Qspice KSKelvin Symbol Explanation

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Created on 9-3-2023
Last Updated on 4-30-2024

Ideal Opamp

Qspice : Opamp_Ideal.qsym

Ideal Operation Amplifier - Overview

Qspice : ComptrOD_Ideal.qsym

- Ideal Opamp Sub-Circuit
  - opamp.sub in LTspice library

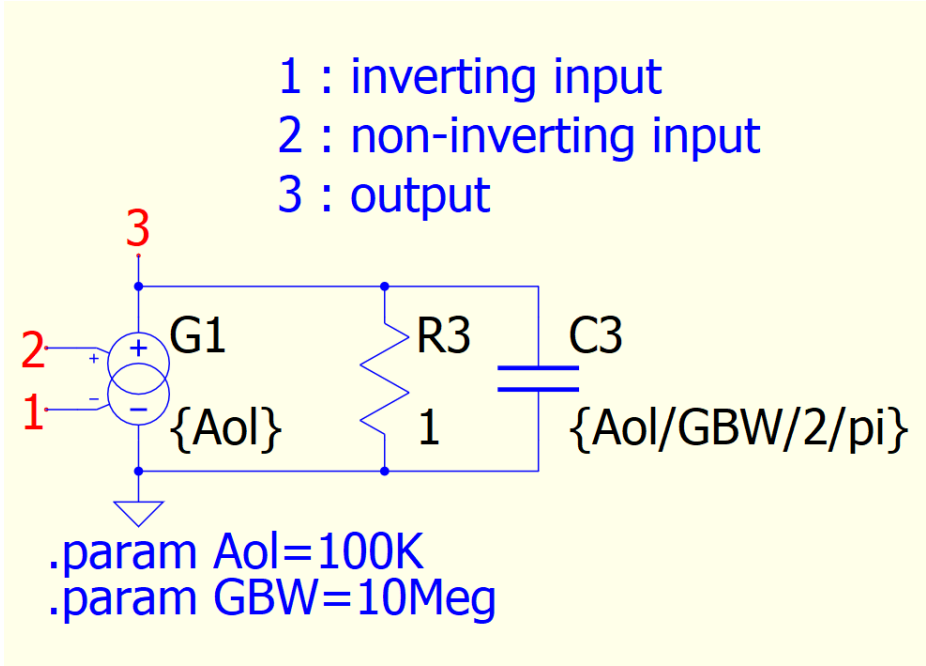

```
.subckt opamp 1 2 3
G1 0 3 2 1 {Aol}
R3 3 0 1.
C3 3 0 {Aol/GBW/6.28318530717959}
.ends opamp
```

- Opamp equivalent formula

$$V_{output} = Z(R_3, C_3) \times Aol \times I_{G1}$$

$$V_{output} = (R_3 \,//\, \frac{1}{j\omega C_3}) \times Aol \times (V_p - V_n)$$

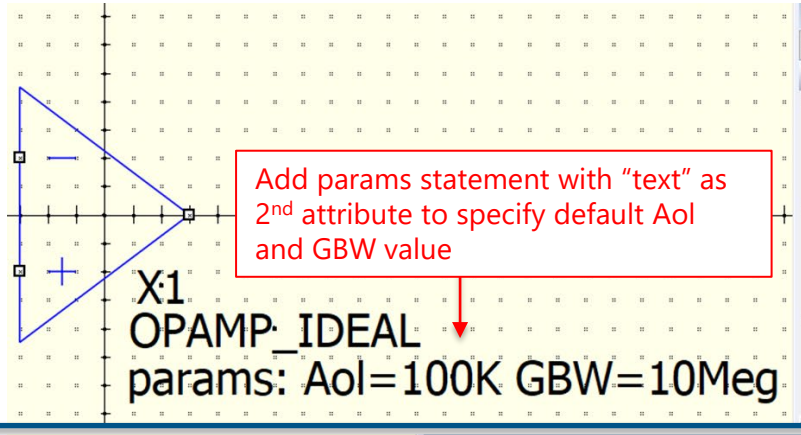
Opamp.sub Equivalent Schematic



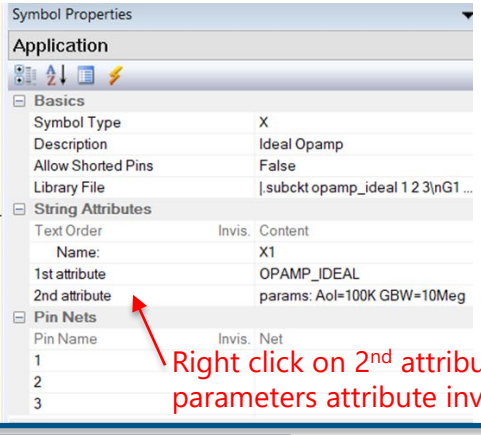
Ideal Operation Amplifier – Parameters of Symbol

Qspice : ComptrOD_Ideal.qsym

Method #1

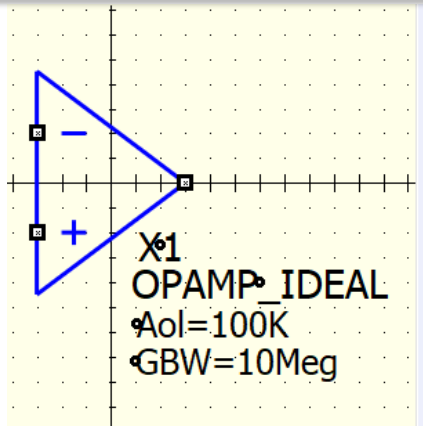


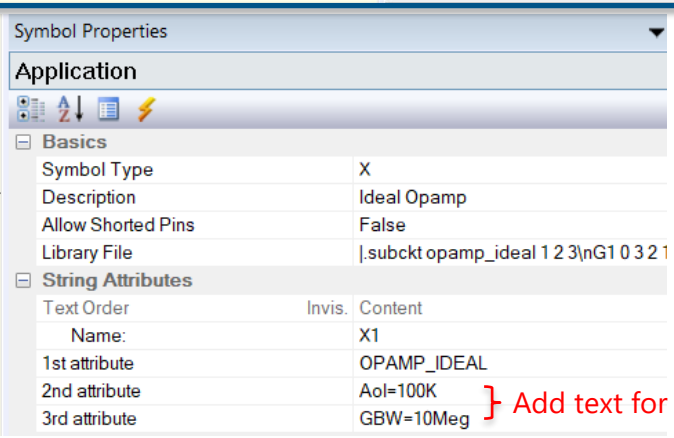
Add params statement with "text" as 2nd attribute to specify default Aol and GBW value



