



Vackar VFO oscillator

Jirí Vackár invented his VFO oscillator during late 40s. It is probably the most stable VFO oscillator known. Vackar configuration is rarely used because of known reason. (The NIH, 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 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. 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 oscillator for PLL 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 guarantees frequency and thermal drift. **Limiting diode = bs.** for the least understanding personnel, copying mistakes in QST etc. The tuning range is poor, the output voltage swing is unstable, and the frequency stability is poor as well. The industry tries hard to make it's 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's 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 cores are good. I don't know why. In thermal stability they are better than some heavy ferrite. Amidon and Micrometals cores use iron powder technology from the 50's, nobody use it any more. They are quite lossy, the grains are not properly bound together. You will get "brown fingers". (That's better than brown nose). Quite good are Ferroxcube-Philips ferrite cores, presently manufactured in Spain. Generally, ferrite is based on NiZn or MnZn alloy. Iskra-Feriti from Slovenia manufactures good ferrite products, toroidal cores and double hole cores, excellent for transformers. However, this is about VFO.

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. The LM317 voltage regulator is not the right choice. LM317 is good for car battery chargers and that's it. Rather use MAC01 type for voltage regulator with low noise, even LM7806 with 50uV of noise is fine. Expect 80dB spur free spectrum. The TFT caps are very good. The mechanical design has to be stable. The coupling with buffer is loose at low impedance. Varicap coil tapped, or cap divider tapped for fine-tuning will slightly change the linear temperature coefficient. Direct tuning with varactor will ruin temperature characteristics and phase noise of every oscillator. Watch how many designs with single varactor and 500kHz tuning range killed all the advantages. Varactor behaves as non-linear resistor with variable capacitor. All parameters change with temperature, DC voltage, and RF voltage. Varactor is good for design where $K_{vco} = 150\text{MHz/V}$ and above. **Varactor = bullshit.** Another attitude improving the performance by implementing AGC is: The AGC circuit adds noise, phase noise. Gotcha?

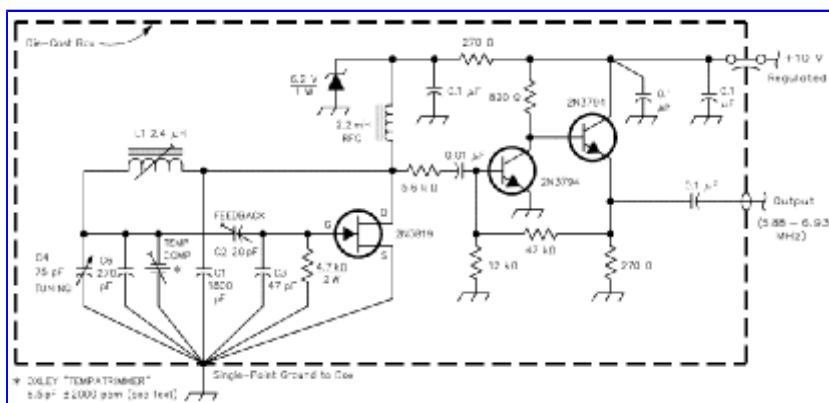
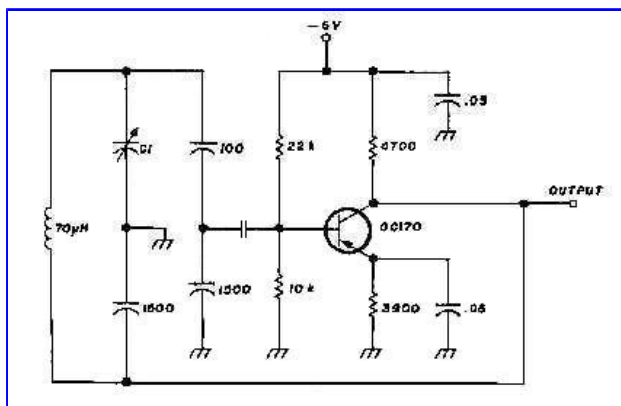
I used ceramic coil form with diamagnetic tuning slug for better temperature stability. (brass, aluminium, different approach is BS). Solid Teflon tubes or Plexiglas will work as well. Keep the Q high, and shield the whole box. Stability of 2Hz at 7MHz was measured. Under 1ppm? Here I stopped. "The VFO 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 phase noise is lower than any synthesizer use to have. The processor burns power, radiate heat, and generates broadband spur spectrum. The DDS requires backpack full of lead batteries. The DDS phase noise and noise floor is so bad, only morons will use it for receiver application.

It is better solution than the AD9850,9891 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 clock tree radiation, integer PLL clock multiplication (more power and spurs), DAC aliasing, discrete spurs, discrete dynamic spurs, rich grass spectrum, and finite flat background phase noise. The last parameter is the worst performance issue. Divide the output signal by ten, the background noise is still there lower by 10dB. If you want phase noise of -80dBc/Hz or worse, use the DDS.

Careful observation of the oscillator performance reveals well known issue, the limited dynamic range and limited S/N ratio of present HP spectrum analyzers. Use rather Rohde & Schwarz (R&S) or your own spectrum analyzer. The circuit works well with J-FETs (square law). Components with cubic transfer characteristic (dual gate, tunnel diode) have excellent frequency stability and performance.

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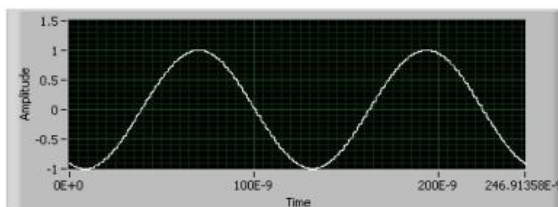
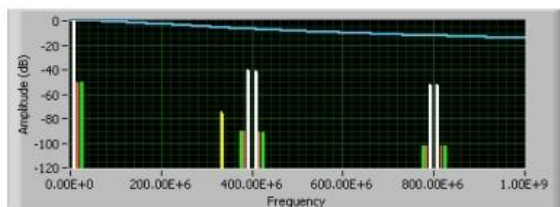


click to zoom

Example:

The genuine Vackar oscillator circuit by G3PDM. With $C1/(C4+C6)$ and $C3/C2 = 6$ Use a high-quality variable capacitor (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 important. The inductor used a ceramic form. Thick solid wires (#16 to #18 gauges) for mechanical stability. Take out the Zener and replace it with something better. Clean all components and the box.

Good luck! va3diw



DDS ??? That's a big question. Welcome to the aliasing world.

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