\chapter{Design of Voltage Controlled Oscillator

}

\label{ch:chap1}

\section{Objective}

Assignment 02 for our "EN3013 – Analog Circuit Design" course is an opportunity to dive into the practical aspects of designing a Voltage-Controlled oscillator (VCO) using LT Spice XVII. The assignment unfolds in three steps, starting with a close look at our LAB-1 ring oscillator design, tweaking it with header and footer switches, and experimenting with control voltages. We then move on to optimizing the circuit parameters to enhance the output waveform and rectify any issues observed. The ultimate goal is to fine-tune our VCO until we achieve a satisfying design. The last step involves documenting our journey, creating timing diagrams using LT Spice's waveform viewer, and summarizing our findings in a report. This assignment not only builds our hands-on design skills but also encourages us to think critically and communicate our results effectively.

\section{Procedure}

\section\*{STEP-1}

\begin{enumerate}

\item Launch LT-Spice simulator.

\item Open your LAB-1 ring oscillator design. Check whether the following transistor directives are used in your design.

\textbf{NMOS Transistor:}

\begin{verbatim}

L = 10u W=100u

.MODEL CMOSN NMOS KP=96u VTO=0.786 LAMBDA=0.01 TOX=21n

GAMMA=0.586 CGDO=402p CGSO=402p CGBO=362p

\end{verbatim}

\textbf{PMOS Transistor:}

\begin{verbatim}

L=10u W=200u

.MODEL CMOSP PMOS KP=96u VTO=-0.906 LAMBDA=0.01 TOX=21n

GAMMA=0.486 CGDO=54p CGSO=54p CGBO=336p

\end{verbatim}

Please note the minus sign and units carefully.\\

\item Modify the inverters with a header switch and a footer switch as shown below. (Refer to Figure 1)

\begin{figure}[h]

\centering

\includegraphics[width=0.2\textwidth]{EN3013-Assignment 2\_Page\_1\_Image\_0001.jpg}

\caption{}

\label{fig: }

\end{figure}

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\item Supply the appropriate control voltages to \(V\_{CP}\) and \(V\_{CN}\) and observe the output frequency.

\begin{figure}[h]

\centering

\includegraphics[width=1\textwidth]{VCO1.png}

\caption{}

\label{fig: }

\end{figure}

\item Change the control voltages \(V\_{CP}\) and \(V\_{CN}\) and plot the output frequency versus the control voltages.

\begin{table}[h]

\centering

\begin{tabular}{|c|c|c|c|}

\hline

$V\_{CP}$ & $V\_{CN}$ & Period & Frequency \\

\hline

3.52 & 1.48 & 1046 & 0.956 \\

\hline

3.43 & 1.57 & 770.8 & 1.297 \\

\hline

3.3 & 1.66 & 573.2 ns & 1.745 MHz \\

\hline

3.22 & 1.78 & 429 ns & 2.33 M \\

\hline

3.08 & 1.92 & 324 & 3.086 \\

\hline

2.91 & 2.08 & 248 & 4.032 \\

\hline

2.74 & 2.26 & 193.8 & 5.16 \\

\hline

2.5 & 2.5 & 154.7 & 6.464 \\

\hline

\end{tabular}

\end{table}

\begin{figure}[h]

\centering

\includegraphics[width=0.6\textwidth]{Graph.png}

\caption{}

\label{fig: }

\end{figure}

\begin{figure}[h]

\centering

\includegraphics[width=1\textwidth]{results\_Page\_3\_Image\_0001.png}

\caption{}

\label{fig: }

\end{figure}

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\item Modify the circuit to have a common control voltage (\(V\_C\)). Investigate the following methods and select one that suits your circuit better:

a) Remove footer switch so that you can control using the header switch with \(V\_{CP}\).

b) Remove header switch so that you can control using the footer switch with \(V\_{CN}\).

c) Insert a circuit so that a common single input voltage controls both \(V\_{CP}\) and \(V\_{CN}\).

\end{enumerate}

\section\*{STEP-2}

\begin{enumerate}

\item Identify the clock parameters that need improvements.

\item Modify your circuit and/or transistor parameters to improve the output waveform.

\item What is your observation about \(V\_{out}\) (peak-to-peak) in your output?

\item How do you rectify this shortcoming?

\item Modify your circuit and simulate your final design until you get a reasonably good Voltage-Controlled Oscillator (VCO).

\item Plot the output frequency versus the control voltage and identify the linear region where you can confidently say \(f\_{out} = K \cdot V\_{in}\).

\end{enumerate}

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