

## A.3 - Frequency Modulation

### A.3.1. Experimental Setup for Frequency Sensitivity of VCO

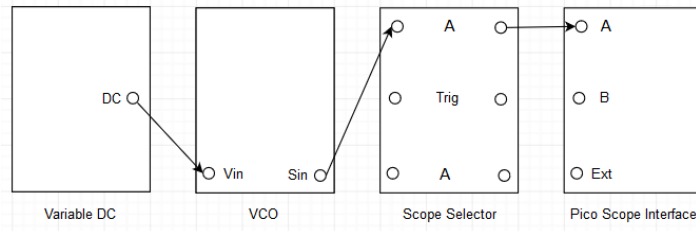


Figure A.3.1: Setup for frequency sensitivity of VCO.

### A.3.2. Laboratory Exercise for Frequency Sensitivity of VCO

- i. Set the variable DC to generate -1 V signal.
- ii. Take a screenshot of output of the variable DC under the scope mode.
- iii. Toggle the on board switch-SW2 of the VCO to VCO and toggle the front panel switch of the VCO to LO. Turn both the knobs of the VCO to minimum.
- iv. Adjust the frequency knob of the VCO to generate 10 kHz sine signal.
- v. Make the setup as shown in the Figure A.3.1.
- vi. Observe that the gain knob of the VCO is at minimum, i.e., input voltage to the VCO is 0 V. Take a screenshot of output of the VCO under the spectrum mode.
- vii. Adjust the gain knob of the VCO to generate 11 kHz sine signal.
- viii. Observe that the input voltage to the VCO is no more 0 V. Take a screenshot of output of the VCO under the spectrum mode.
- ix. Calculate the frequency sensitivity of the VCO for the current setup.

### A.3.3. Experimental Setup for NBFM and WBFM

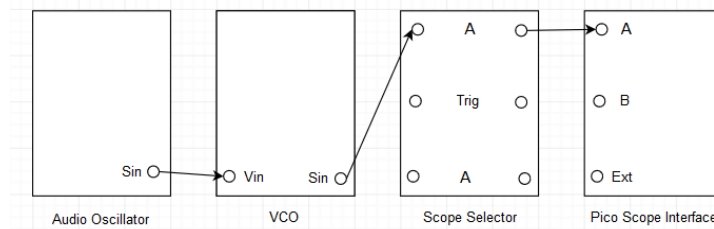


Figure A.3.2: NBFM and WBFM modulator setup.

### A.3.4. Laboratory Exercise for NBFM and WBFM

- i. Calculate the theoretical frequency deviation of the VCO, for modulation index of 0.3, message frequency of 5 kHz and message amplitude of 4 V peak to peak.
- ii. Set an audio oscillator to generate 5 kHz sine signal.
- iii. Set the variable DC to generate -2 V signal.
- iv. Toggle the on board switch-SW2 of the VCO to VCO and toggle the front panel switch of the VCO to HI. Turn both the knobs of the VCO to minimum.
- v. Adjust the frequency knob of the VCO to generate 100 kHz sine signal.
- vi. According to section A.3.2, set the VCO to operate for theoretical frequency deviation.
- vii. Unplug the signal from DC of the variable DC to input of the VCO. Plug the signal from output of the audio oscillator to input of the VCO.

