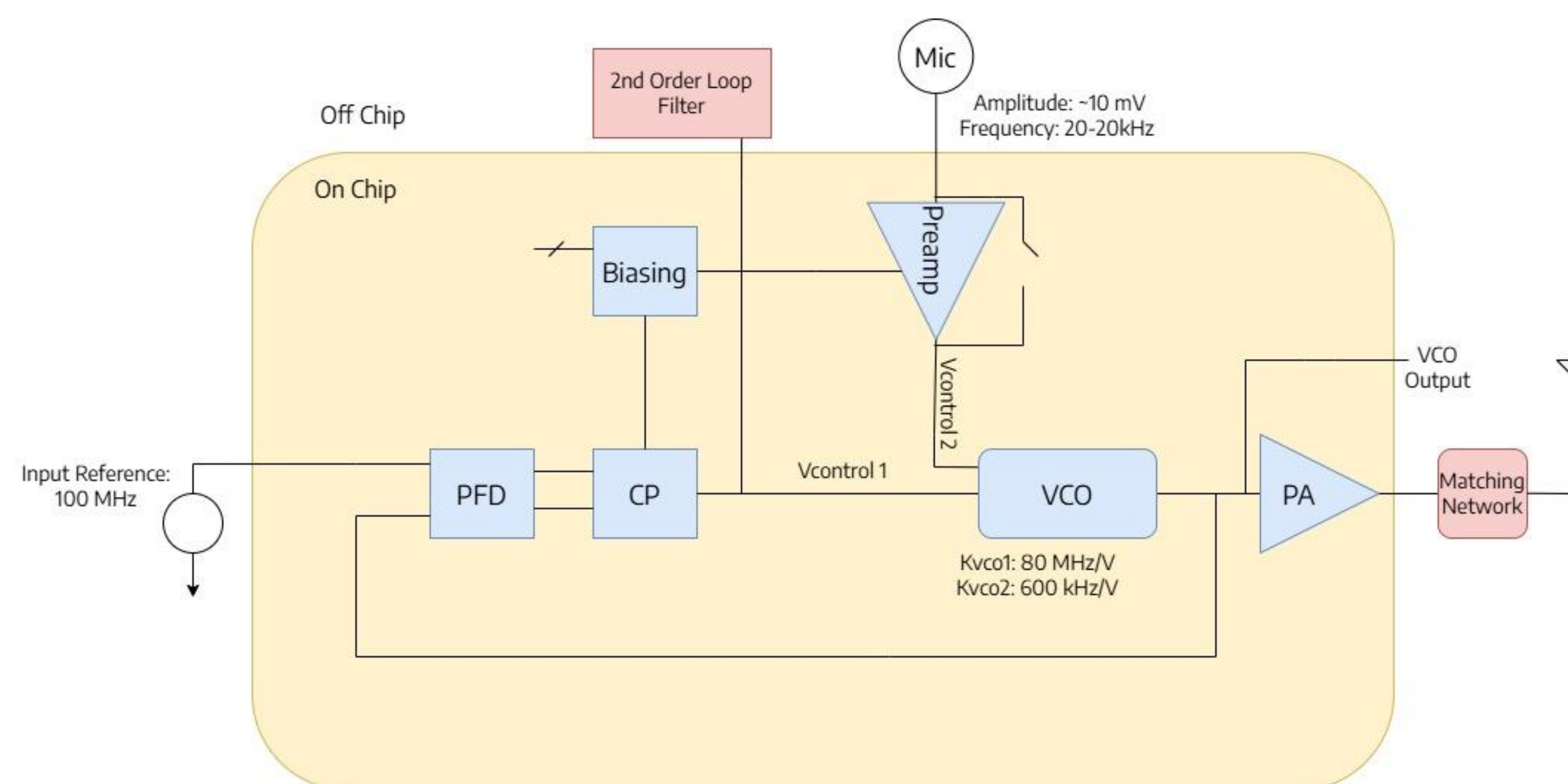


Objective

- Successfully tape out an FM transmitter IC capturing audio from a microphone and transmitting to a radio receiver at distances up to 10 meters.
- Design and verify a direct VCO-modulated FM transmitter system capable of audio transmission in the commercial FM band.

