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FM DEMODULATION WITH PLL

The phase locked loop - PLL.

The phase locked loop is a non-linear feedback loop. To analyze its performance to any degree of accuracy is a non-trivial exercise. To illustrate it in simplified block diagram form is a simple matter. See Figure 1.

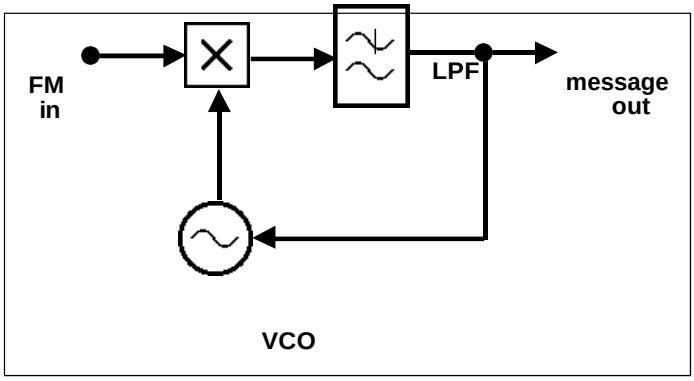

Figure 1: the basic PLL

This arrangement has been used in an earlier experiment (this Volume), namely that entitled *Carrier acquisition and the PLL*, where an output was taken from the VCO. As an FM demodulator, the output is taken from the LPF, as shown.

It is a simple matter to describe the principle of operation of the PLL as a demodulator, but another matter to carry out a detailed analysis of its performance.

It is complicated by the fact that its performance is described by non-linear equations, the solution to which is generally a matter of approximation and compromise.

The principle of operation is simple - or so it would appear. Consider the arrangement of Figure 1 in open loop form. That is, the connection between the filter output and VCO control voltage input is broken.

Suppose there is an unmodulated carrier at the input.

The arrangement is reminiscent of a product, or multiplier-type, demodulator. If the VCO was tuned precisely to the frequency of the incoming carrier, say, then the output would be a DC voltage, of magnitude depending on the phase difference between itself and the incoming carrier.

For two angles within the 360^0 range the output would be precisely zero volts DC.

Now suppose the VCO started to drift slowly off in frequency. Depending upon which way it drifted, the output voltage would be a slowly varying AC, which if slow enough looks like a varying amplitude DC. The sign of this DC voltage would depend upon the direction of drift.

Suppose now that the loop of Figure 1 is closed. If the sign of the slowly varying DC voltage, now a VCO *control voltage*, is so arranged that it is in the direction to urge the VCO back to the incoming carrier frequency , then the VCO would be encouraged to 'lock on' to the incoming carrier.

This is the principle of carrier acquisition. This was examined in the experiment entitled *Carrier acquisition and the PLL*, where this same description was used.

Next suppose that the incoming carrier is frequency modulated. For a low frequency message, and small deviation, you can imagine that the VCO will to follow the incoming carrier frequency. What about wideband FM ? With 'appropriate design' of the low pass filter and VCO circuitry the VCO will follow the incoming carrier for this too.

The control voltage to the VCO will to keep the VCO frequency locked to the incoming carrier, and thus will be an exact copy of the original message.