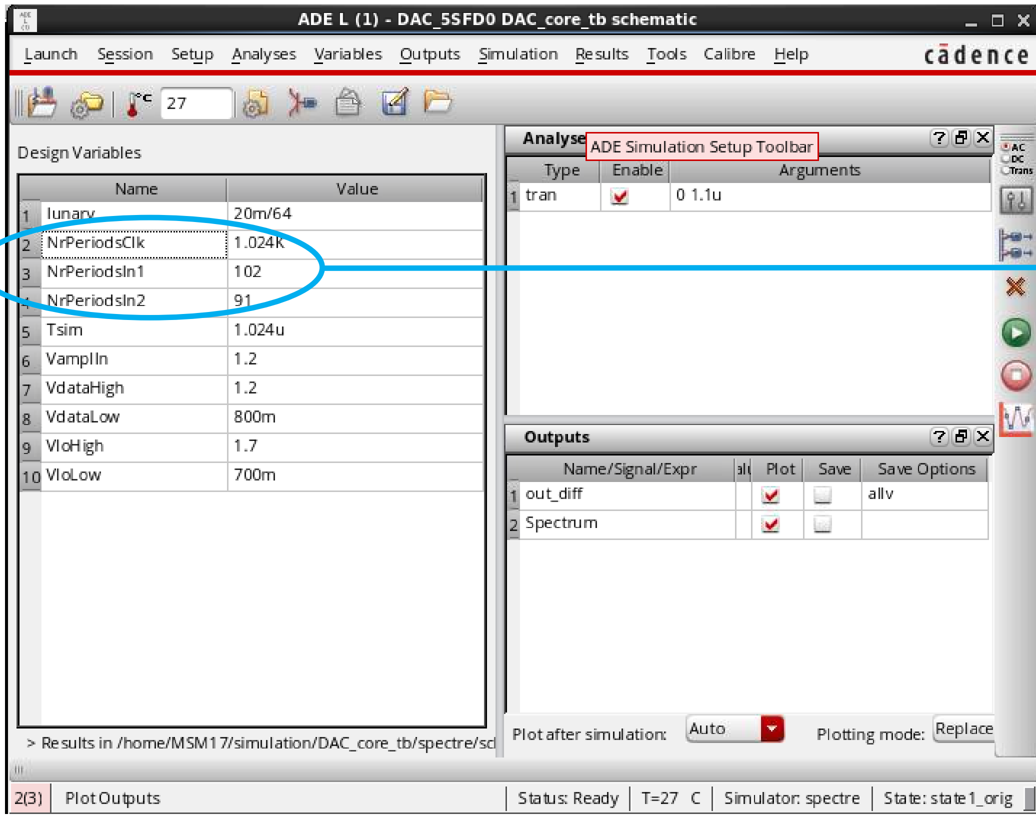

Given a simulation time (Tsim), you can define the frequency of a signal based on the number of periods you fit in that time frame

In this example :