Right click on 2nd attribute and make parameters attribute invisible in symbol if needs

Method #2

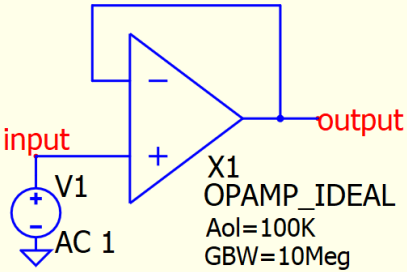




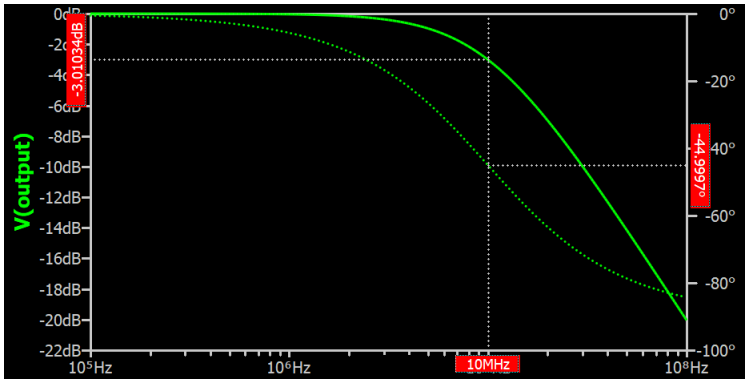
Add text for extra attribute Aol and GBW

Ideal Operation Amplifier - Simulation Example

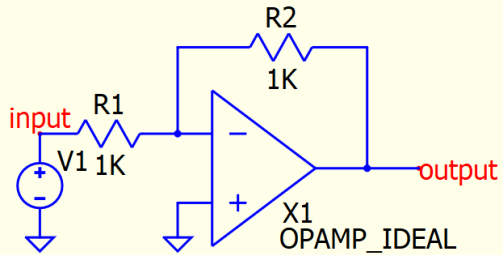
Parent - opamp_ideal (.ac).qsch



.ac dec 100 100K 100Meg
.plot ac V(out)

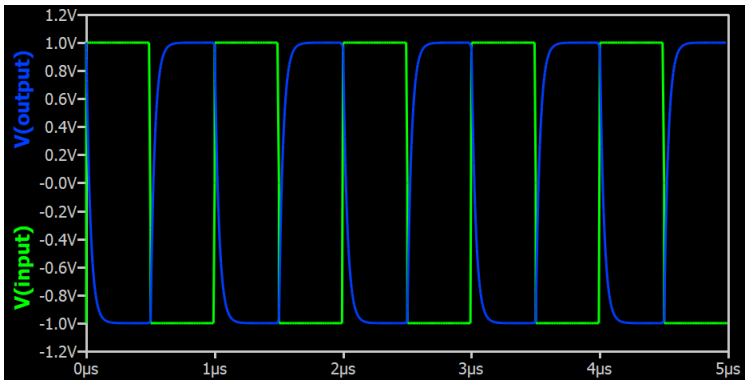


Parent - opamp_ideal (.tran).qsch



pulse -1 1 0 0 0 0.5µ 1µ

.tran 5µ .plot V(input) V(output)



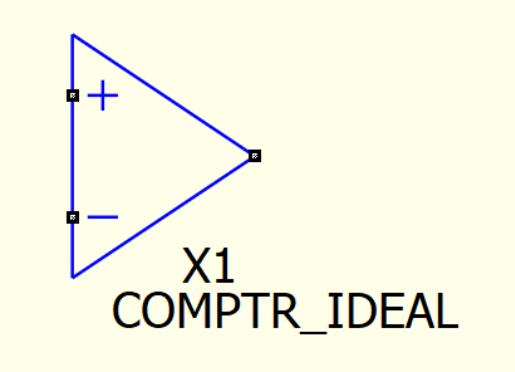
Ideal Comparator

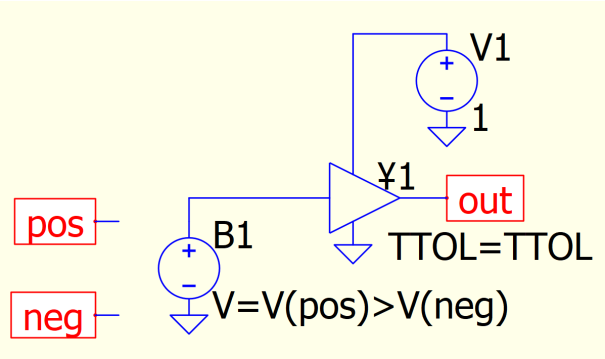
Qspice : Comptr_Ideal.qsym
Qspice : ComptrOD_Ideal.qsym
Qspice : Comptr_Ideal_Supply.qsym

