FM - GENERATION BY VCO

modules:

basic: VCO

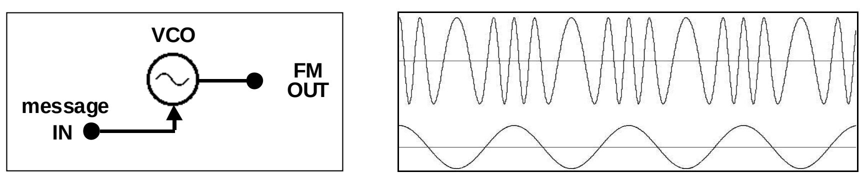
optional basic: AUDIO OSCILLATOR

preparation

A very simple and direct method of generating an FM signal is by the use of a voltage controlled oscillator -VCO. The frequency of such an oscillator can be varied by an amount proportional to the magnitude of an input (control) voltage. Such oscillators, in the form of an integrated circuit, have very linear characteristics over a frequency range which is a significant percentage of the centre frequency.

Despite the above desirable characteristic, the VCO fails in one respect as a generator of FM - the stability of its centre frequency is not acceptable for most communication purposes.

It is hardly necessary to show the block diagram of such an FM generator ! See Figure 1(a).



(a) (b)

Figure 1: FM by VCO (a), and resulting output (b).

Figure 1(b) shows a snap shot time domain display of an FM signal, together with the message from which it was derived. The frequency change is large compared with the unmodulated output frequency, and the carrier frequency is only four times that of the message. So this waveform is not a typical one. But it can be reproduced with TIMS.

Note particularly that there are no amplitude variations - the envelope of an FM waveform is a constant.

experiment

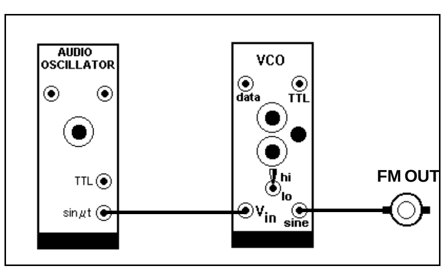


Figure 2: FM generation by VCO

A model of the VCO method of generation is shown in Figure 2. Note that the on-board switch SW2 must be set to 'VCO'.

The message is shown coming from an AUDIO OSCILLATOR, but the 2 kHz sine wave from MASTER SIGNALS can be used instead.

deviation calibration

Before generating an FM waveform it is interesting to determine the deviation sensitivity - and linearity - of the VCO.

Use the front panel 'f_0' control to set the output frequency close to 100 kHz.

Instead of using a sinewave as the message, connect instead the VARIABLE DC voltage to the input V_{in} of the VCO.

The deviation sensitivity can be set with the front panel GAIN control. Set this to about 20% of its fully clockwise rotation.

Vary the VARIABLE DC at the V_{in} socket of the VCO and plot frequency variation versus both negative and positive values of V_{in}. If this is reasonably linear over the full DC range then increase the GAIN control (sensitivity) setting of the VCO and repeat. The aim is to determine the extent of the linear range, restricting the DC voltage to the TIMS ANALOG REFERENCE LEVEL of 4 volt peak-to-peak.

10 kHz deviation

Using the previous results, set up the VCO to a ±10 kHz frequency deviation from a signal at the TIMS ANALOG REFERENCE LEVEL of 4 volts peak-to-peak.

Alternatively:

1. set the DC voltage to ±2 volts
2. set the GAIN control fully anti-clockwise, and the output frequency to 100 kHz
3. advance the GAIN control until the frequency changes by 10 kHz.

sinusoidal messages

Replace the DC voltage source with the output from an AUDIO OSCILLATOR. The frequency deviation will now be about ±10 kHz, since the oscillator output is about 2 volt peak.

To display a waveform of the type illustrated in Figure 1(b) is not easy with a basic oscilloscope, but glimpses may be obtained by *slowly* varying the message frequency over the range say 1.5 kHz to 2.5 kHz.

spectrum analysis

If you have a PICO SPECTRUM ANALYSER, and are familiar with the theory of the FM spectrum, many interesting observations can be made. In particular, confirmation of some of the theory is possible by adjusting the deviation to the special values predicted by their 'Bessel zeros'.

The TIMS Lab Sheet entitled ***FM and Bessel zeros*** demonstrates these phenomena by modelling a simple WAVE ANALYSER.

stable carrier

If the stability of the centre frequency of a VCO is un-acceptable for communications purposes then an Armstrong modulator is an alternative. This is examined in the Lab Sheet entitled ***Armstrong`s frequency modulator***.