$$F_{clk} = \frac{NrPeriodsClk}{T_{sim}} = 1\ GHz$$

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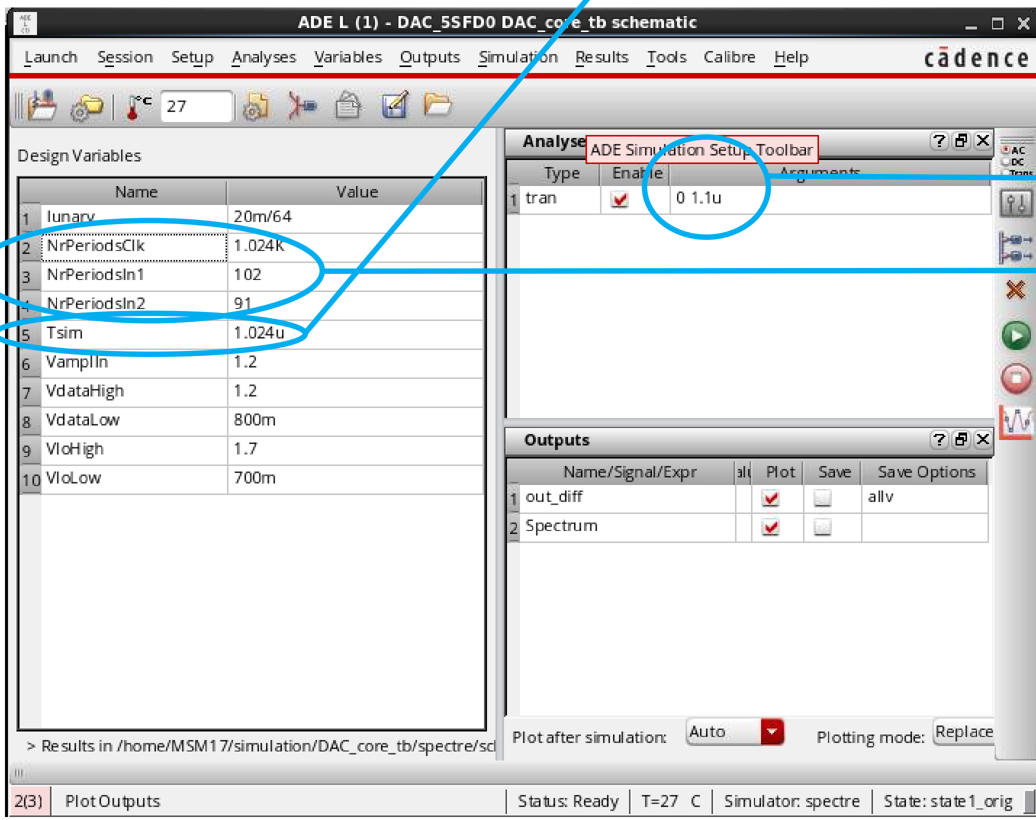
Step 1 : Explanation of the existing test bench

FFT relevant simulation time



Total simulation time

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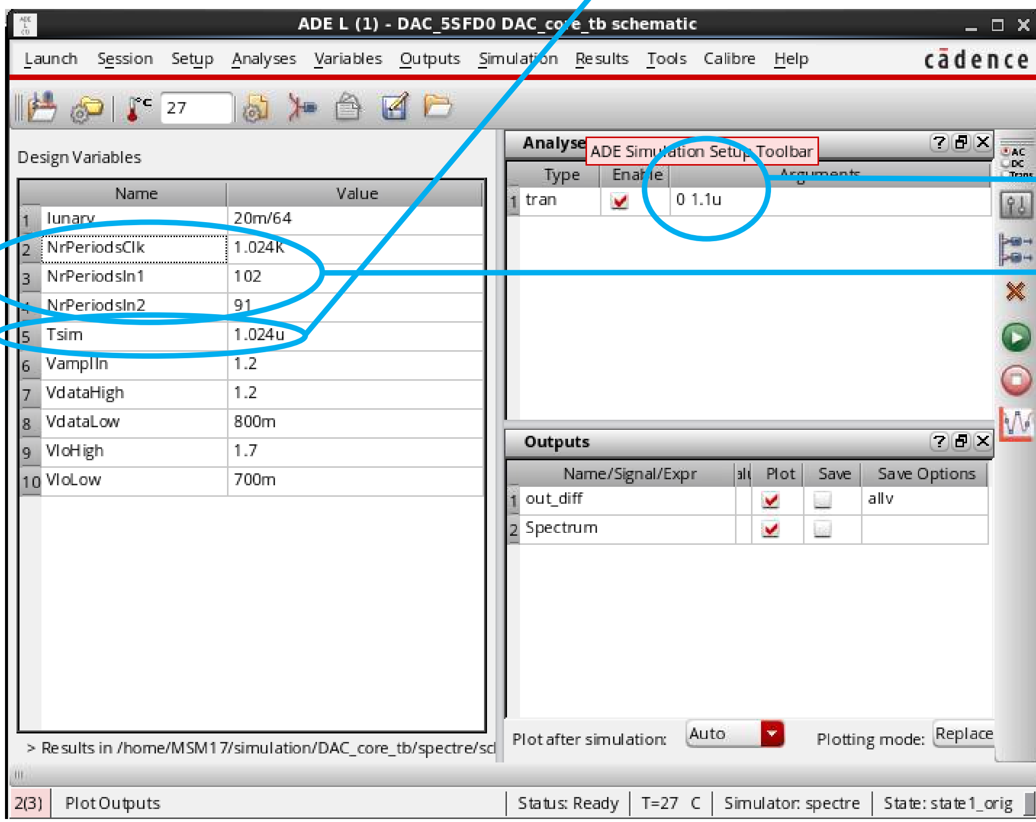
→ The extra time is allowed such that you avoid taking incorrect samples for the FFT during start up of the simulation

→ The selection of the input frequencies will be discussed in the following slides.