3 type of Ideal Comparators Overview

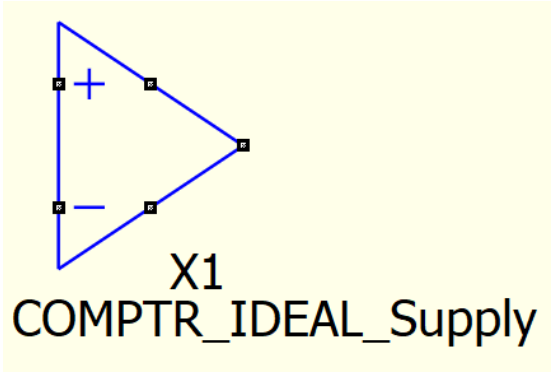
Qspice : Comptr_Ideal.qsym / Comptr_Ideal_Supply.qsym / ComptrOD_Ideal.qsym

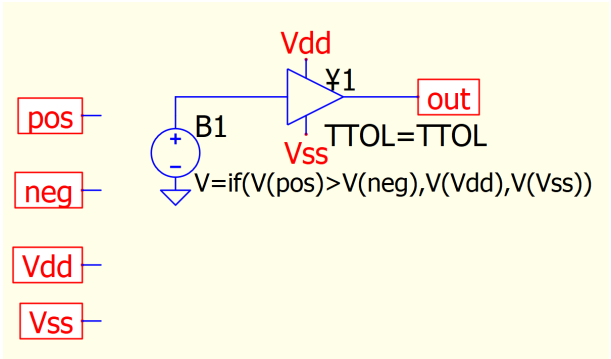
Ideal Comparator (Output 0/1)
Comptr_Ideal.qsym



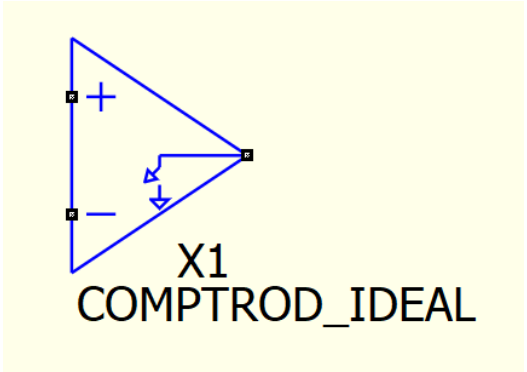


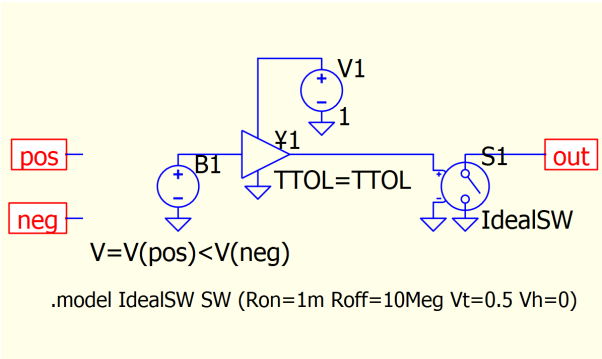
Ideal Comparator (Vdd/Vss)
Comptr_Ideal_Supply.qsym





