allows the creation of error signals approaching 500kHz (the Nyquist point, etc). These error signals can be used to counteract the VCO noise sidebands right from close in to the nominal carrier frequency to several hundred kHz out. In an ideal circuit, the noise present in the VCO/LO output would be purely that of the crystal oscillator and the low frequency VFO, regardless of how noisy the VCO circuit was to start with.

Fig. 8 shows the circuit diagram of the band-switched crystal oscillator. Complete sub-circuits, rather than individual crystals, are switched by the DC control lines which activate the reed relays in the VCO circuit. This type of crystal oscillator is inherently low noise and thanks go to Richard Davis G3TDL for pointing it out to me. The circuit functions both on fundamental and overtone crystals. The actual mode is selected by the components in the drain circuit. The low noise aspect comes about because the buffer circuit is fed through the crystal rather than directly from the oscillating device. As well as providing a resonant circuit, the crystal acts as a filter unit reducing the sideband noise even further. Theory suggests that this type of oscillator circuit should show a 10 to 20 dB improvement on conventional designs.

The capacitor shown in the source circuit of the first buffer transistor controls the coupling between the oscillators and buffer circuitry. Its value should be chosen so that every crystal sub-circuit – especially the ones operating in the overtone mode above 20MHz – oscillates robustly. Precise frequency trimming is not necessary since calibration can be provided at the VFO level.

The phase comparator

The circuit for this is shown in **Fig. 11.** The circuit is entirely conventional except that discrete logic gates are used to allow the phase detector to operate up to 2MHz. The edge triggered flip-flop arrangement, which is effectively open-circuit in the phase-locked condition, has the distinct advantage that is frequency as well as phase sensitive. No matter how far the reference and input signals are out of lock, the comparator circuit will always pull the VCO back into line provided that the tuning range had not been exceeded.

The other advantage of digital edge triggered phase comparators is the absence of significant 2f terms in the output. This makes for much easier design of a loop filter since, when the system is in lock, the only output from the phase comparator will be 50nS (or thereabouts) glitches. These are easily removed with a simple lowpass filter.

The loop filter, **Fig. 9**, acts as an error amplifier and also increases the available varicap swing from the 12V of the comparator logic to the 30V of the NE531 supply rail. A high speed wide bandwidth op-amp is essential in this position, to keep the VCO output noise-free a long way from the centre frequency.

The loop mixer mixes the VCO and crystal signals together to provide a difference output for frequency and phase comparison with the VFO in the digital phase comparator. There is an f1 + f2 term with this type of mixer which is removed by the lowpass filter following the double balanced mixer. Note that it is essential to provide isolation between the various circuit modules. Transformers, coax and screening will all be necessary to obtain the desired spectral purity at the VCO output. Watch carefully for signal earth loops. ●