ELEC 4505:

Telecommunication Circuits

Lab 1: Tuned Amplifiers

30 Sept 2017

Section: A20

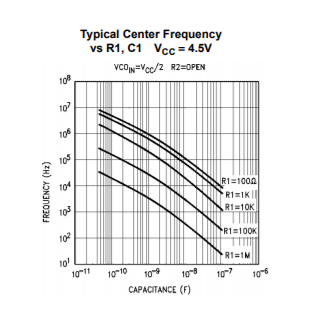
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Part 1 – Characterization of the Phase Locked Loop

1. The VCO

Before obtaining the data to characterize the KVCO, we must find the values for the capacitor and the resistance value, R1. As R2 is opened, only R­1 needs to be picked. Using the data sheet that is provided, a graph (Figure 1) of the Typical Center Frequency vs R1, C1 is used to determine the proper value to meet specification.



Since the nominal frequency is between 1.5MHz to 1.125 MHz, we selected the capacitance value, C1 = 180 pF, while the resistance value to 10kΩ. However, in lab condition, 180pF were unavailable to be used for the experiement. The closest value that can be matched to the theoretical value is a capacitance value of 270pF. By doing another iteration by matching the value to the graph, R1 = 10kΩ produces a much more desirable result which will be seen in the later sections.

1.2 – Plot of the VCO Frequency vs DC Tuning Voltage

By connecting the jumper to the circuit with the potentiometer, we are able to change the output DC voltage measured on the digital multimeter with respect to the frequency. Below shows a table at which

|  |  |
| --- | --- |
| Vco | Frequency |
| 1.35 | 5.00E+05 |
| 1.85 | 7.50E+05 |
| 2.08 | 1.13E+06 |
| 2.1 | 1.13E+06 |
| 2.12 | 1.14E+06 |
| 2.14 | 1.15E+06 |
| 2.16 | 1.16E+06 |
| 2.18 | 1.17E+06 |
| 2.2 | 1.18E+06 |
| 2.22 | 1.19E+06 |
| 2.26 | 1.20E+06 |
| 2.3 | 1.21E+06 |
| 2.32 | 1.22E+06 |
| 2.36 | 1.23E+06 |
| 2.4 | 1.24E+06 |
| 2.5 | 1.25E+06 |
| 2.58 | 1.26E+06 |
| 2.6 | 1.27E+06 |
| 2.7 | 1.28E+06 |
| 2.86 | 1.29E+06 |
| 2.87 | 1.30E+06 |
| 2.92 | 1.31E+06 |
| 2.96 | 1.32E+06 |
| 3.01 | 1.33E+06 |
| 3.08 | 1.34E+06 |
| 3.15 | 1.35E+06 |
| 3.2 | 1.36E+06 |
| 3.29 | 1.37E+06 |
| 3.3 | 1.38E+06 |
| 3.36 | 1.39E+06 |
| 3.41 | 1.40E+06 |
| 3.43 | 1.41E+06 |
| 3.45 | 1.42E+06 |
| 3.49 | 1.43E+06 |
| 3.55 | 1.44E+06 |
| 3.61 | 1.45E+06 |
| 3.68 | 1.46E+06 |
| 3.73 | 1.47E+06 |
| 3.8 | 1.48E+06 |
| 4 | 1.49E+06 |
| 4.05 | 1.50E+06 |

1.3 Calculate KVCO

However in order to characterize the KVCO value, we must take the slope value and converting from [Hz/V] to [(rad/s)/V]

The expression for the conversion can be shown below

Where m is the slope of the linear equation,

Question 2: The Characterization of the 3 Phase Detectors

Phase Detector 1

|  |  |  |  |
| --- | --- | --- | --- |
|  | Phase 1 Detector | |  |
| Time Diff | Phase rad | Phase degree | Voltage |
| 2.51E-07 | 0.289515 | 16.588 | 5.02E-01 |
| 5.08E-07 | 0.61083 | 34.998 | 1.02E+00 |
| 7.34E-07 | 0.916769 | 52.527 | 1.47E+00 |
| 9.84E-07 | 1.233424 | 70.67 | 1.97E+00 |
| 1.23E-06 | 1.544407 | 88.488 | 2.46E+00 |
| 1.51E-06 | 1.882233 | 107.844 | 3.02E+00 |
| 1.77E-06 | 2.204997 | 126.337 | 3.54E+00 |
| 2.02E-06 | 2.518091 | 144.276 | 4.04E+00 |
| 2.24E-06 | 2.84466 | 162.987 | 4.48E+00 |