Ideal Comparator (Open Drain)
ComptrOD_Ideal.qsym

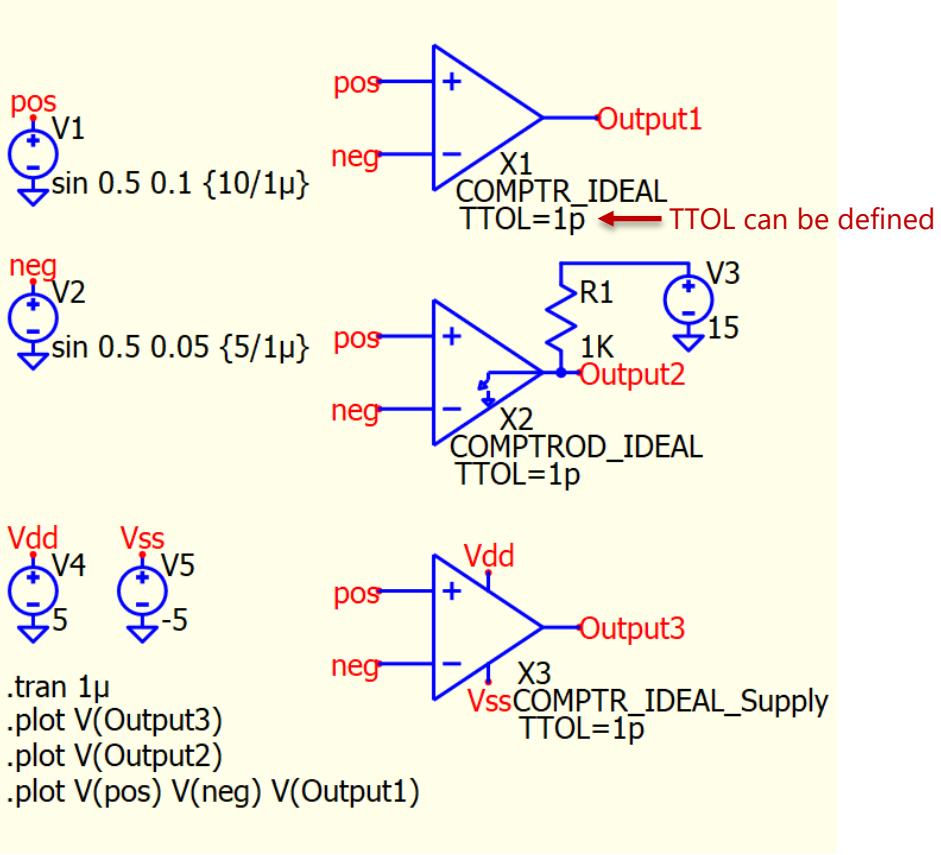


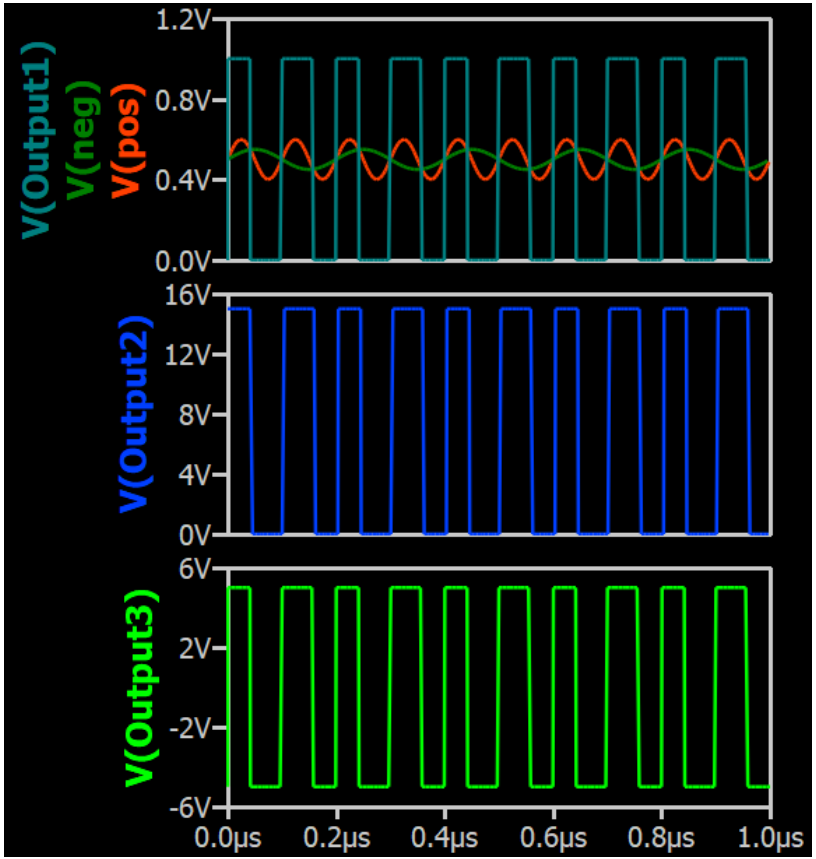


** Buffer ¥1 is used to include TTOL timing parameter

3 type of Ideal Comparators – Simulation Results

Qspice : Parent - Comparator.qsch





Control System

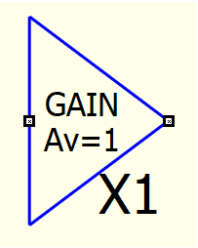
Gain, Different, PID and Signal Limiter

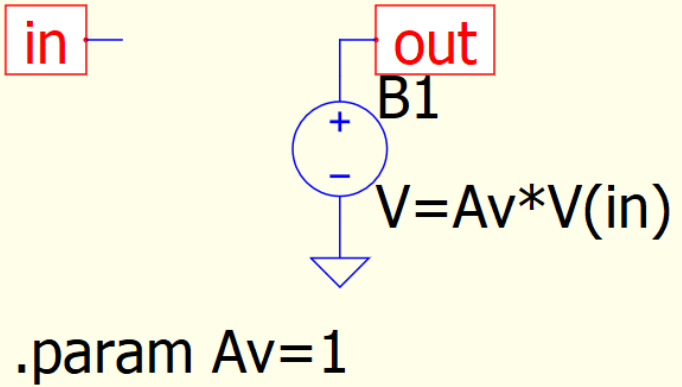
Qspice : Gain.qsym
Qspice : Different.qsym
Qspice : PID.qsym
Qspice : Signal_Limiter.qsym

Gain and Different

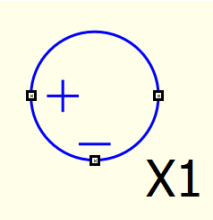
Qspice : Gain.qsym / Difference.qsym

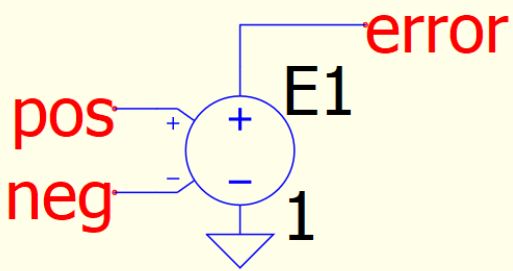
- Gain
  - $V_{out} = Av \times V_{input}$