System Architecture



Specifications

Spec	Target
FM Band	100.1 MHz +/- 100 kHz
Loop Bandwidth	< 500 Hz
Power	< 10 mW
Phase Noise @ 1 kHz	< -35 dBc/Hz
Output Power	10 dBm
FCC Field Strength Rule @ 3m	150 uV/m
FCC Regulation on Spurious Emissions	-40 dBc

- 93.5 and 100.1 bands are relatively unoccupied in Seattle
- Exceeding FCC regulations requires an operation license

Model & Approach

Phase Locked Loop:

A type II PLL is chosen with an input reference of 100 MHz and an output carrier frequency of 100 MHz.

PFD: Detects an error in phase or frequency between the input reference clock and the output of the VCO.

Charge Pump: Converts this error signal into a voltage by pumping charge into a loop filter, which is 2nd order and off chip due to large passive sizes

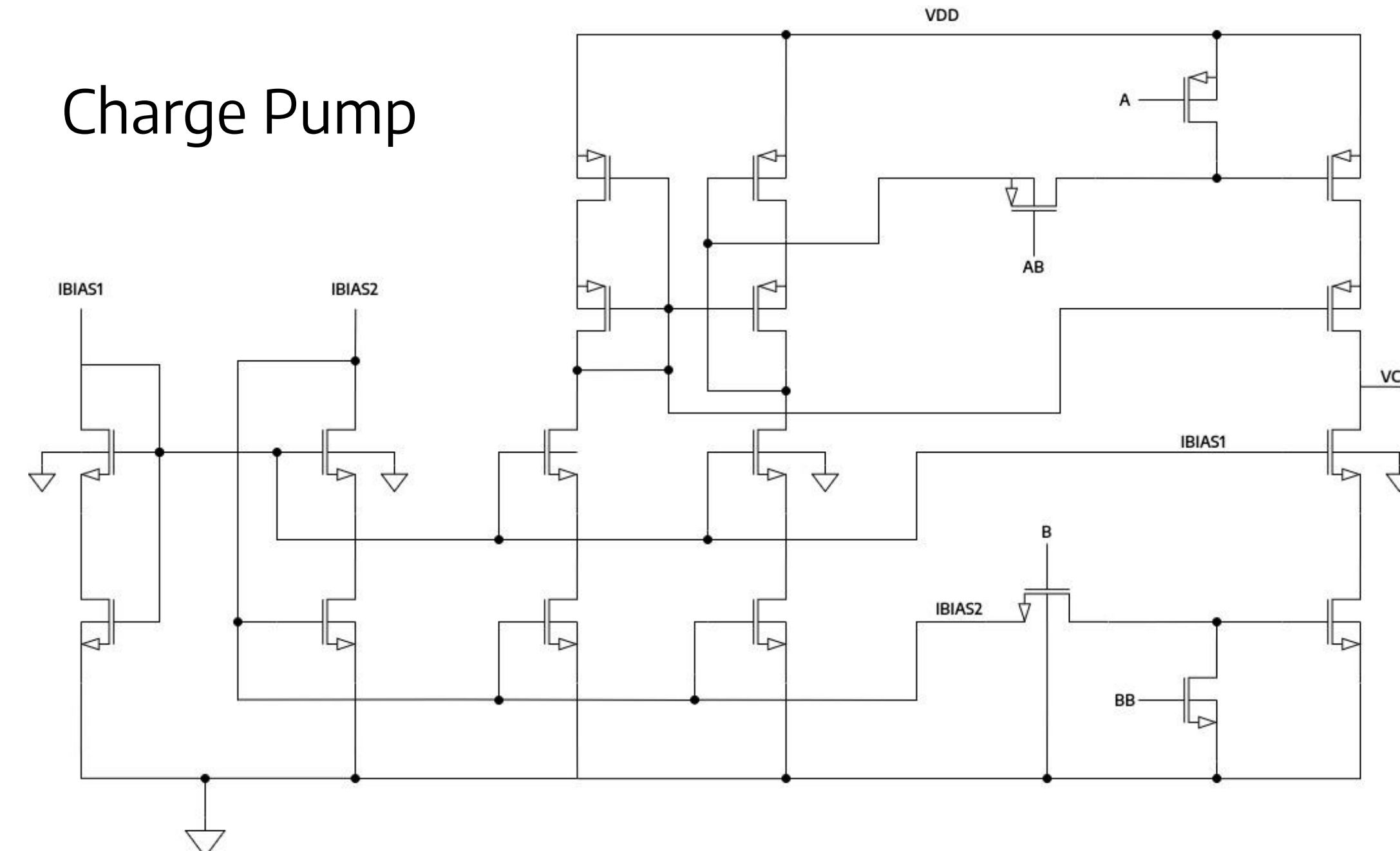
VCO: A current starved VCO is chosen, which uses a tail current source to vary the oscillation frequency. Additionally, a mos varactor is used as a second control voltage to allow for the audio modulation.