Step 1 : Explanation of the existing test bench

FFT relevant simulation time



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Step 2 : How to select the input frequencies

The following example will help you understand how to setup the FFT :

Lets say : F_s = 1GHz

Nfft = 1024 → This is the number of FFT points

Tsim = Nfft/F_s=1.024us

Now i want to calculate the FFT of the input frequency of 353 MHz.

→ First things to consider :

a. My input frequency has to be highly uncorrelated with F_s

b. I have to fit an integer number of periods within the Tsim otherwise leakage will occur

Step 2 : How to select the input frequencies

→ If you just use 353 MHz as an input frequency then :

NrPeriodsSin1 = 1.024us*353M/s = **361.472 → Not integer → Leakage!**

Step 2 : How to select the input frequencies

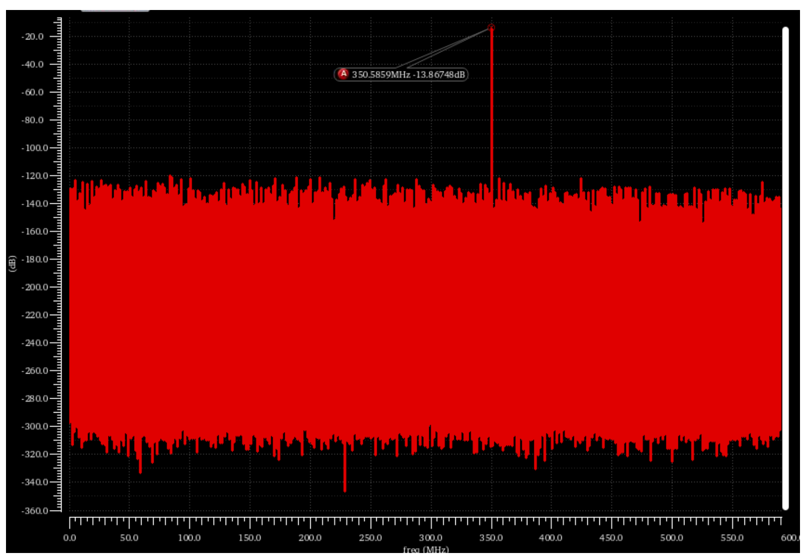
→ What you should do is the following :

a. NrPeriodsSin1 = 1.024us*353MHz = **361.472**

b. closestPrimeNumber(NrPeriodsSin) = 359

c. F_{in_new}= 359/1.024u = 3.50585937500000e+08

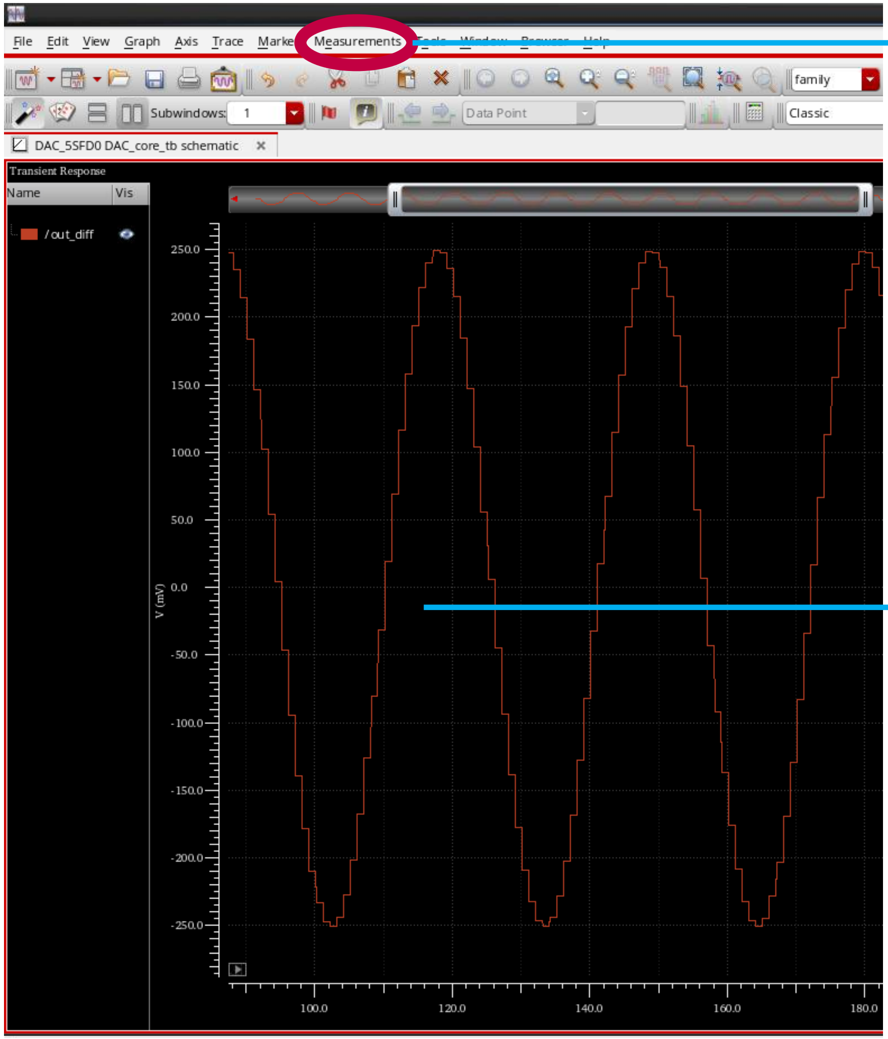
→ Please keep in mind that even a single digit will make the difference in the FFT



