APPLICATION NOTE

Voltage Controlled Oscillators

In this application note, let us model some Voltage Controlled Oscillators (VCOs), such as, Dual Integrator VCO and Controlled Reactance VCO, using PSpice. Most of the examples in the application note use the Analog Behavioral Modeling capabilities of PSpice.

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Dual Integrator VCO

An alternate approach to a behavioral model VCO is to start from a 2-integrator loop. Changing the time constant of one or both integrators allows the frequency of oscillation to be controlled. Some form of limiting is required in order to produce output of bounded amplitude.

A particularly elegant example can be found in Reference[1]. This sinusoidal VCO has independent control of both frequency and amplitude. It's black-box representation reduces to:

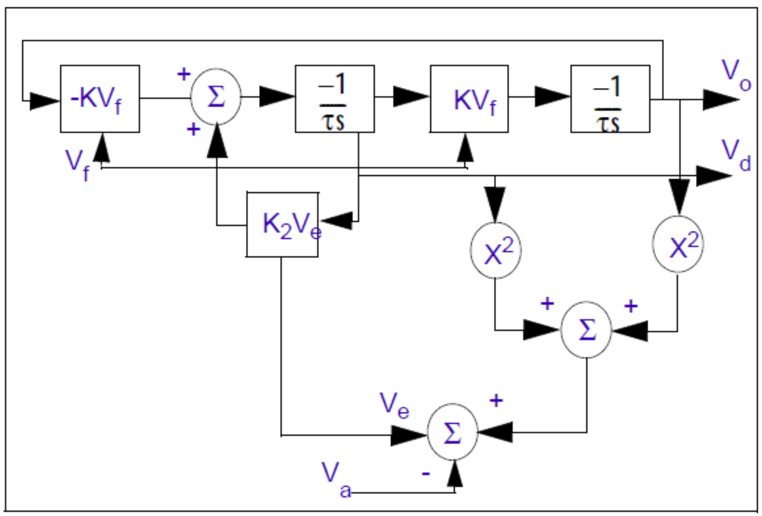

Figure 1: Black-box representation of a sinusoidal VCO

Outputs V_d and V_o are in quadrature. The amplitude error term is obtained by squaring and summing the quadrature outputs, and subtracting the amplitude-setting voltage V_a.

Using the `.FUNC` command, the entire VCO can be reduced to two integrators with controlled current sources whose expressions incorporate the multiplications, additions, and subtractions.

Following is an example to model the above VCO:

* Filanovksy VCO

```
.func ve(x,y,z) k*(pwr(x,2)+pwr(y,2)-pwr(z,2)

.param k=0.1, cv=10u

 g1 vd 0 value {k*((-v(vo)*v(vf))+(ve(v(vo),v(vd),v(va))*v(vd)))}

 c1 vd 0 {cv}

 r1 vd 0 1G

 g2 vo 0 value {k*v(vd)*v(vf)}

 c2 vo 0 {cv}
```

```
 r2 vo 0 1G

.ic v(vd)=0.1, v(vo)=0

 va va 0 1v

 vf vf 0 1v
```