- Difference
  - $V_{out} = V_+ - V_-$

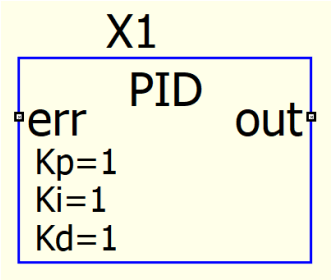


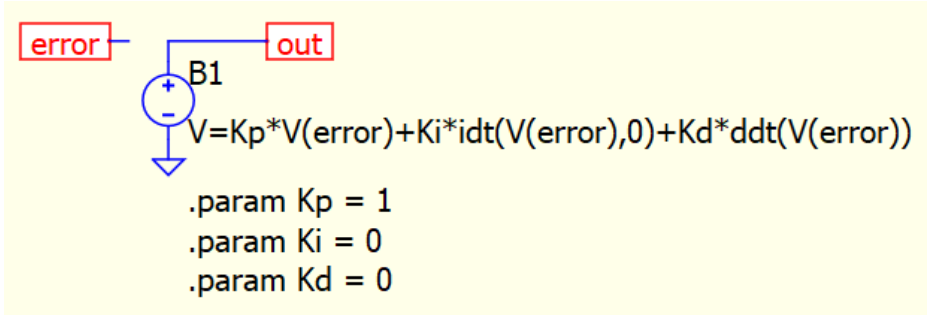


PID Controller and Signal Limiter

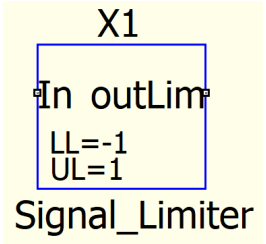
Qspice : PID.qsym / Signal_Limiter.qsym

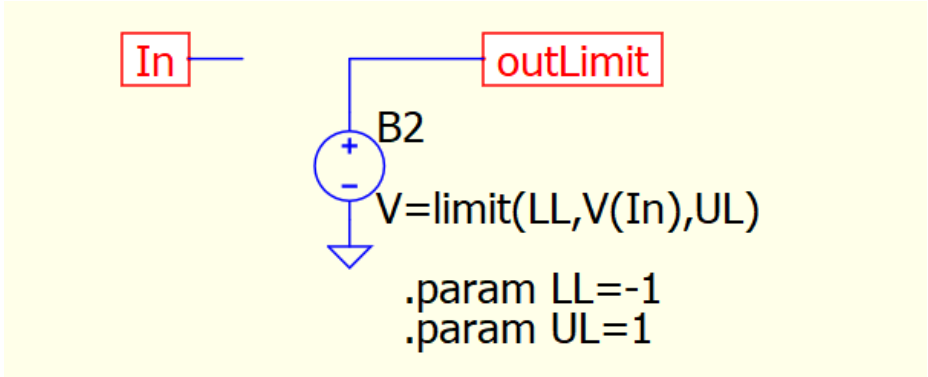
- PID Controller
  - $V_{out} = K_p V_{error} + K_i \int V_{error}\, dt + K_d \frac{dV_{error}}{dt}$





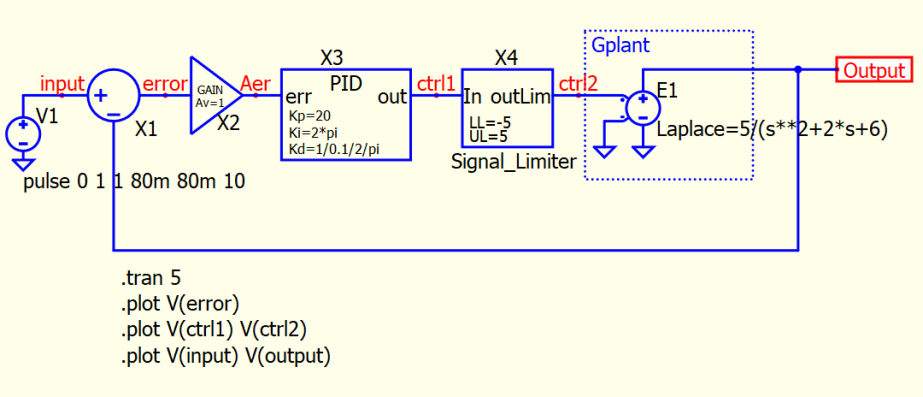
- Signal Limiter
  - limit(x,y,z) | intermediate value of x, y, and z, equivalent to min(max(x,y),z)

