The Vackar VFO oscillator

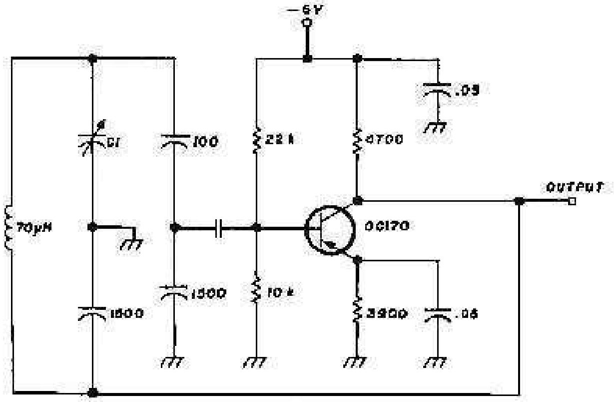
Jiri Vackar [Jiří Vackář], (correctly pronounced as "Vatzkaarz")
invented his VFO oscillator during late 40s. It is probably the most stable VFO oscillator known. Thanks George!
The Vackar oscillator configuration is rarely used because of known reason.
(NIH, the not-invented-here syndrome).

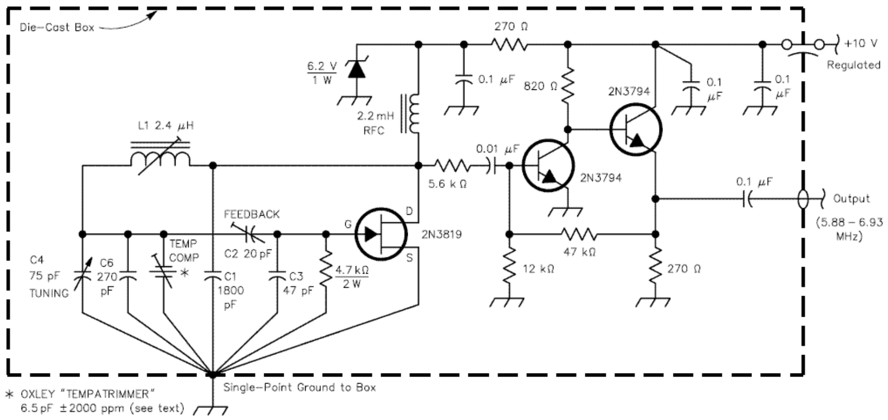
The frequency tuning range is above 2.5, not observable in any other type of oscillator. The Coupling ratio is fixed; typical range is 1:4 up to 1:9. The frequency tuning is provided independently of coupling. Transistor's parametric variables are isolated from the resonator. The transistor input is not overloaded as Clapp or other circuits. The collector output is at low impedance providing low gain just to maintain the oscillation. The feedback division ratio is fixed. Even if the VFO is tuned, the impedance divider is fixed. The stability is close to XO - crystal oscillator. Jiri Vackar published his work in a book, providing theory and analysis of each type of his oscillator. What was the last model, V66? Who knows?
A while ago, I thought about fine tuning oscillator for PLL based VHF synthesizer. Few designs failed high expectations. I used Colpitts, Clapp, Hartley, Pierce, and Seiler. Junk. The Butler is better than single active component oscillator, but it is not good enough. Commonly used oscillator configuration does not guarantee good performance. The signal clipping by diodes guarantees additional phase noise and thermal frequency drift. The best oscillators very commonly use two or three active devices. This is valid for VCOs, TCXOs and OCXOs. The second device acts as an impedance converter, isolation amplifier, AGC circuit, and a phase shifter. The articles in QST very often copy old mistakes, and limiter diodes. U.L.Rohde from Univ. of Washington wrote few articles about the poison of limiter diodes in oscillators. TS-950 use limiter diodes in oscillators.
Ordinary oscillator has poor tuning range, the output voltage swing is unstable, and the frequency stability is poor as well. The industry tries hard to make its sale pitch, to replace single oscillator with 50 ICs, digital dividers, approximation registers, thermostats, and other junk. Now what?
I checked the Vackar. First measurements with frequency counter were quite positive. The Vackar VFO was running in freezer at -30C. That is about -22F. Not bad for Yukon Territory. Stable. Can it run more stable? The ferrite and iron-powder tuning slugs went out, down the pipes. There is a strong public belief the iron powder tuning slug cores are good. It's not. In thermal stability, they are better than ferrites. They can take higher maximum magnetic flux than heavy ferrites. Micrometals cores use iron powder technology from the 50's, nobody use it any more. The iron powder cores are quite lossy in terms of resulting Q. The grains are not properly bound together. You will have "brown fingers" from handling these cores. Generally, ferrite is based on NiZn or MnZn alloy.
Quite good are Ferroxcube-Philips ferrite cores, presently manufactured in Spain. The Spanish sampling service was good. The reps for US are fine. The Ferroxcube's sales reps in Poland are asking $230 for delivery of $1.0 stuff. Sort of robbers the Poles, is that right?
Iskra-Feriti from Slovenia manufactures good ferrite products, toroidal cores and double hole cores, excellent for transformers. I recommend this company.
The experience with Epcos ferrites is weird. Epcos is not able to deliver anything in time, delivering "we forgot". Rest in piece, Epcos.