Step 2 : How to select the input frequencies

- → For the dual tone test :
- → The second frequency should be made such that AGAIN the NrPeriodsSin2 is integer in the relevant simulation time

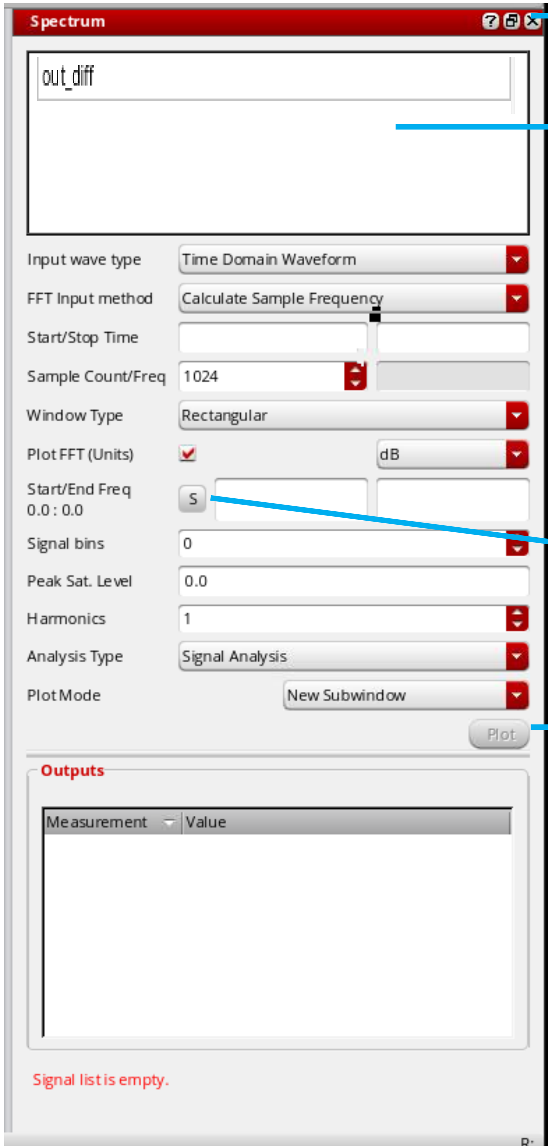
Step 3 : Measurements



Click on Measurements → Spectrum

This is the output signal

Step 3 : Measurements



You will observe this on the right of your window

Drag and drop the signal into this rectangle