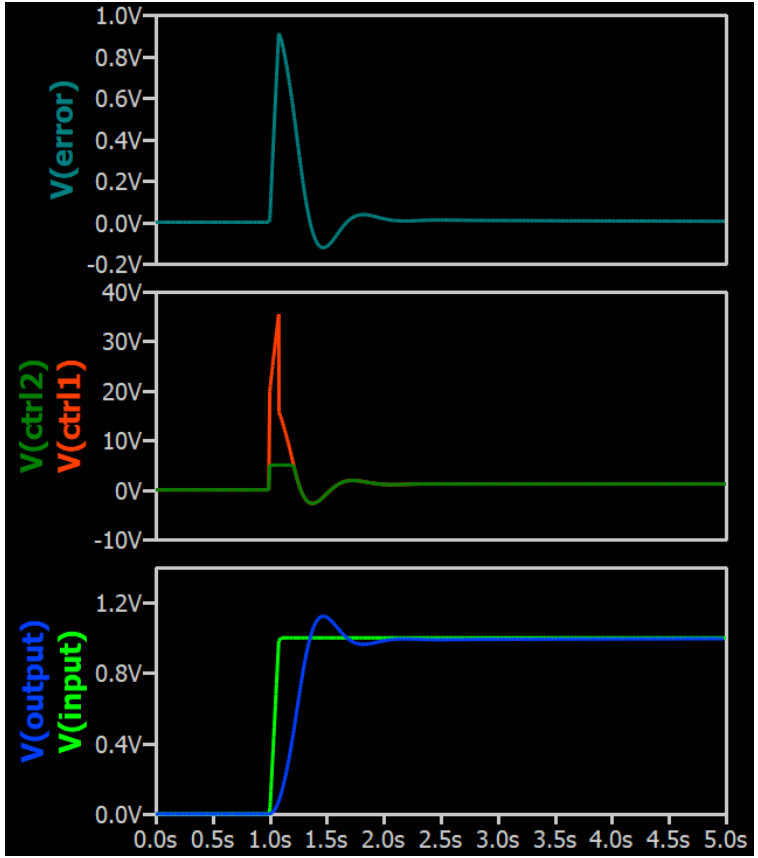




Control System Symbol : Transient Simulation Example

Parent - PID CloseLoop (.tran).qsch



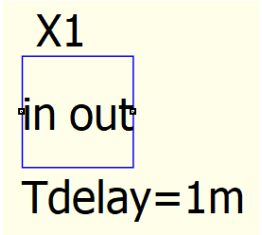


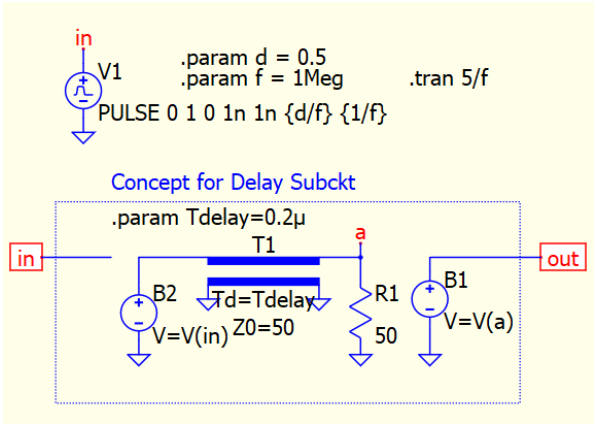
General Purpose

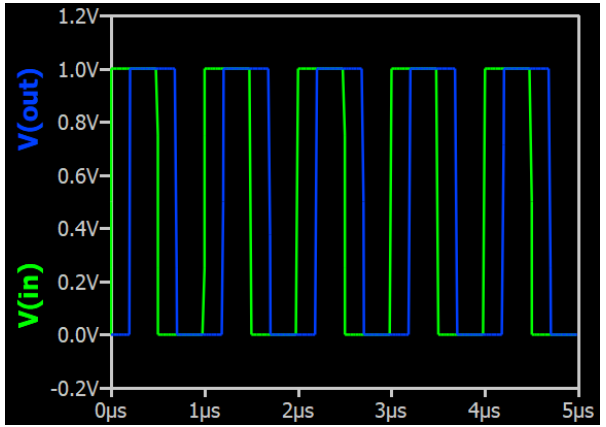
Delay

Qspice : Delay.qsym

- Delay
  - Reason for Implementation
    - Qspice B-source not offers delay function before 09/22/2023, but after that, Mike Engelhardt implemented delay(input,time) for arbitrary behavioral sources.
  - Concept of Design
    - T1 : Td (delay) in ideal transmission line determines signal delay time
    - R1 : To prevent signal reflection, transmission line must terminate with Zo
    - B1 : To prevent loading effect when using delay block
  - Symbol of delay.qsym



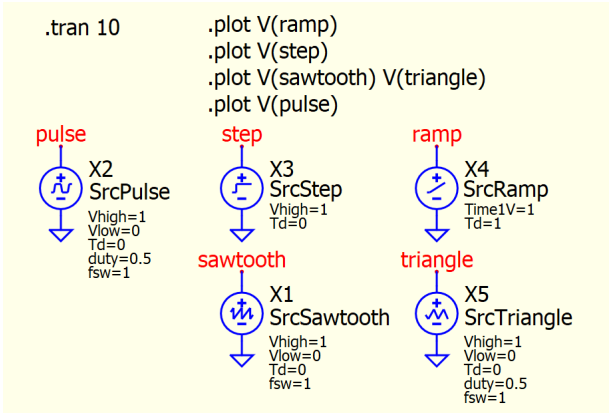


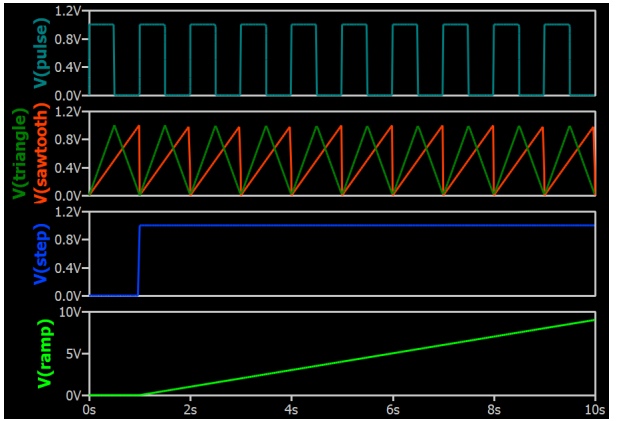


SrcXXX Special Voltage Source and Potentiometer

Qspice : Scrxxxx.qsym / Potentiometer.qsym

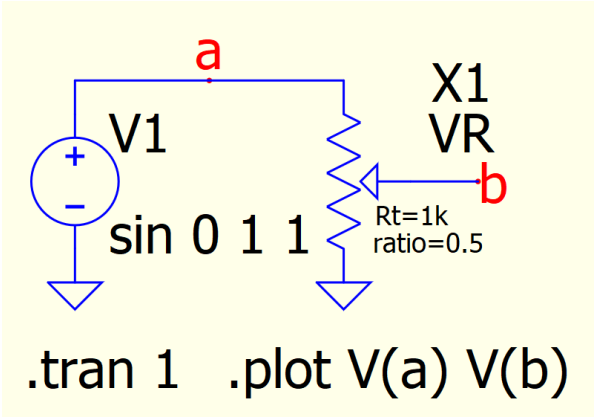
- ScrXXX
  - SrcPulse.qsym
  - SrcSawtooth.qsym
  - SrcTriangle.qsym
  - SrcStep.qsym
  - SrcRamp.qsym

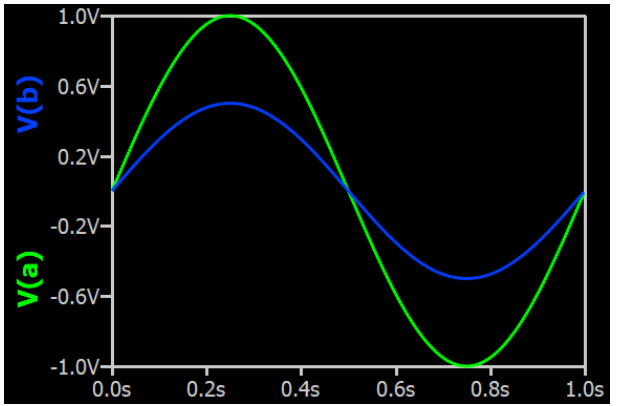




- Potentiometer
  - Symbol : Potentiometer.qsym
  - Ratio is limited to [1m,0.999]
  - Sub-circuit script

```
.subckt VR + - m params: Rt=1k ratio=0.5
.param w = limit(1m,ratio,0.999)
R1 + m (1-w)*Rt
R2 m - (w)*Rt
.ends VR
```