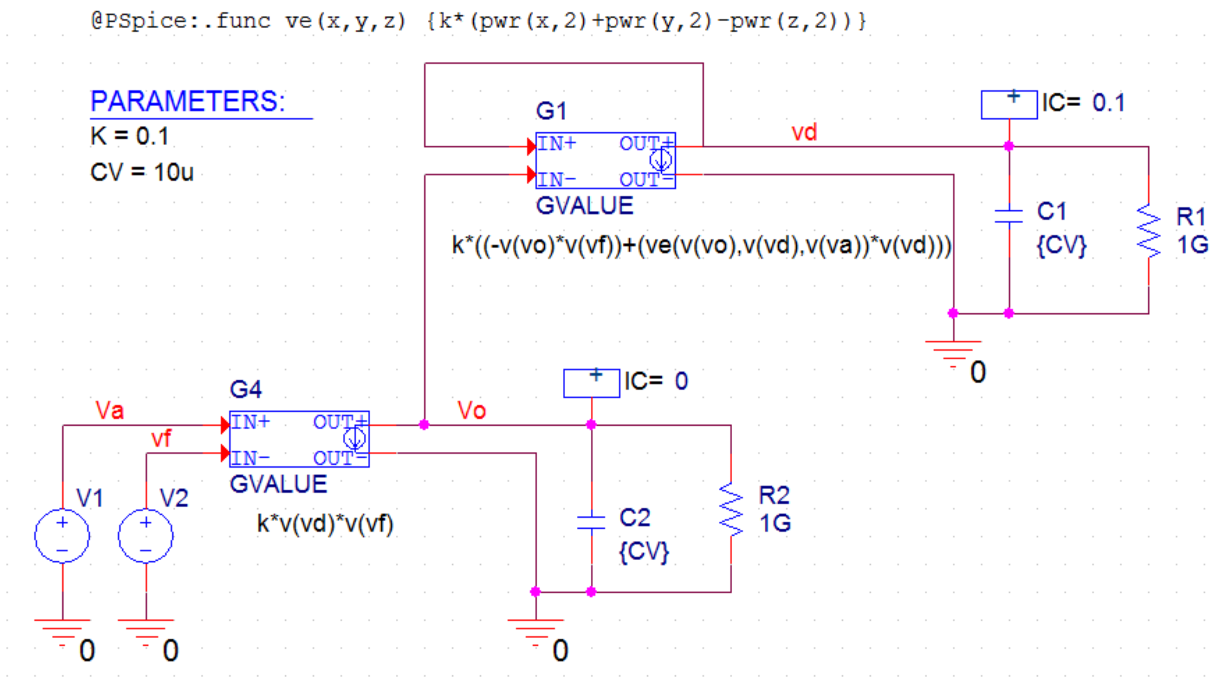

Figure 2: Circuit Design for Filanovsky VCO

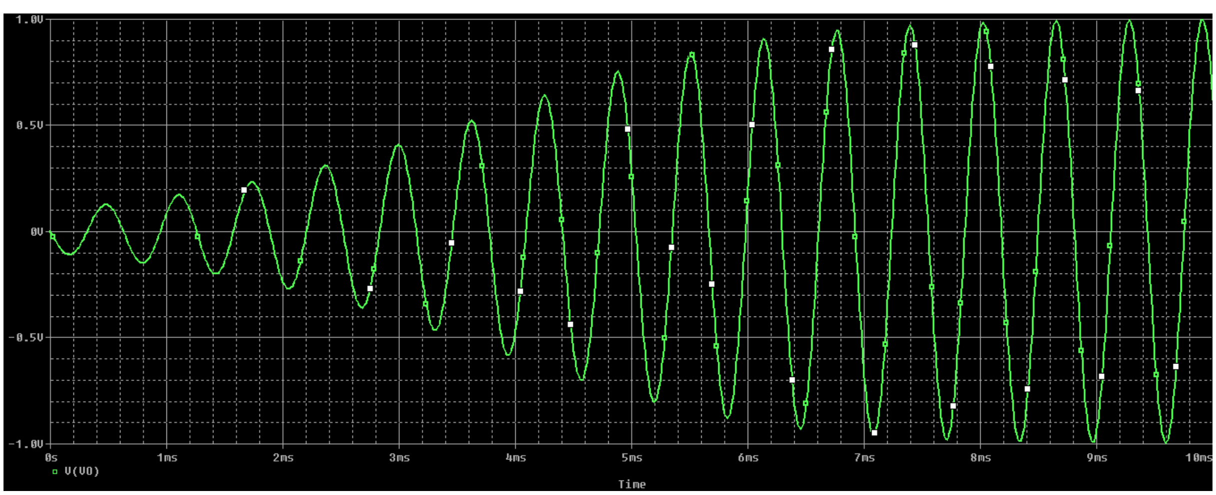

Figure 3: Simulation results for Filanovsky VCO

Controlled Reactance VCO

A more circuit oriented approach to build a VCO is to take a simple tank oscillator and use a voltage-dependent reactance for one of the tank components. The following example is a Colpitts oscillator. The `zx` device is used to implement a voltage-controlled lossy inductor.

```
  xvi ctrl 0 ref vcc c zx;Colpitts with variable tank element,

  lref ref ref1 15u

  rref ref1 0 2.0

  c1 c e 20n

  c2 e 0 200n

  q1 c 0 e q2n2222

  re e vee 2k

  vcc vcc 0 10v

  vee vee 0 -10v

  vctrl ctrl 0 pwl(0,1.5v 124u,1.5v 125u,2.5v)

 .ic v(c) = 10 v(e) = -0.7
```

