

FAST 'HUFF & PUFF' STABILISER IN A PIC. Ever since the original publication in 'TT' in 1973 of the effective VFO stabiliser developed by the late Klass Spaargaren, PAOKSB, that I subsequently named 'Huff & Puff' in view of its action resembling that of an old gas engine, the system has continued to attract attention and further advances. These include a fast acting version first described by Peter Lawton, G7IXH in 'TT' December 1997 and subsequently in more detail in QEX, December 1998, that represented very significant advances over the previous stabilisers. Now Ron Taylor, G4GXO, writes:

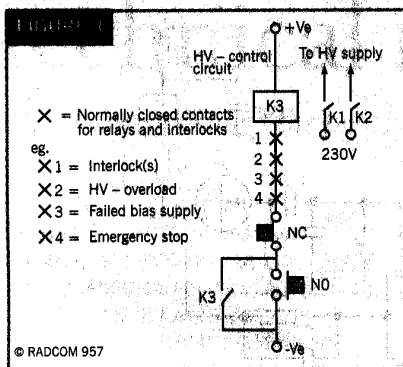


Figure 4: G3ISB/DJ00K recalls that this form of both high-voltage and over load shut-down protection has been widely used at GPO high-power transmitting stations.

"I was approached by G7IXH who, having seen our counter-type X-lock VFO stabiliser kit, asked if it would be possible to implement a Fast Huff-Puff scheme within a PIC (programmable IC). G7IXH's original design and other derivatives which followed, such as the 'Slow-Tuning Fast Stabiliser' by Chas Fletcher, G3DXZ ('TT') and the ingenious designs of Hans Summers (<http://www.hanssummers.com/radio/huffpuff/>) were built from discrete logic but as an overall process. The fast stabiliser seemed to lend itself to software and hardware architecture of many types of PIC. Peter asked and encouraged me to 'have a go'.

"The PIC16F628A was chosen mainly because it was to hand but also because in common with many similar PICs, its architecture seemed to be well suited to the task. Unfortunately, the smaller 8-pin 12F devices were unsuitable as the clock crystal shared the input that would be used for the VFO signal.

"After several false starts a working design was produced with a 5kHz sample rate and an 80Hz lock point spacing – not ideal but it proved the technique was viable. Having got this far, I drew an equivalent circuit of the software and hardware processes to better understand the stabilising action. My first reaction was one of surprise, it reminded me of some 'TT' items of many years ago (August, 1972 and July 1975) and a project in *VHF Communications* describing VFO stabilisation systems using PAL colour TV delay lines. A phase-shifting circuit, possibly developed during WW2 for D/F applications, called a

'Goniometer', was used to shift the VFO phase to provide continuous tuning. (Goniometers were used in Bellini-Tosi D/F systems almost a hundred years ago – G3VA). These designs were entirely analogue and whilst probably could not be claimed as forebears of 'Fast Huff Puff' they were clearly on a parallel evolutionary path.

"Figure 5 shows a simplified block diagram of the PIC stabiliser. The input signal is squared and divided by two (as a consequence of the PIC hardware) after which it is sampled by a clock derived from the processor crystal clock. It is this that sets the long-term stability of the stabilisation process. Note that this sampling frequency is much lower than the VFO frequency and the duration the sampling will span many cycles of VFO. Importantly however the process is consistent in time and produces a 1 or 0 depending upon the phase of the VFO at the instant the sampling gate shuts. The sampled signal branches into two paths, one goes direct to the phase detector (a software XOR function), the other enters a delay line formed by a shift register, again clocked by the sampling clock. The shift register delay is the number of stages multiplied by the sampling clock period. The output of the shift register which carries the delayed samples, is passed to the other input of the XOR for comparison with the current samples. After that the output of the XOR is presented externally to the PIC for averaging by the time constant circuit before being applied to the correction varactor in the VFO.