Special Subckt

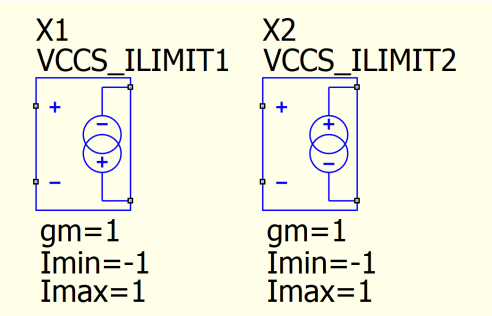
Voltage Control Current Source with Current Limit

Qspice : VCCS_Ilimit.qsym

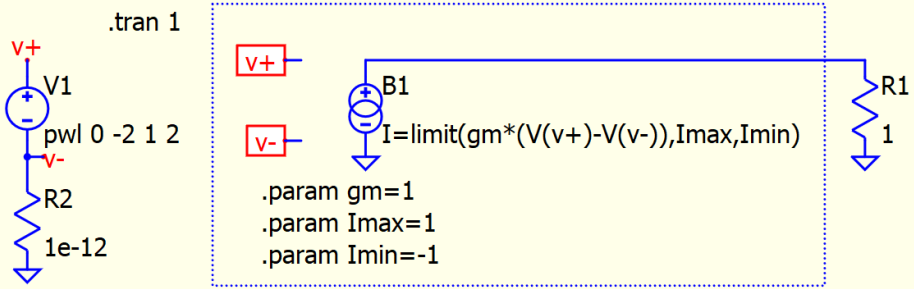
- VCCS_Ilimit
  - Use Behavioral source with limit(x,y,z) function
    - Intermediate value of x, y, and z
  - Sub-circuit

```
.subckt VCCS_Ilimit v+ v- out+ out-
B1 out- out+ I=limit(gm*(V(v+)-V(v-)),Imax,Imin)
.ends VCCS_Ilimit
```

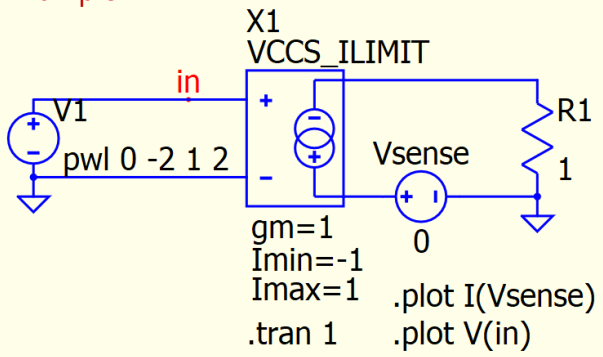
  - Symbols

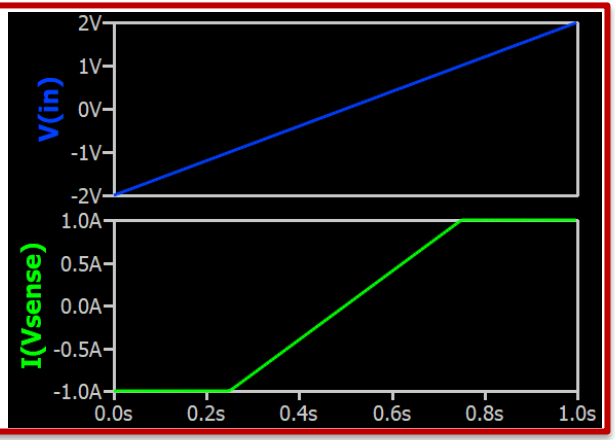


Idea of VVCS with Current Limit



Example





Phase Shift Pulse with Delay Control

Qspice : PhaseShift_KSK1.qsym

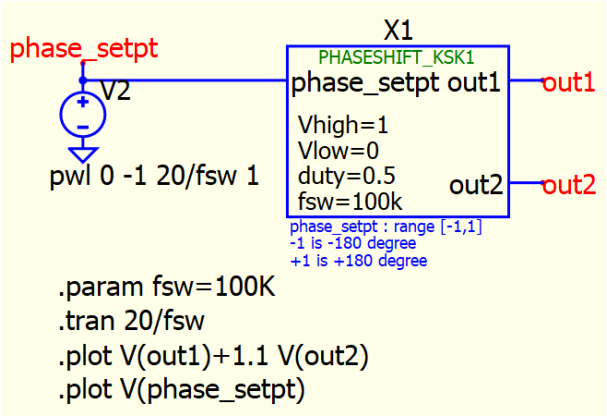
- PhaseShift_KSK1.qsym
  - Use behavioral source with delay function to generate phase controlled pulse source
  - User to define switching frequency and duty as input parameters (these cannot be change during simulation)
  - Phase_setpt is input port which control delay time in delay(), the delay is controlled with formula $\frac{v_{phase\_setpt}}{2f_{sw}}$
    - A $\frac{1}{fsw}$ is used to prevent negative y value into delay(x,y,z)
    - z set to $2f_{sw}$ to reduce waveform memory in simulation