Start/stop time : For this example

Start = Total time – Tsim = 1.1u-1.024u = 0.076u

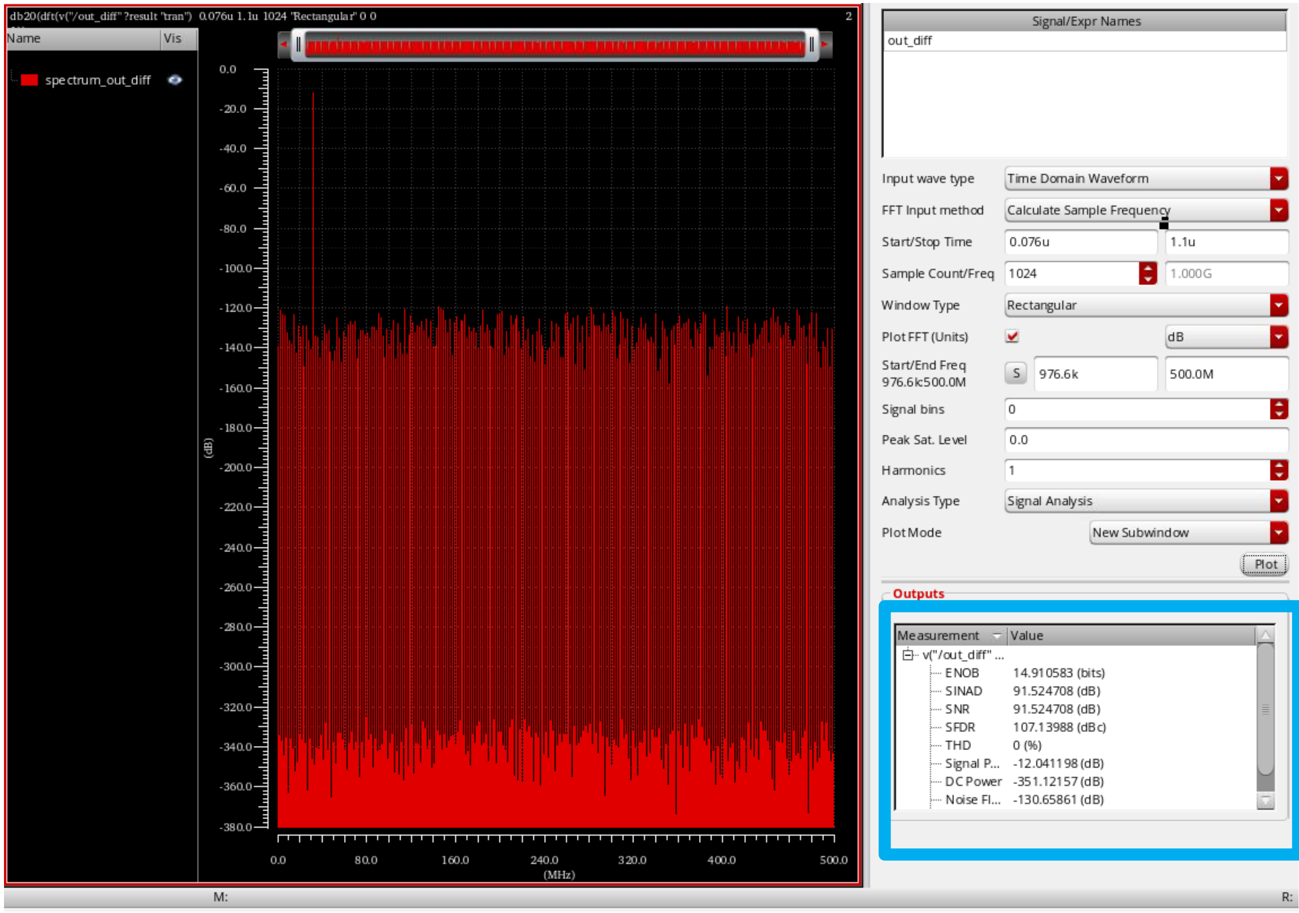
Stop time = Total time

Sample Count/Freq = NFFT

Click this button

→ And then Plot

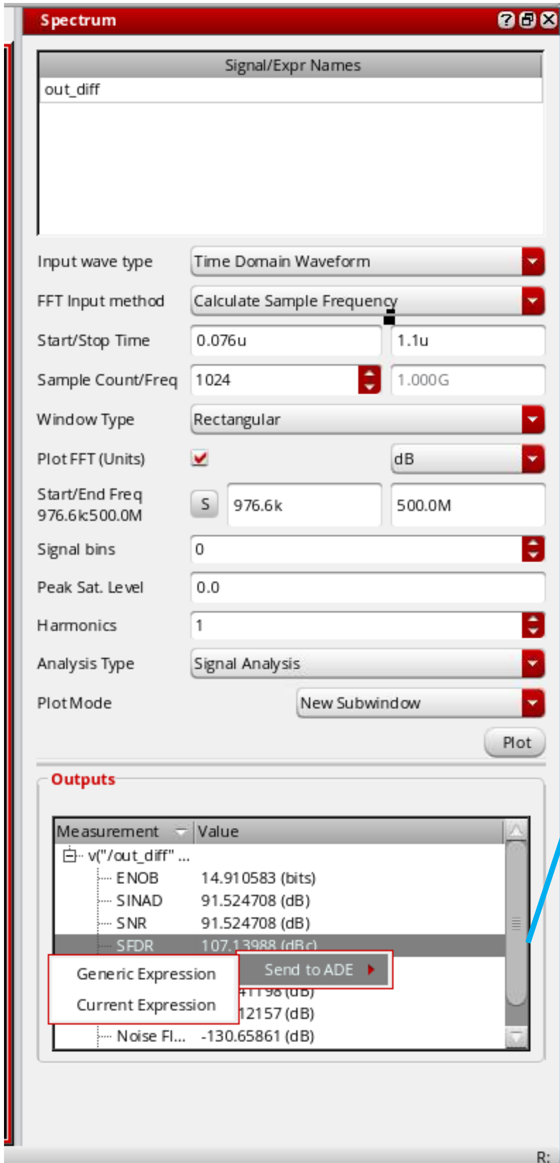
Step 3 : Measurements



→ The spectrum appears

→ The measurements SFDR SNDR ENOB e.t.c are on the Bottom right of your screen

Step 3 : Measurements



→ Right click on the measurement you want then → Send to ADE→ Generic expression