"The XOR phase detector is worth further mention since its action in this type of stabiliser has puzzled many. The following analogy may go some way to giving an impression of how it works. As a

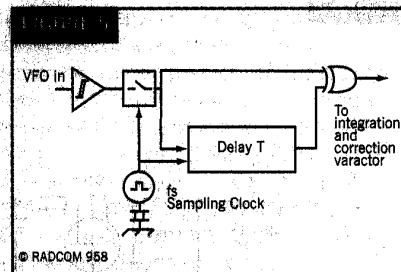


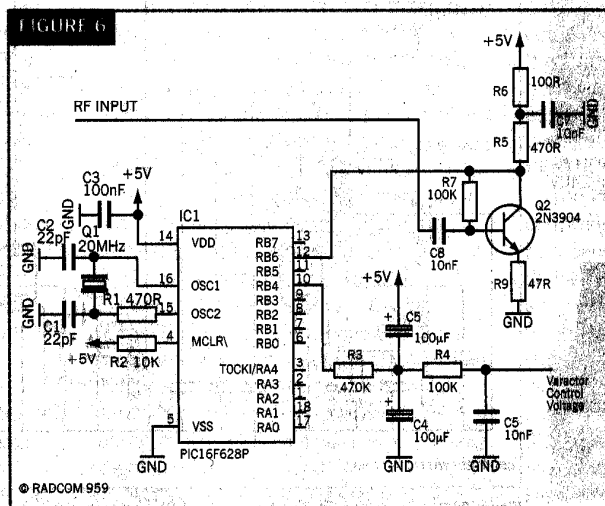
Figure 5: Simplified block diagram of G4GXO's fast huff-puff stabiliser using a PIC microchip.

Junior Officer at RMAS, one of the key leadership messages we had drummed into us was: "Always make a decision, don't hesitate. It doesn't matter if it is the wrong decision; it can be put right later. Just decide..." The XOR works on a similar principle. It always produces an output irrespective of whether one is needed. Sometimes it is right; other times it is wrong, but when wrong the phase relationships at its input cause it to correct itself on the next 'decision'. As Peter, G7IXH, described, over many samples the XOR will statistically always produce an output that will drive the VFO towards the nearest lock point. The phase detector displays a 'zero crossing' at VFO frequencies corresponding to harmonics of the sampling frequency.

"Further development of the software has now produced an improved version with a 10kHz sample rate and 1000 step shift register, again using the 16F628A. This combination produces a 20Hz lock point spacing, although by lowering the sample rate to 5kHz, a 10Hz lock point spacing will be possible. Lock point spacing (Hz) = $2f_s/N$, where f_s is the sampling frequency and N is the number of shift register stages.

"When used in connection with a roughly built 12MHz VFO, the results proved remarkable. The VFO settled down very quickly after switch-on and remained on frequency for many hours. The tuning range of the varactor (a red LED) used in our test VFO is about 20kHz for a 0 to 5V control range. Current PIC performance should allow operation at input frequencies up to 50MHz, although this has yet to be tested. Higher input frequencies at VHF and UHF could also be accommodated by either mixing down and dividing the oscillator source before applying it to the PIC input. If division is used this will increase the lock point spacing as a factor of the divisor value.

"Whilst using a microprocessor



to stabilise a VFO may seem like overkill, there are significant advantages in circuit simplicity and cost. Figure 6 shows the minimal component count. In some applications, the addition of an op-amp integrator may be desirable to provide adjustment of the varactor tuning range. There is also plenty of scope for future development with newer PIC families, offering potential for larger shift registers and lower lock point spacing at higher sampling rates. Controls could also be easily added to tailor the delay and sampling rate to suit a particular application.

Software for the circuit in Figure 6 can be downloaded from Ron's web site at <http://www.cumbriadesigns.co.uk> (select "resources" > "downloads" from the home page). There is a very useful graphical simulation to aid the development of Huff & Puff schemes at <http://tinyurl.com/y5hk67>.