- viii. Observe the NBFM spectrum, how many number of sideband pairs are visible above  $-40 \text{ dB}\mu$ ?
- ix. Take a screenshot of output of the VCO under the spectrum mode.
- x. Increase the gain knob of the VCO to observe the NBFM spectrum change into the WBFM spectrum. What causes the increase in number of sideband pairs?
- xi. Adjust the gain knob of the VCO to obtain modulation index of 1.45, i.e., power of the carrier and power of either or both of the sidebands of first pair are equal. How many number of sideband pairs are visible above  $-40 \text{ dB}\mu$ ?
- xii. Take a screenshot of output of the VCO under the spectrum mode.
- xiii. Calculate the theoretical frequency deviation of the VCO for the current setup.
- xiv. Unplug the signal from output of the audio oscillator to input of the VCO. Plug the signal from DC of the variable DC to input of the VCO. Measure the observed frequency deviation of the VCO.
- xv. Unplug the signal from DC of the variable DC to input of the VCO. Plug the signal from output of the audio oscillator to input of the VCO.
- xvi. Adjust the gain knob of the VCO to obtain modulation index of 2.45, i.e., power of the carrier drops to minimum or first Bessel zero. How many number of sideband pairs are visible above  $-40 \text{ dB}\mu$ ? Repeat step **xii** through step **xv**, accordingly.
- xvii. Adjust the gain knob of the VCO to observe power of the second pair of sideband drop to minimum or third Bessel zero. How many number of sideband pairs are visible above  $-40 \text{ dB}\mu$ ?
- xviii. Take a screenshot of output of the VCO under the spectrum mode.
- xix. Unplug the signal from output of the audio oscillator to input of the VCO. Plug the signal from DC of the variable DC to input of the VCO. Measure the observed frequency deviation of the VCO and calculate the modulation index for the current setup.

### A.3.5. Experimental Setup for PLL

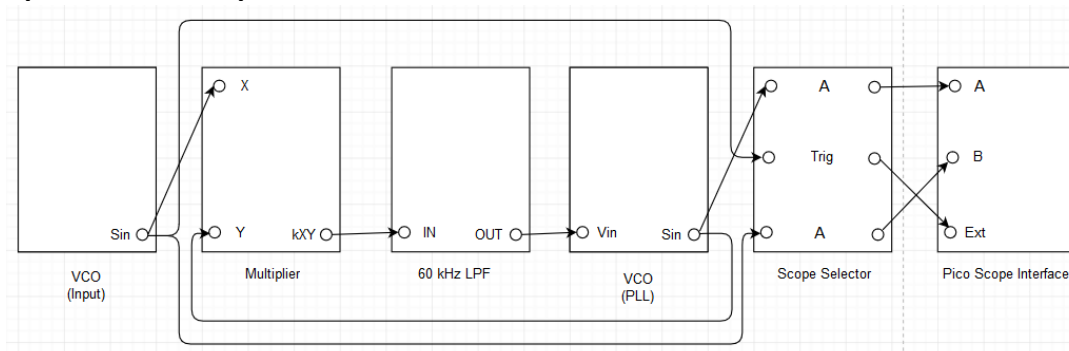


Figure A.3.3: Setup for PLL.

NOTE: Above given experimental setup consists of two VCOs, i.e., input VCO and PLL VCO.

### A.3.6. Laboratory Exercise for PLL

- i. Toggle the on board switch-SW2 of the input VCO to VCO and toggle the front panel switch of the input VCO to HI. Turn both the knobs of the input VCO to minimum.
- ii. Adjust the frequency knob of the input VCO to generate 100 kHz sine signal.

- iii. Toggle the on board switch-SW2 of the PLL VCO to VCO and toggle the front panel switch of the PLL VCO to HI. Turn both the knobs of the PLL VCO to minimum.
- iv. Adjust the frequency knob of the PLL VCO to generate 101 kHz sine signal.
- v. Make the PLL setup as shown in the Figure A.3.3.
- vi. Toggle the front panel switch of the multiplier to DC. Turn the knob of the 60 kHz LPF to minimum.
- vii. Observe that the frequency and phase of the input VCO sine signal are not equal to the frequency and phase of the PLL VCO sine signal.
- viii. Take a screenshot of output of the PLL VCO and output of the input VCO under the scope mode.
- ix. Adjust the knob of the 60 kHz LPF and the gain knob of the PLL VCO to lock both the sine signals.
- x. Take a screenshot of output of the PLL VCO and output of the input VCO under the scope mode.