There are few critical components - good caps of known properties, inductors, voltage regulator, and the transistor. It will run with dual gate MOSFET as well. Low noise MAC01 voltage regulator will do the job. Even LM78L06 with 50uV of noise is fine. LM317 is good for car lead battery charger. The best generic voltage regulator of all times is maybe the LM723. :-) Ignore the +7V Absolute max voltage technology. For the oscillator, expect 80dB spur free spectrum. The TFT caps are very good. The mechanical design has to be stable. The coupling with buffer is loose, and at low impedance. The varactor is coil tapped, or cap-divider tapped. The fine tuning with varactor will slightly change the frequency-temperature coefficient. Direct tuning with varactor will ruin temperature characteristics and phase noise of every oscillator. Watch how many designs with single varactor and a 500 kHz tuning range ruined all advantages of the oscillator. Varactor behaves as a non-linear resistor with variable capacitor. All parameters change with temperature, DC voltage, and RF voltage. Varactor is for designs with e.g. Kvco = 150MHz/V. Direct varactor tuning of low noise oscillator is nonsense.
I used ceramic coil form with diamagnetic tuning slug for better temperature stability (brass, aluminum). The brass slug works as a single short turn, and tunes the frequency up. Teflon coil form is good, or Plexiglas will work as well. Keep the Q high, and shield the whole box. Stability of 2Hz at 7MHz was measured. Under 1ppm? Here I stopped. "The VFO can create stable beat with crystal oscillator, and it will stay like that for hours".
The concern was why to use another PLL loop? The oscillator phase noise is lower than any synthesizer use to have. The controller used for synthesizer burns power, radiate heat, and generates broadband spur spectrum. The DDS requires a huge battery to power up the device. The DDS phase noise and residual noise floor is so bad, only moron will use it for receiver application. The VFO is better solution than the AD9850, AD9891 DDS - direct digital synthesizer chip. The DDS chip has fine-tuning of fractions of Hz. That's right. With X-Tal tolerance of 25ppm. Major performance limitations are digital clock tree radiation, crystal multiplication (more spurs and more power dissipation), DAC aliasing, discrete spurs, discrete dynamic spurs; very rich grass type of parasitic spectrum, finite level of residual flat background phase noise, and the output frequency is never a round number (5,000.000 kHz). The

phase noise parameter is the worst performance issue. It takes 10-14 bits to create single sine wave. The reconstruction filter is not there. If you want phase noise of -80dBc/Hz @10kHz and worse, use the DDS.
Careful observation of the oscillator performance reveals well-known issue, the limited dynamic range and S/N ratio of HP Spectrum Analyzers. Compare with Rohde & Schwarz. The oscillator circuit works well with J-FET (square law). Components with cubic transfer characteristic (dual gate, tunnel diode) have excellent frequency stability and performance.

[Links related (UK):]





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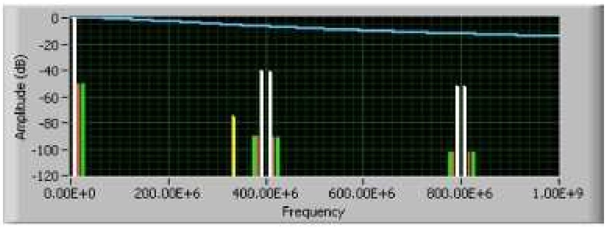
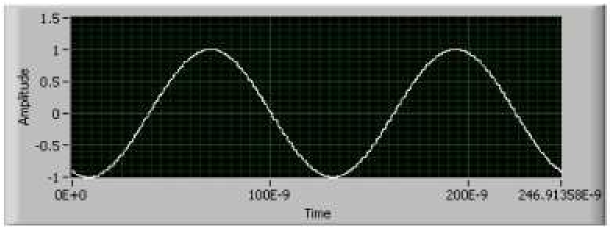
The genuine Vackar oscillator circuit by G3PDM.
With C1/(C4+C6) and C3/C2 = 6. Use a high-quality variable capacitor with ball bearings, two-wheel transmission. Adjust feedback control C2, an air-dielectric trimmer, so the circuit just oscillates. Use a strong box from solid metal. C1, C3 and C6 are silver-mica or ceramic types glued to a solid support to reduce sensitivity to mechanical shock. The buffer amplifier is essential. Circuits using external gate-to-ground diode suffer from high phase noise and instability. The diode loads the circuit. The signal is rectified by the diode, and dynamically shifts the operating point of the J-FET. Single-point grounding is fundamental. The inductor used a ceramic form. Use thick solid wires (#16 to #18 gauges) for mechanical stability. The coil is always mechanically fixed by paint. My choice is transparent nail polish with lacquer thinner. Mechanical 20:1 reduction gearing with anti-backlash may do the trick. Take out the Zener and replace it with voltage regulator. Clean all components and the box in ultrasound cleaner.
The bias and feedback caps ratio changes the close-in phase noise. A wonderful nice sine wave output doesn't mean it is a low phase noise oscillator. Calculate a T or PI type, five element low pass filter with 1dB ripple. Place is on the output. Tchebyshev or Elliptic structure is fine. Don't forget the termination resistances. Think about the frequency plan and frequency dependency, and different types of pulling. The buffers are essential. You can divide down.

What is the TEMPCO compensation?
The ceramic capacitors are manufactured with different Temperature Coefficients of Capacitance (K). It means, choosing the right combination of capacitors will get you zero thermal frequency shift. The cap combination you have to find out by thermal measurement. Standard TEMPCO values for capacitors are Kc = +44(white), +33, -47(NPO COG), -125, -470, -750(purple), -1250 and whatever more. The resulting cap value is
C' = Co *(1 + deltaTemp*K*1E-6).   [pF, C or Kelvin]
Tuning caps have high negative K. Coils have positive K. Capacitor manufacturers design caps with different K. There

are about fifty manufacturers. AVX, Murata, ATC... Expect lead time of few weeks. It is useful to keep a set of caps with different K. A throughole ceramic cap from TV tuner can solve, what you can't find.

Good luck!
va3diw





DDS? That's a big question. Welcome to the aliasing world and phase noise background. The DDS chips are not developed for receiver applications. Do you know that?

After ten years, this article still evokes questions to think about. [QST]

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