→ Now what is left is to run a parametric Frequency sweep to obtain SFDR vs NrPeriodsSin1/Tsim (=Input Frequency). **YOU WILL VARY NrPeriodsSin1**

→ If you also want the FFT setup, just click on the FFT and then on the calculator. Copy the expression and create a new output on the ADEL

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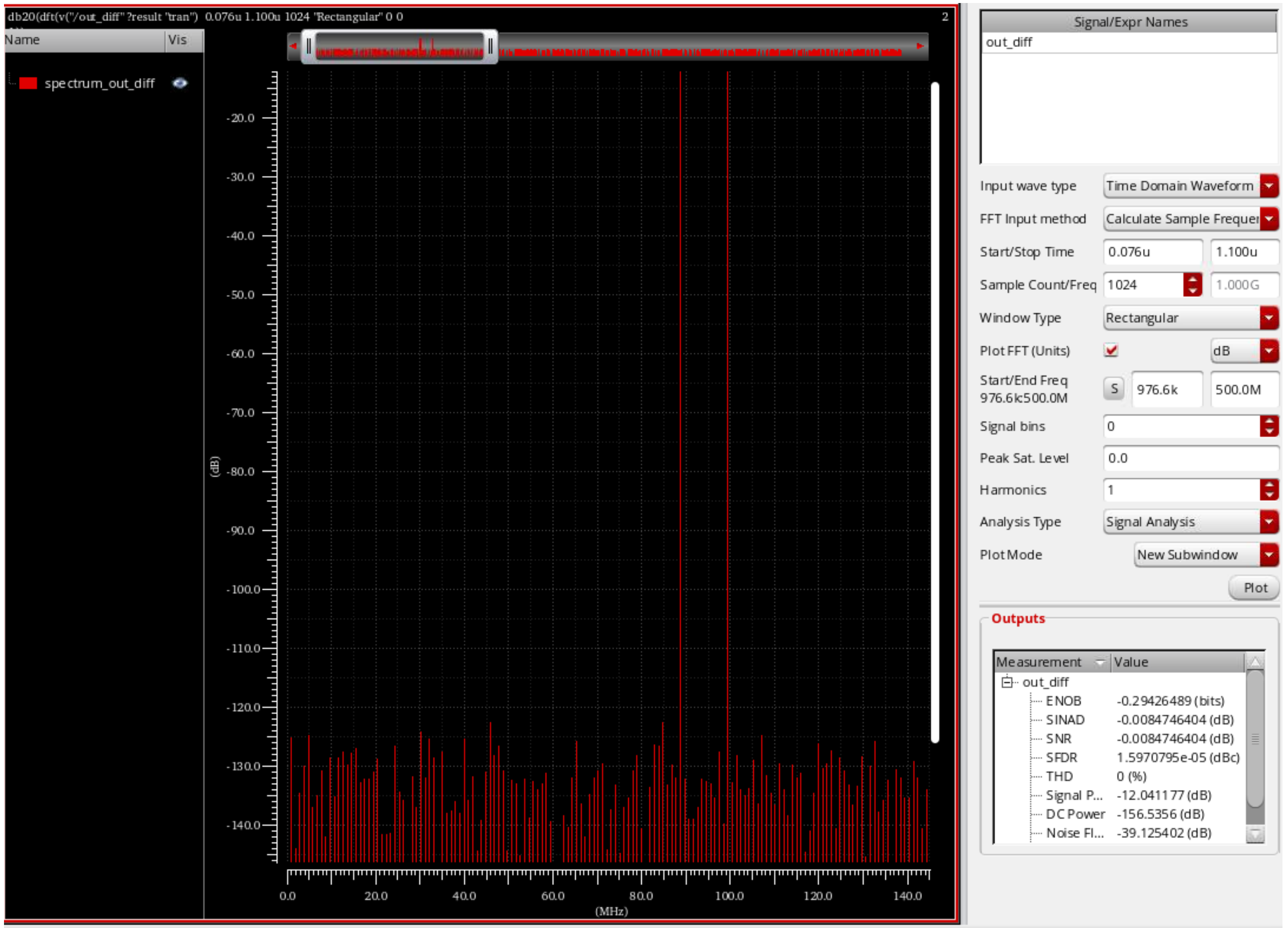
Step 3 : Measurements – IMD3