Phase Detector 2

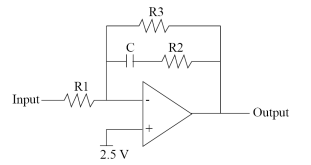
|  |  |  |  |
| --- | --- | --- | --- |
|  | Phase 2 Detector | |  |
| Time Diff | Phase rad | Phase degree | Voltage |
| 2.28E-07 | 0.2803 | 16.06 | 2.39E+00 |
| 5.02E-07 | 0.570025 | 32.66 | 2.25E+00 |
| 7.51E-07 | 0.916996 | 52.54 | 2.12E+00 |
| 9.96E-07 | 1.233424 | 70.67 | 2.00E+00 |
| 1.22E-06 | 1.56186 | 89.488 | 1.89E+00 |
| 1.52E-06 | 1.882233 | 107.844 | 1.74E+00 |
| 1.77E-06 | 2.216568 | 127 | 1.62E+00 |
| 2.02E-06 | 2.517201 | 144.225 | 1.49E+00 |
| 2.23E-06 | 2.827433 | 162 | 1.39E+00 |

Phase Detector 3

|  |  |  |  |
| --- | --- | --- | --- |
|  | Phase 3 Detector | |  |
| Time Diff | Phase rad | Phase degree | Voltage |
| 2.14E-07 | 0.290946 | 16.67 | 0.214 |
| 4.97E-07 | 0.609312 | 34.911 | 0.4968 |
| 7.34E-07 | 0.916996 | 52.54 | 0.7344 |
| 9.95E-07 | 1.232202 | 70.6 | 0.9948 |
| 1.23E-06 | 1.549852 | 88.8 | 1.23 |
| 1.51E-06 | 1.897173 | 108.7 | 1.51 |
| 1.77E-06 | 2.204473 | 126.307 | 1.77 |
| 2.02E-06 | 2.51659 | 144.19 | 2.02 |
| 2.23E-06 | 2.825688 | 161.9 | 2.23 |

Part 2

For small signal, take positive terminal f filter as 0 V(Short voltage source)



Q2)

Choose capacitor’s value as 100nF,

Q3)  
The approximations can be used when which occurs for our components since ()

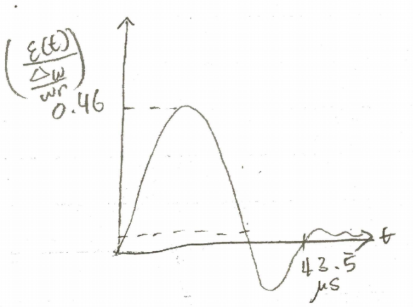
For the following expression for F(S) can be used for frequencies much higher than

The negative sign from F(s) is removed for stable operation.

Q4)

Input frequency step = 50kHZ

Maximum error at , ,

 Min

5)

For maximum error

For a phase error of less than 0.5 radians,

Phase error ≤ 0.5 rad for an input freq range of

**Plot phase variation vs input frequency**

Table 5 shows the measured phase differences and control voltage for various input signal frequencies.

**Explain if lock range is related to** 𝝎𝒏

**Plot VCO control voltage vs signal frequency. Calculate** 𝑲𝑽𝑪𝑶 **and compare to either measurements**

**Reduce gain to 1, how did you do this?**

The gain is given by the ratio 𝑅3/𝑅1. We changed 𝑅1 to equal 𝑅3=330 𝑘Ω so that it was equal to 𝑅3, giving a gain of 1.

**Calculate new** 𝝎𝒏**,** 𝜻

Using the calculated (phase detector 1) from the previous parts,

**References**

**[1] Calvin Plett, “Lab1\_Assign1\_Tuned\_Amp\_2017.pdf”, Department of Electronics, Carleton University, September 2017**