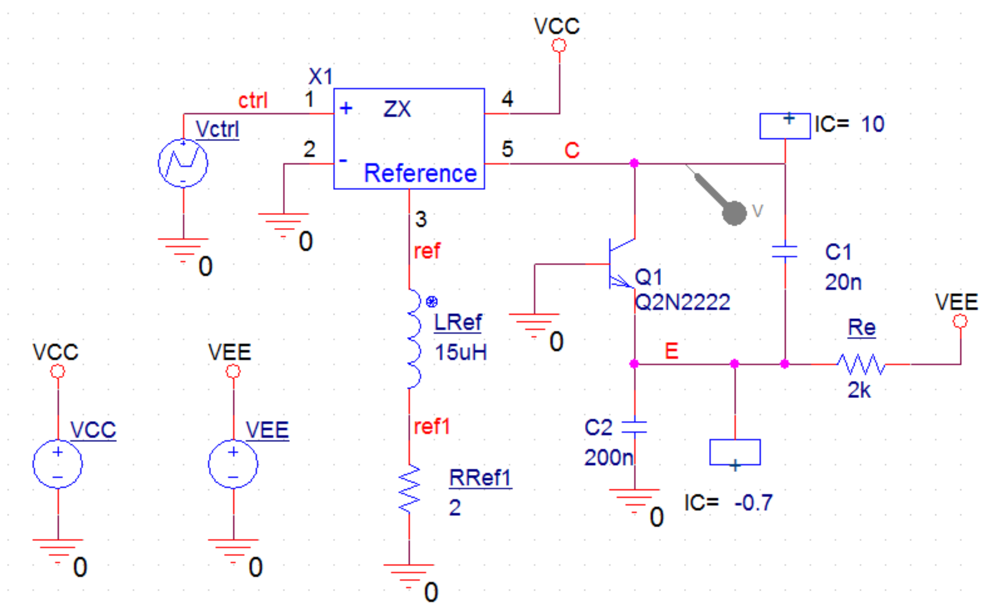

Figure 4: Circuit Design for Controlled Reactance VCO

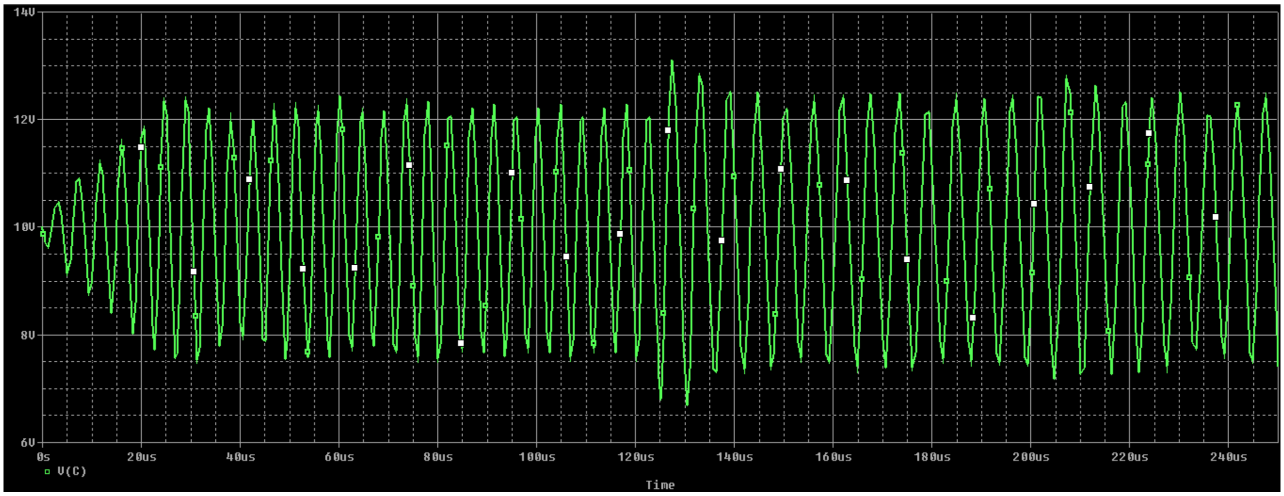

Figure 5: Simulation results for Controlled Reactance VCO

Reference

[1] I. M. Filanovsky, “Sinusoidal VCO with Control of Frequency and Amplitude,” Proceedings of the 32nd Symposium on Circuits and Systems, IEEE, Vol I, 446-449 (1989).