→ **Same setup as before but now two tones input**



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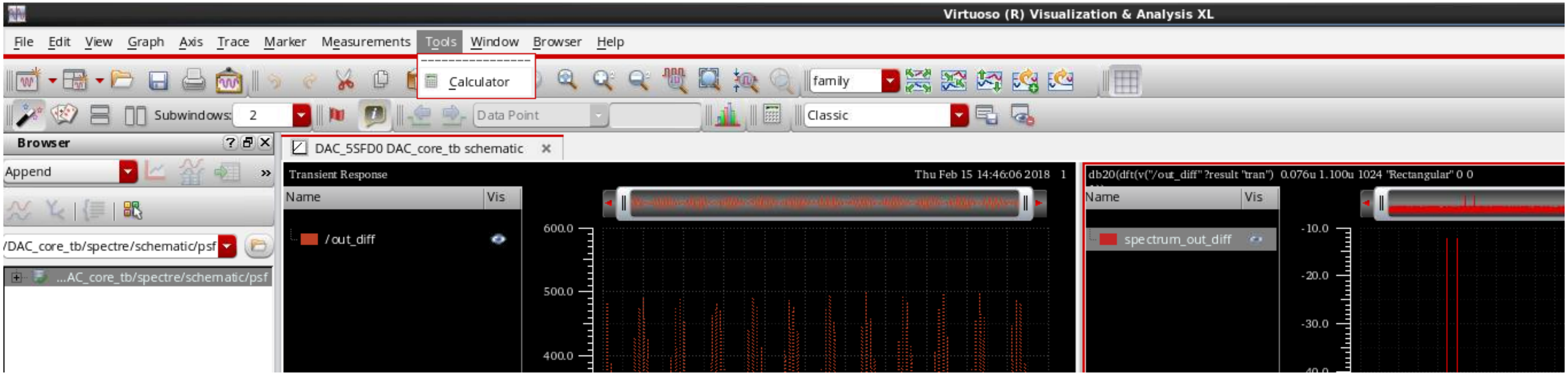
Step 3 : Measurements – IMD3

→Tools→ Calculator



Step 3 : Measurements – IMD3

→ Enter the following expression:

value(db20(dft(v("/out_diff" ?result "tran") 0.076u 1.100u 1024 "Rectangular" 0 0 1)) 2*VAR("NrPeriodsIn2")/VAR("Tsim")-VAR("NrPeriodsIn1")/VAR("Tsim"))

→ Compare the result with the cursor measurement
→ If its the same copy the expression then go to ADEL → right click on the outputs → Edit :
Name: IMD3 – HF
Expression : paste the expression
Apply and OK
→ Run a parametric sweep on NrPeriodsIn1 : Remember you will have to keep |NrPeriodsIn1-NrPeriodsIn2 | constant
→ You can do that by simply defining NrPeriodsIn2 = NrPeriodsIn1+10(or 20 or 100 depending on the NFFT points and the target frequency difference between the two tones)

Now you are set to GO!

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