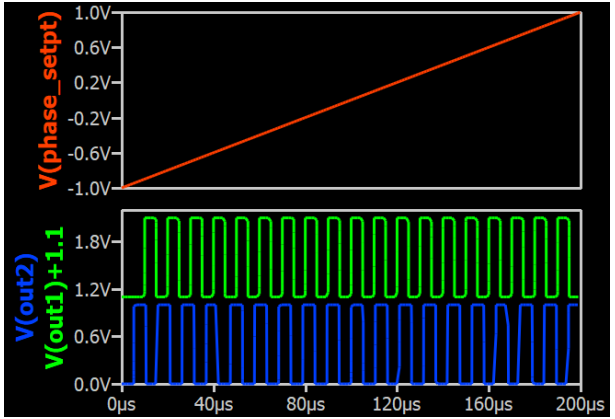
Ideal of PhaseShift_KSK1 subckt

```
.param Vhigh=1
.param Vlow=0
.param duty=0.5
.param fsw=100K

.tran 20/fsw
.plot V(out1)+1.1 V(out2)
.plot V(phase_setpt)

Ref
V1
pulse Vlow Vhigh 0 0 0 duty/fsw 1/fsw
phase_setpt
V2                    phase_setpt : range [-1,1]
pwl 0 -1 20/fsw 1     -1 : -180 degree
                      +1 : 180 degree
Td
B3
V=limit(V(phase_setpt),-1,1)
out1
B2
V=delay(V(Ref),1/fsw,2/fsw)
out2
B1
V=delay(V(Ref),1/fsw+1/fsw*V(Td)/2,2/fsw)
delay(x,y,z) with z=2/fsw is to reduce waveform memory
```

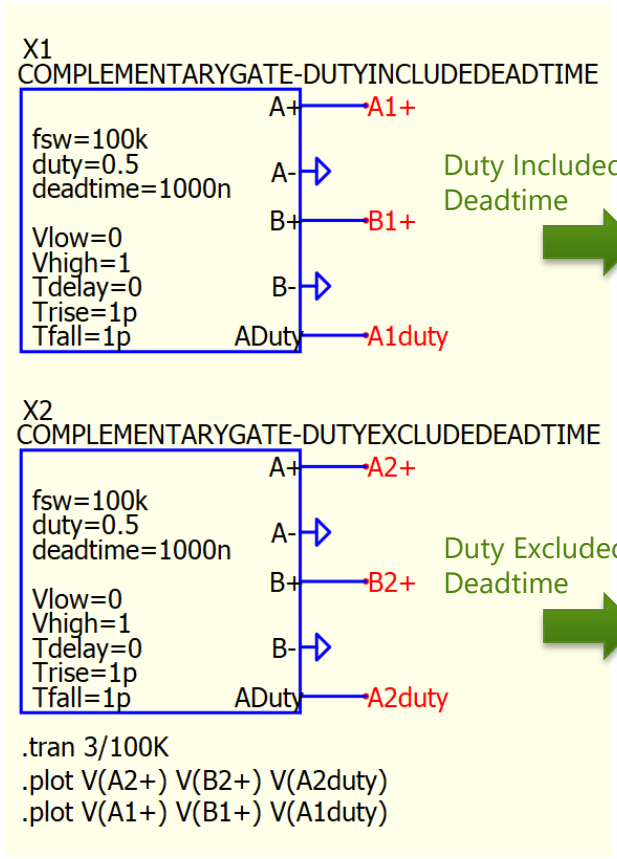




Complementary Gate Signal with Deadtime

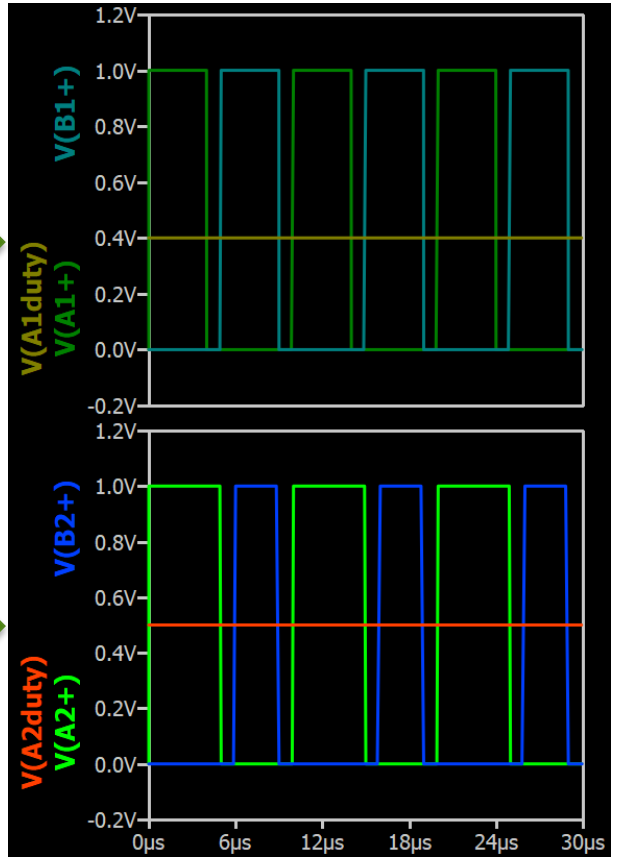
Qspice : ComplementaryGate-DutyExcludeDeadtime.qsym | ComplementaryGate-DutyIncludeDeadtime.qsym

- Complementary Gate
  - To generate complementary gate signal (differential output) with deadtime
  - Symbol with duty to include or exclude deadtime
    - Include Deadtime, A+ ON time is $\frac{duty}{period} + deadtime$
    - Exclude Deadtime, A+ ON time is $\frac{duty}{period}$



Duty Included Deadtime

Duty Excluded Deadtime



Complementary Gate Driver with Deadtime

Qspice : Gate-DeadTime.qsym

- Complementary Driver
  - Symbol
    - Gate-DeadTime.qsym
    - Gate driver with complementary output signal separated by deadtime
  - Input Parameters
    - Deadtime : deadtime in second
    - TTOL : Temporal tolerance
    - (Invisible) Hi : Output High Level
    - (Invisible) Lo : Output Low Level
  - ** beware that as deadtime is required, the ON duration of IN and Q will be different by the deadtime