Signal Conditioning

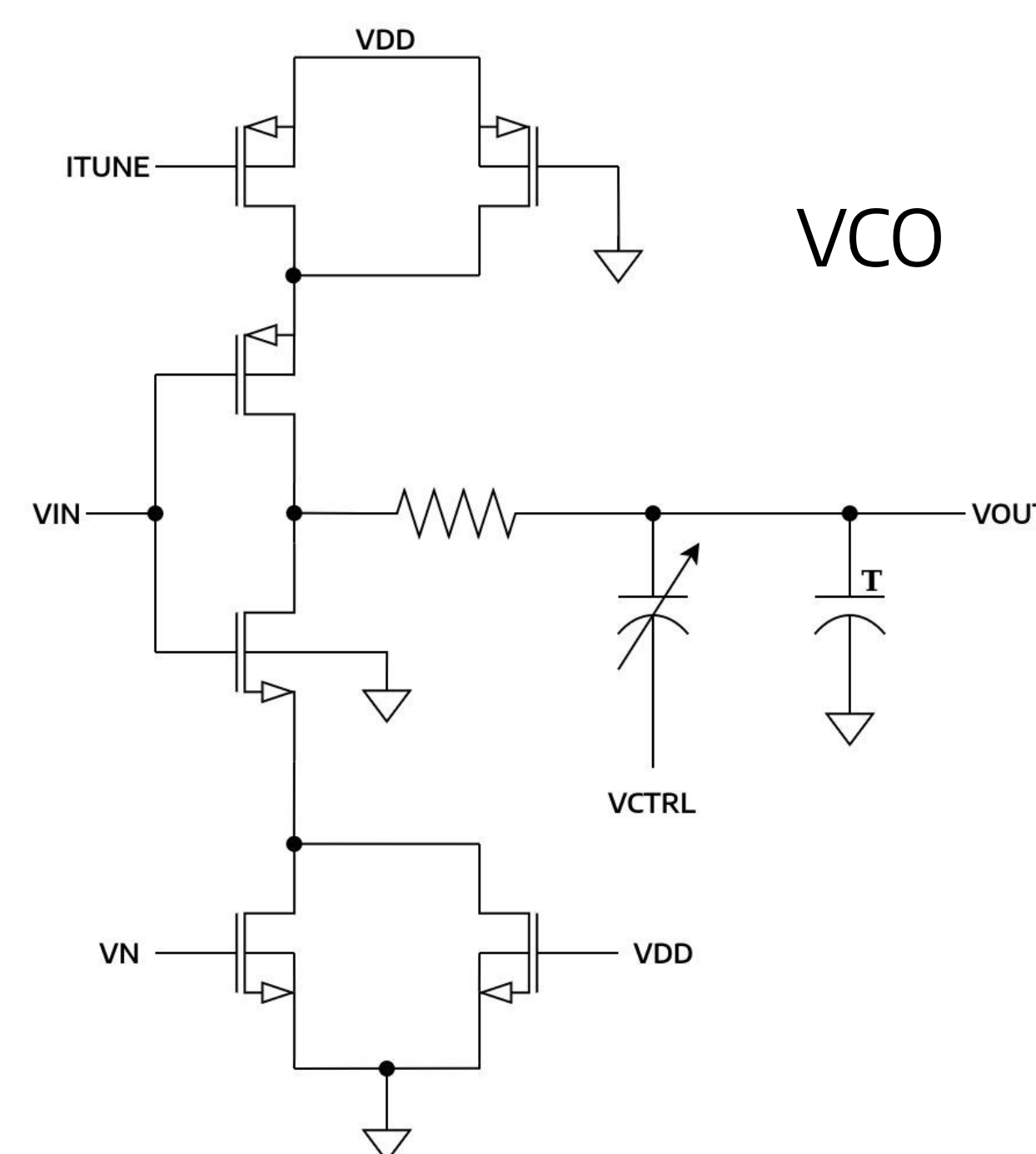
Audio Preamplifier: Amplifies the low-level microphone signal to a level suitable for VCO modulation.