### A.3.7. Experimental Setup for NBFM and WBFM Demodulation

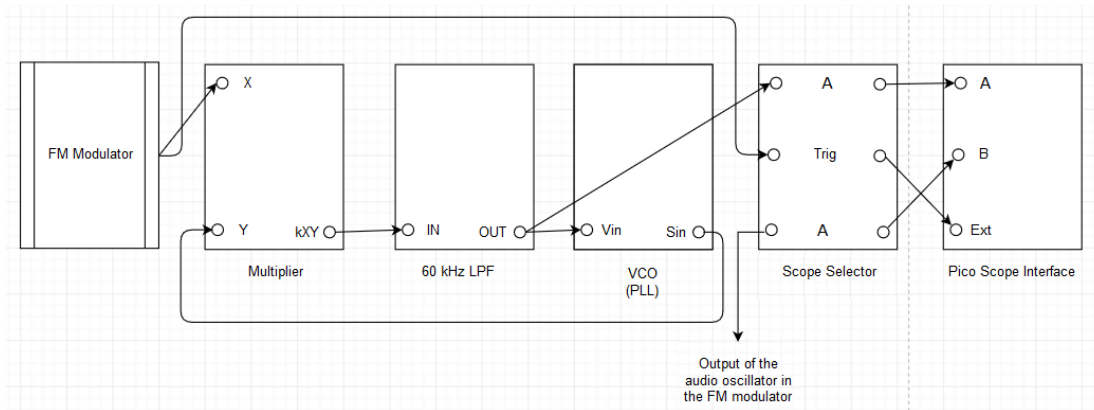


Figure A.3.4: NBFM and WBFM demodulator setup.

### A.3.8. Laboratory Exercise for NBFM and WBFM Demodulation

- i. Retain the modulator setup with modulation index of 0.3 and make the demodulator setup as show in the Figure A.3.4.
- ii. Toggle the front panel switch of the multiplier to DC, toggle the on board switch-SW2 of the PLL VCO to VCO and toggle the front panel switch of the PLL VCO to HI. Turn both the knobs of the PLL VCO to minimum and turn the knob of the 60 kHz LPF to minimum.
- iii. Adjust both the knobs of the PLL VCO and the knob of the 60 kHz LPF to obtain the demodulated message signal with minimum phase shift.
- iv. Take a screenshot of output of the 60 kHz LPF and output of the audio oscillator under the scope mode.
- v. Repeat step iii and step iv, for modulation index of 1.45, 2.45 and  $\approx 5$ , accordingly.

### A.6.1. Experimental Setup for FSK Modulation

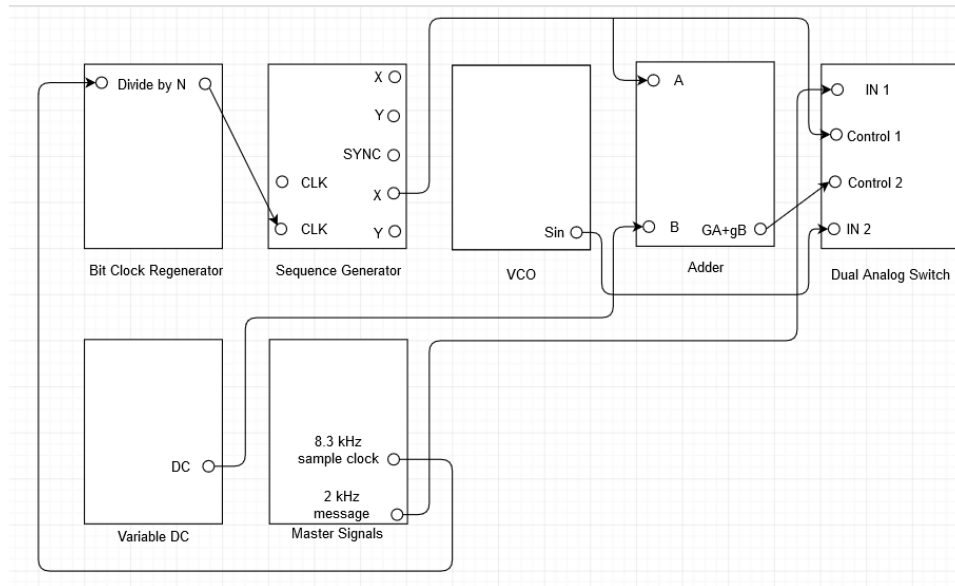


Figure A.6.3: FSK modulator setup.

