New thoughts on demodulation

Edward Forster investigates the performance of Archie Pettigrew's award-winning amplitude-locked loop demodulation technique in both AM and FM receivers.

The amplitude-locked loop or ALL was not described as an automatic-gain system*, but it clearly is a distinct form of one. Generally, agc systems use gain-controlled amplifiers i.e. multipliers, with a logarithmic or semi-log law to obtain large dynamic range. The dynamic range of an ALL with linear multiplier is described as 26dB.

Automatic gain control is rarely used to entirely suppress the amplitude modulation but this is only a matter of bandwidth. It is true that the ALL outputs the reciprocal of envelope amplitude together with a fully compressed envelope signal within its operating range. But how useful this is remains to be seen.

Demodulating AM

The ALL is used here to provide a constant envelope signal to the demodulator which is of the square law carrier recovery type[1] using a phase locked loop, or pll. This might be unexceptional were it not for the claims made for this circuit. This is certainly not an advance in the art nor is it an optimum system. The ALL is said to provide special features which cannot be met by a limiter.

At threshold levels I suggest that a soft limiter having a gain of 26dB put in place of the ALL would yield identical results. This is because at the end of its range the ALL also has a constant gain of 26dB and it would be impossible to distinguish between the two. At high carrier levels it also makes no difference which is used.

The subsequent pll shown in the circuit as the carrier recovery device is not an optimum type. This is a common mistake. It raises the question of what the point of the system is in the first place. The problem of AM full carrier reception in conditions of multipath interference and doppler shifts – such as found on the hf broadcasting bands – was successfully solved in the *Liniplex F1/2* receiver made by Phase Track Limited throughout the eighties. This used a synchronous pll AM demodulator[2] at intermediate frequency in a superheterodyne receiver.

Figure 1 shows the pll carrier recovery system of that receiver which is a type II system, ie, it contains two perfect integrators these being an active integrator and the voltage controlled oscillator (vco). In servo parlance this is known as a proportional plus integral feedback loop. Although this is well known some of its characteristics as applied to this problem are apparently not well known.

Figure **1b** shows that the active filter can be redrawn as the equivalent sum of the proportional 'P' component and the integral 'I' component. This allows you to see more clearly what happens. **Figure 2** is the idealised response to a step offset of the vco. The 'P' component has a fast response but it eventually returns to zero. The 'I' component response is to gradually ramp towards the final control voltage needed.

When the response subsides there is zero static error in the system. The loop may be opened without any effect. The same thing results if the input carrier also disappears for some time during a fade. The loop remains essentially locked and can provide the necessary carrier for effective synchronous demodulation of sidebands to continue undisturbed. When the carrier returns there is no re-locking as the loop never lost lock.

Another feature of the type II pll is that it offers the freedom to optimise the loop bandwidth without any restriction other than that the loop should follow any doppler shifts and vco drift. In the type I loop setting the bandwidth correctly can result in the hold-in range of the pll being too small for practical use.

It is also necessary to have as small a loop bandwidth as possible. This is to prevent the control signal from frequency modulating the vco within the modulation band as this produces distortion.

Many such pll AM demodulators have appeared in up-market broadcast receivers. But because of this distortion, their audio quality was indistinguishable from the conventional envelope demodulator.

*June 1996 issue, page 466. Demodulation – a nerw approach by Archie Pettigrew.

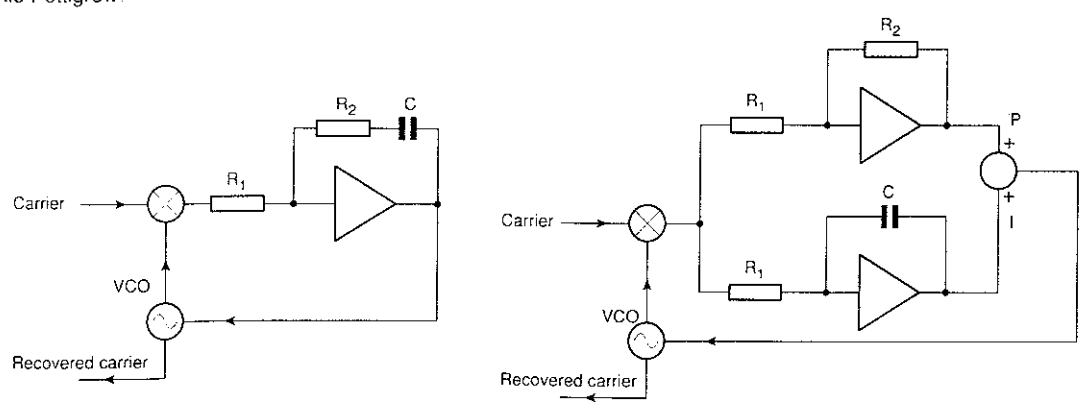

Fig. 1. Carrier recovery by type II PLL; b) equivalent to a)