Power Amplifier: Boosts modulated signal and drives the antenna load

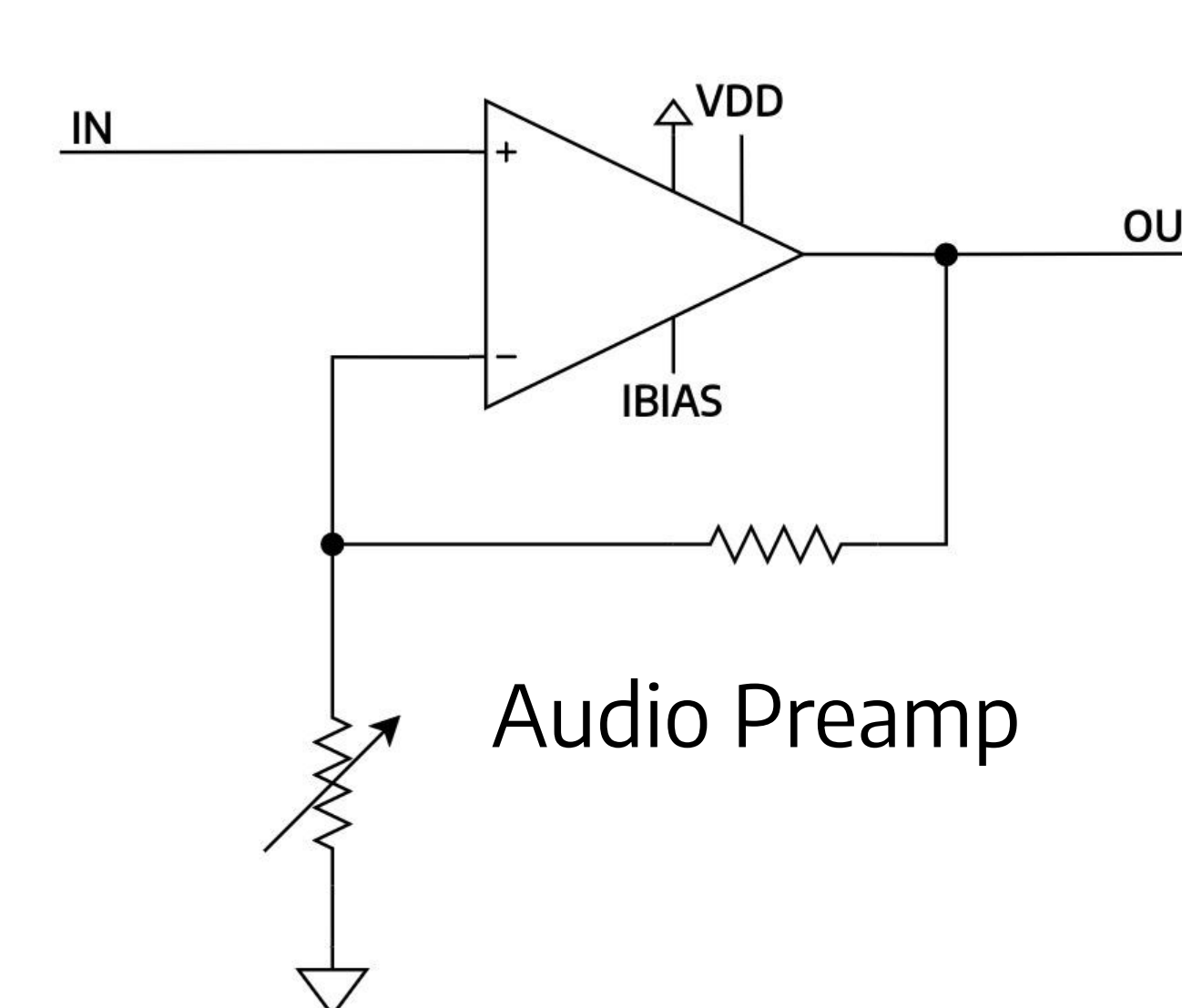
Charge Pump



VCO

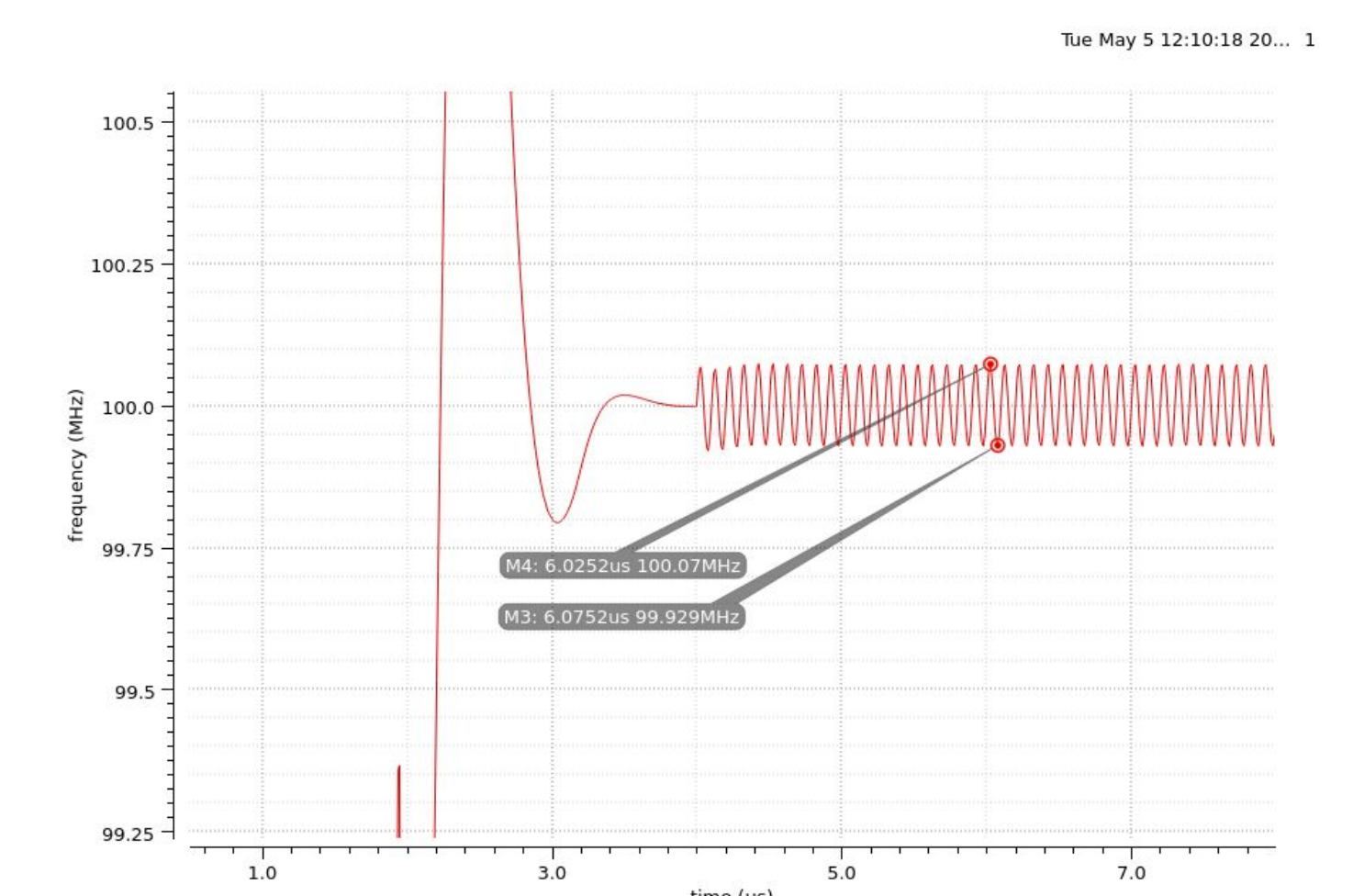
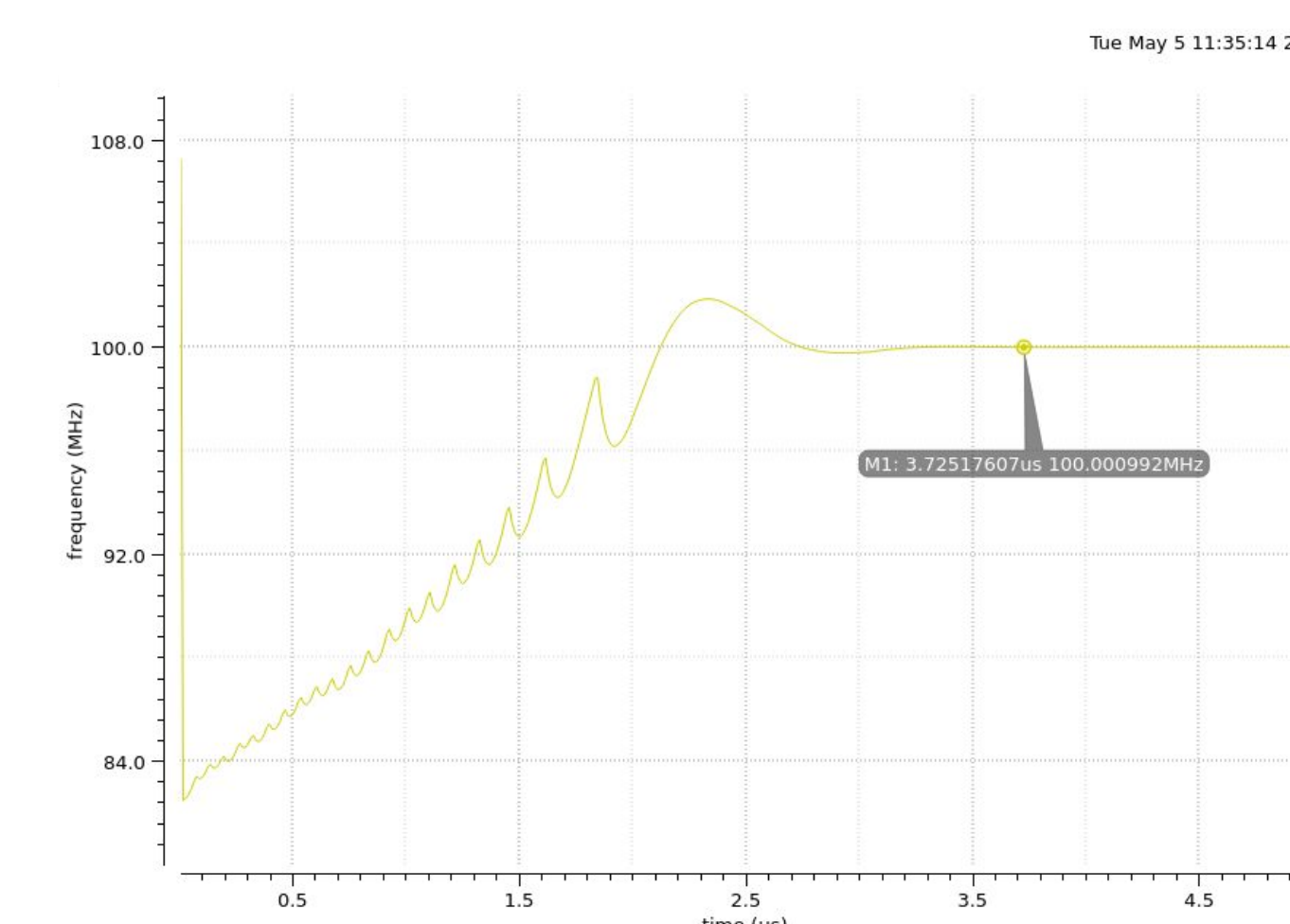
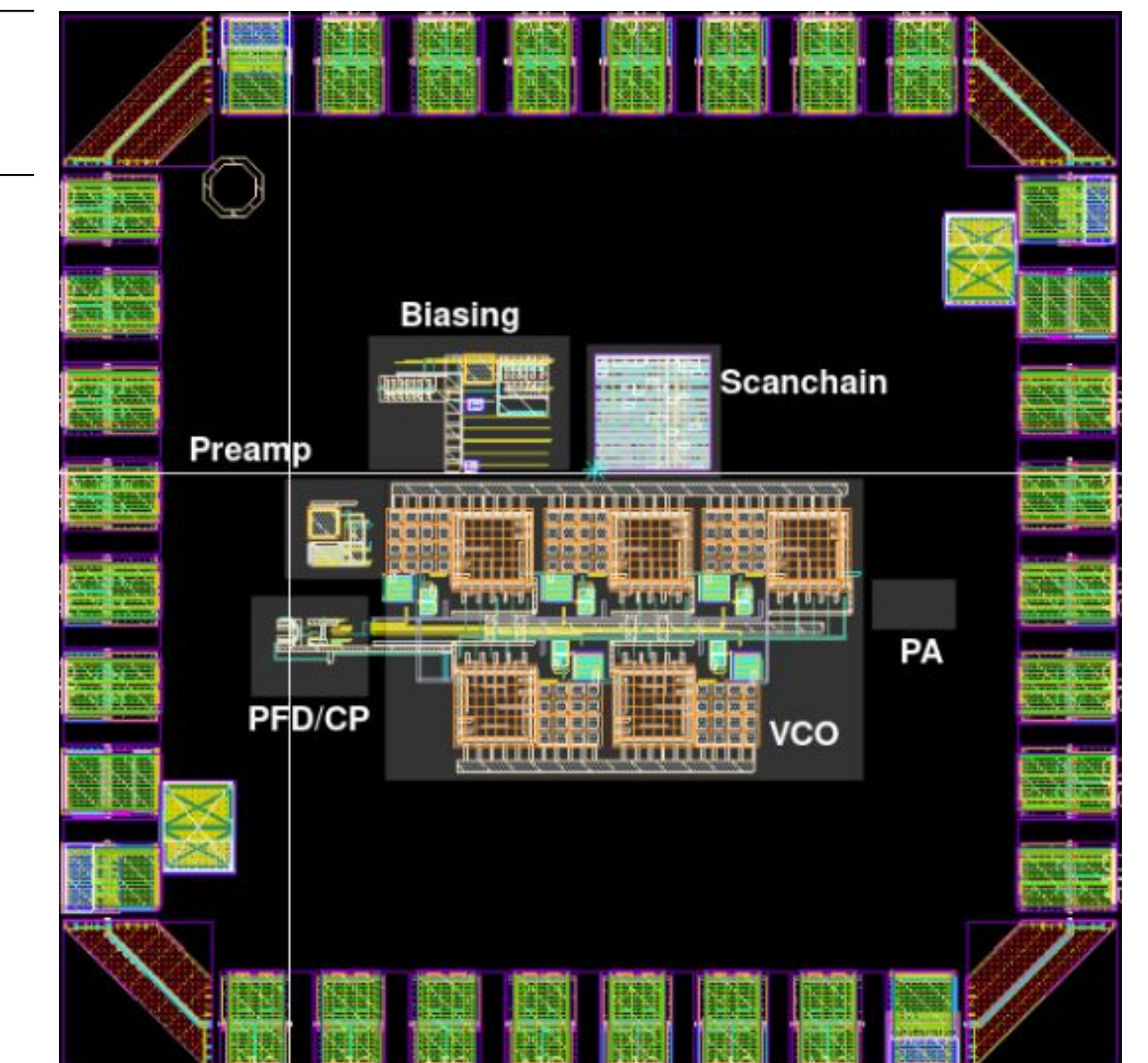


Audio Preamp



Results

Spec	Result
Power	7.58 mW
Output Power	10.13 dBm
Phase Noise @ 1 kHz	-36.66 dBc/Hz
Preamp Gain Range	7.4-81.5 V/V



Future Work, References, & Acknowledgments

- Complete chip tape-out by June 10, 2026, with packaged devices expected to be returned in September 2026.
- Design and assemble a custom PCB test platform during the summer to support post-silicon validation.
- Key PCB components: Low pass loop filter, microphone input AC coupling and CM setting, PA matching network, and antenna.
- Perform functional testing and characterization of the FM transmitter during the following academic year.

Faculty Mentor: Chris Rudell

Industry Mentor: Omid Najari, Frank O'Mahoney

[1] B. Razavi, *Design of CMOS Phase-Locked Loops*. Cambridge University Press, 2020.

[2] A. Hajimiri, S. Limotyrakis, and T. H. Lee, "jitter and phase noise in ring oscillators," *IEEE Journal of Solid-State Circuits*, vol. 34, no. 6, pp. 790-804, Jun. 1999.