### A.6.2. Laboratory Exercise for FSK Modulation

NOTE: Refer the user manual to learn about the features of Bit Clock Regenerator (BCR) [2].

- i. Toggle the on board switch-SW2 of the VCO to VCO and toggle the front panel switch of the VCO to LO.
- ii. Adjust the frequency knob of the VCO to generate 5.21 kHz sine signal.
- iii. Make the modulator setup as shown in the Figure A.6.3.
- iv. Toggle both the pins of the on board switch-SW2 of the BCR down. Turn both the knobs of the adder to minimum and turn the knob of the variable DC to minimum.
- v. View the signals from output of the adder and output of the sequence generator.
- vi. Adjust both the knobs of the adder to obtain a unipolar inverted message sequence between 0 V and +5 V amplitude.
- vii. Observe that two unipolar message sequences of equal amplitudes and opposite polarities are generated by the sequence generator and the adder.
- viii. Take a screenshot of output of the adder and output of the sequence generator under the scope mode.
- ix. Switch to view the signals from output of the DAS and output of the sequence generator.
- x. Take a screenshot of output of the DAS and output of the sequence generator under the scope mode.
- xi. Switch to view the signals from output of the DAS and output of the adder.

- xii. Take a screenshot of output of the DAS and output of the adder under the scope mode.

### A.6.3. Experimental Setup for FSK Demodulation

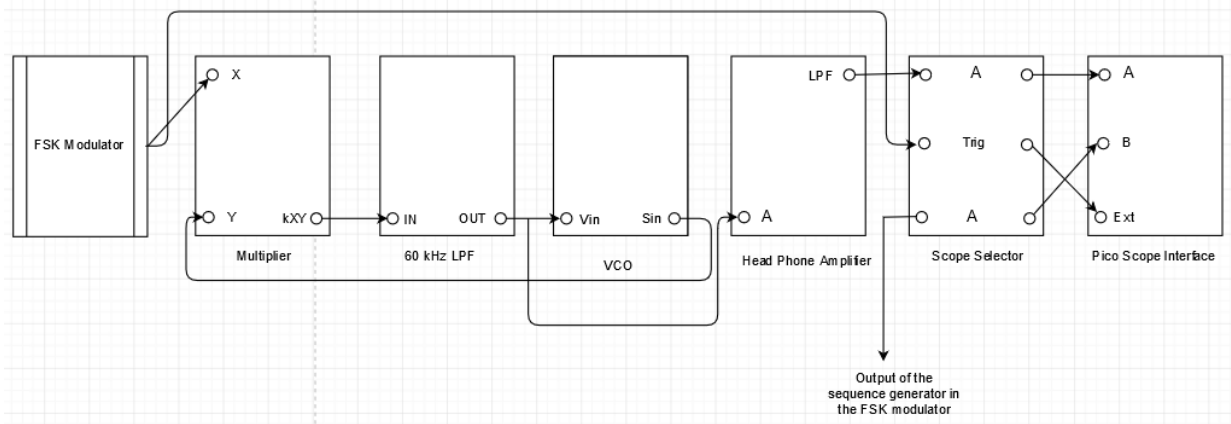


Figure A.6.4: FSK demodulator setup.

### A.6.4. Laboratory Exercise for FSK Demodulation

- i. Retain the modulator setup and make the demodulator setup as shown in the Figure A.6.4.
- ii. Toggle the on board switch-SW2 of the VCO at the demodulator to VCO, toggle the front panel switch of the VCO at the demodulator to LO, toggle the front panel switch of the multiplier to DC and toggle the front panel switch of the headphone amplifier to IN. Turn both the knobs of the VCO at the demodulator to minimum and turn the knob of the 60 kHz LPF to minimum.
- iii. Adjust the PLL setup to obtain the demodulated message sequence with minimum phase shift and equal amplitude.
- iv. Take a screenshot of output of the LPF at the headphone amplifier and output of the sequence generator under the scope mode.