CHAOS Worksheet

Revised November 2016

Your Name:______________________________Signature:___________________________

Lab Partner(s):____

Course and Section:______________ Station Number:________ Date:______________

D.1 Record the Apparatus Presets:

Record the frequency found on your RLC box (and which you are presetting with your frequency generator) in kHz :_____________

Record the oscilloscope preset TIME/DIV in μs/cm:__________________

and the oscilloscope preset CH1 VOLTS/DIV in volts/cm:________________

and the oscilloscope preset CH2 VOLTS/DIV in volts/cm:________________

D.2 Observe Low Input and Output Voltages and Measure the Input Frequency

Sketch the input CH1 voltage pattern:

Sketch the output CH2 voltage pattern and *comment on the difference* with the input pattern:

Input voltage frequency according to the oscilloscope: Count the number of **periods** N (including any fraction) that fit into n **grid steps** on the oscilloscope screen.

Number of periods N: ________ Number n:__________(multiples of Δt = TIME/DIV)

Total time τ:___________μs (this is n times Δt, the TIME/DIV setting)

Period T:_____________μs (this is just τ divided by N)

Therefore your measured input frequency is:__________________kHz

Comment on how this compares with the frequency generator digital readout:

D.3 Observe Period Doubling with a Slow Increase in Input Voltage

A) As Time Series Describe BRIEFLY including sketches for what you see qualitatively as you increase the voltage throughout the range available (check that the peak-to-peak voltage of the input agrees with the FG digital readout):

B) As Parametric Plots ("Loops") Describe BRIEFLY including sketches for what you see qualitatively as you increase the voltage throughout the range available (including the initial "foldover" transition) which you have to pass through before you enter into the regular period-doubling range) :

D.4 Estimate the Famous Period Doubling Parameters:
Crude Estimate of the First Feigenbaum Number:

Measure the period doubling $V_0(n)$ in x-y mode (the FG gives the peak-to peak input voltage directly, $2V_0$, and keep as many digits as you can) and you can just keep the factor of two because it cancels out in the ratio for δ) for n = 1,2,3

$2V_0(1)$:_____________(volts) $2V_0(2)$:______________(volts) $2V_0(3)$:_____________(volts)

$\delta(2) = [2V_0(2) - 2V_0(1)]/[2V_0(3) - 2V_0(2)] =$ __________________

How does your value compare with the theoretical limit of δ? Try to estimate what $2V_0(4)$, and hence δ(3), might be and see if you're trending in the right direction.

D.5 Observe Geometrical Decrease in the Maximum Output Voltages Splittings at Period-Doubling: Rough Estimate of the Second Feigenbaum Number:

Measure the peak splitting ε(n) in x-y mode (the vertical splitting observed and estimated by the oscilloscope grid):

ε(1):_____________(millivolts) ε(2):______________(millivolts)

$\alpha(2) = \varepsilon(1)/ \varepsilon(2) =$ __________________

While you should not expect it to be close, how does your value compare with the theoretical limit of α? Try to roughly (guess if you have to) what ε(3), and hence α(3), might be and see if you're trending in the right direction.

D.6 Discussions and Errors

δ(2): Estimate roughly the error in your δ(2) by a "bracket," i.e., an upper limit and a lower limit. That is, for the upper limit, put in your FG voltage measurement error (what do you think it is?) so as to make the numerator biggest and the denominator smallest (add the error to $V_0(2)$ and subtract it from $V_0(1)$ and $V_0(3)$). For the lower limit, do the reverse.

α(2): Estimate roughly the error in your α(2) by putting in your grid voltage measurement error (what do you think it is?) so as to make the numerator biggest and the denominator smallest (add the error to ε(1) and subtract it from ε (3)). For the lower limit, do the reverse.

Discuss very briefly some of the limitations of this experiment – include considering how you are obtaining measurement numbers and the number of period doubling transitions.

GRADE:____________ GRADED BY:__________(TA's initials)