ECE 4117
Experiment #3

The experiments here should be in your manual, following p. 144. We will do the first two of these and will also generate an FSK signal by direct drive of the VCO (not using the "FSK mode" of the VCO module.

The basis for both modulation and demodulation here is the use of a voltage controlled oscillator. This is an oscillator whose frequency can be varied directly by application of a voltage to its input. A DC voltage applied to its input shifts the output frequency from its "free-running" value to some new value, with the amount of change proportional to the amount of applied voltage. An AC voltage applied to its input results in an AC variation of frequency (but not amplitude) around the center frequency. This provides an extremely direct and simple way to generate FM.

The VCO module of TIMS allows adjustment of the free-running frequency with a control on its front.

I. FM – GENERATION BY VCO

Check the PCB board of the VCO module to be sure the switch "SW-2" is set to "VCO"mode.

Figure 2 shows the setup for the experiment, but first adjust the frequency deviation as follows. (Do not do the "deviation calibration" specified in the manual.) Set the free-running frequency of the VCO to 100 kHz, then apply a DC voltage of either plus or minus 2 volts to its input. Set the gain control of the VCO so that you get 10 kHz deviation from carrier. Leave the VCO gain control at that setting. Its frequency will now go to about 90 kHz input when input VCO voltage is 2 volts and to about 110 kHz when input voltage is -2 volts.

Set up as in Fig. 2 and follow instructions under "**sinusoidal messages**". When the oscillator sweep speed is too slow you may get a waveform that looks like amplitude modulation; evidently this is an artifact of the sampling speed of the ADC (too slow).

See if you can get a waveform recording showing visibly the variation of carrier frequency between 90 kHz and 110 kHz as the oscillator voltage goes between positive and negative peaks. It may be difficult to see the regions of high and low frequency of the carrier distinctly, so switching to the low frequency setting of the VCO can help considerably. Record a sample of the waveform and record the PSD.

We will not explore the "Bessel zeroes" mentioned under "spectrum analysis".

The setup you have here will be used in Part II of the experiment, below. If you changed the VCO to the low frequency setting, change back to 100 kHz.

II. FM – DEMODULATION BY PLL

For demodulation, the second VCO will be used in the phase locked loop configuration shown in Figs. 1 and 2. Follow instructions given. Monitor the "message OUT" both on the scope and using earphones. Record as Ch. 2 with

the audio oscillator output into Ch. 1, and move the waveforms close enough to each other so that you can show that the demodulation is working as it should.

Substitute the Speech Module output (after amplification with buffer amplifier) in place of the audio oscillator. Again, compare waveforms on Picoscope, and again verify with earphones that demodulation is occurring.

III. FREQUENCY SHIFT KEYING (FSK)

SOME BACKGROUND

Employed in modems, FSK is highly compatible with telephone lines, and used extensively for PC and FAX transmissions. It is simple and inexpensive for such usage, usually at rates < 9600 bps, although appreciably higher rates are possible if permitted by the medium of transmission.

An early FSK Modem was the Bell-Type 103, with a signaling speed of 300 bps. Its transmit frequencies were 1270 Hz and 1070 Hz for binary 1 and 0, respectively, with receive frequencies at 2225 Hz and 2025 Hz. In answer mode the "transmit" and "receive" frequencies were reversed. This permitted full duplex (simultaneous send and receive) operation if permitted by hardware and software. In this frequency range twisted pair copper wires such as those that provide public telephone service to homes work well.

Generally transmission and reception are asynchronous. Narrow bandpass filters centered on the two received frequencies serve to isolate the ones and zeros, and ordinary envelope detection is applied. Synchronous modulation and demodulation are possible but not as common.

The type of FSK generated by the steps given below is called CPFSK, meaning "continuous-phase" PSK. This is essentially "automatic" because the VCO output cannot change discontinuously. Discontinuous phase FSK (DPFSK) could be generated if the frequency shifts are generated by simply switching between two different oscillators. Since the CPFSK waveform is relatively "smooth" it has a narrower spectrum, i.e., one that falls off more rapidly with frequency, than that of DPFSK. It is therefore more desirable for communications purposes in the case of an environment where bandwidth must be shared with others.

When FSK is used with a carrier of around 100 kHz, reliable transmission over ordinary power lines is reported to be possible up to about a mile or so, but the areas of application seem to be limited at the present time.

FSK is not exclusive to modems; it can be used in many other contexts as well. It is not confined to binary data; multilevel data can be used.

Although, as noted above, the TIMS VCO module has an FSK capability obtained by a setting on its PCB board, we will not use it. Rather, we will drive the VCO directly.

PROCEDURE

FSK by direct drive of VCO.

Dismantle the PLL configuration above. Now we will only use the FM generation circuit (Fig. 2 of the first FM lab sheet). We will generate FSK simply by applying the output of the sequence generator to the input of the VCO. The purpose is to show the working of the VCO in a very direct way. Go through a buffer amplifier so the voltage can be varied. Use 500 Hz as the clock frequency for the sequence generator.

Examine the PSD (that is, your spectrum) with the VCO gain all the way to zero. Set VCO frequency to 12 kHz. You should get, more or less, a single peak.

Now increase the gain control setting of the VCO until (on the time axis of a scope) you see segments of higher frequency alternating with lower frequency in accordance with the binary voltage applied. In the frequency spectrum you should be able to observe a frequency deviation of around plus/minus 2.5–3 kHz each side of 12 kHz. If not, vary the gain until you do.

Record waveforms and give descriptive captions to each to explain what they mean, and to illustrate your results.

Certification: I hereby certify that performance of the experiment above and the writing of this report was entirely by me (or by me and my lab partner). I understand that if this certification is false, I am in violation of Academic Honesty rules and may be subject to serious penalty in accordance with those rules.

Signature ________________________________-
___Date______________