Pulse Frequency Modulation with Adaptive DeadTime

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Pulse Frequency Modulation with Adaptive DeadTime

- Purpose
  - Circuit concept of Pulse Frequency Modulation with controllable dead time percentage (%)
- Part #1 : Voltage controlled frequency source
  - To generate a sine wave with a time-varying frequency in the time domain while ensuring phase continuity
  - The general form of a sine wave with time-varying frequency is

$$x(t) = \sin\big(\theta(t)\big)$$

    where $\theta(t)$ is the instantaneous phase of the sine wave
  - The instantaneous frequency $f(t) = \frac{1}{2\pi}\frac{d\theta(t)}{dt}$
  - Thus, to compute $\theta(t)$, integrate the instantaneous frequency over time

$$\theta(t) = 2\pi \int_0^t f(\tau)\, d\tau + \theta_0$$

    where θ_0 is the initial phase
  - The final formula for a sine wave with smoothly varying frequency is

$$x(t) = \sin\left(2\pi \int_0^t f(\tau)\, d\tau + \theta_0\right)$$

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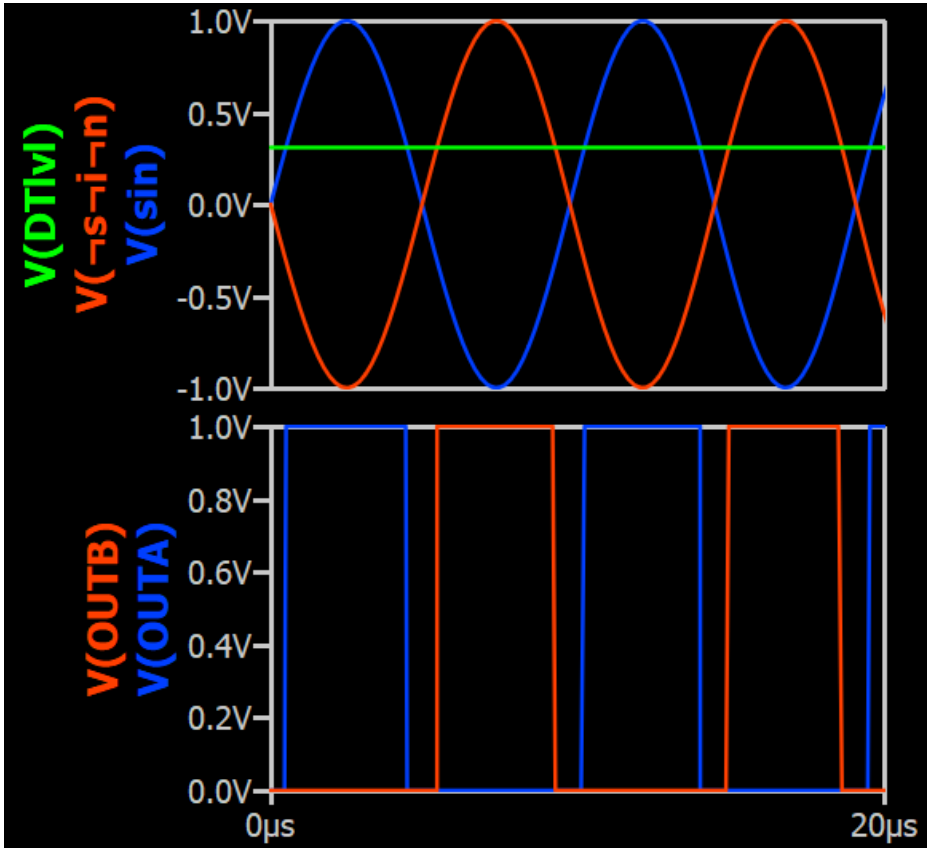
- Part #2 : Complementary Gating
  - If a frequency-dependent sine wave and its inverted signal are compared to a threshold, a complementary gate driving signal can be generated
  - The threshold is used to determine the duty cycle (or the dead time between complementary signals)



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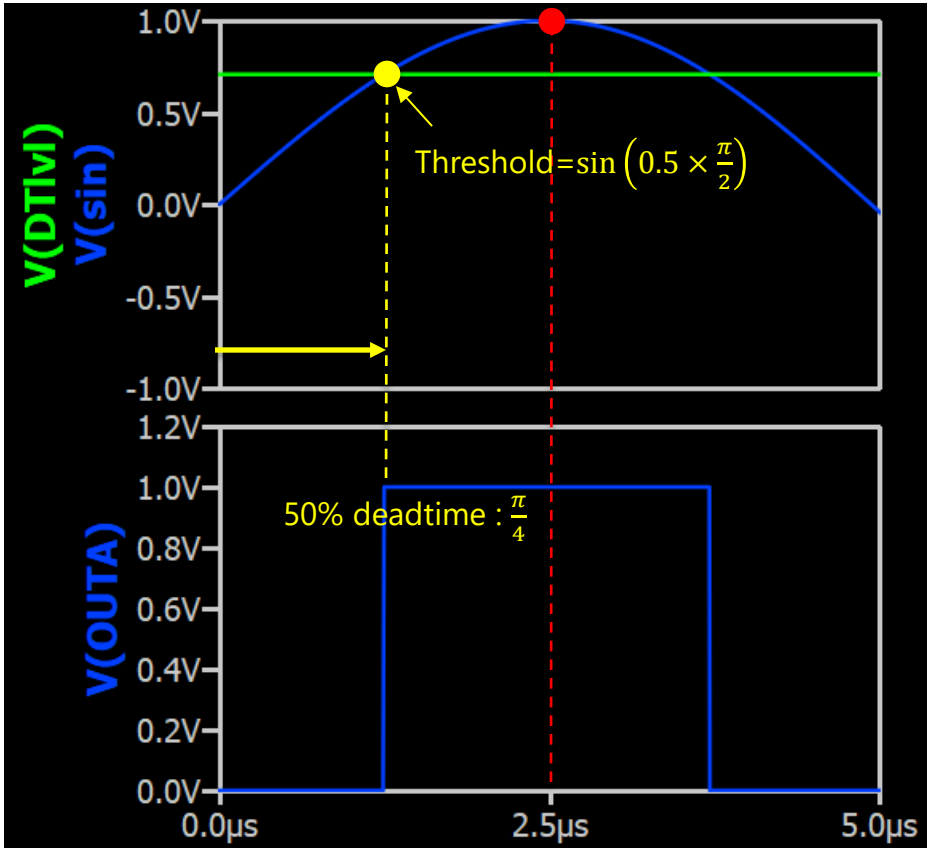
- Part #2 : Complementary Gating
  - Threshold in sine wave comparison to yield percentage of deadtime is threshold = $\sin\left(\frac{Deadtime\%}{100\%} \times \frac{\pi}{2}\right)$



100% deadtime : $\frac{\pi}{2}$

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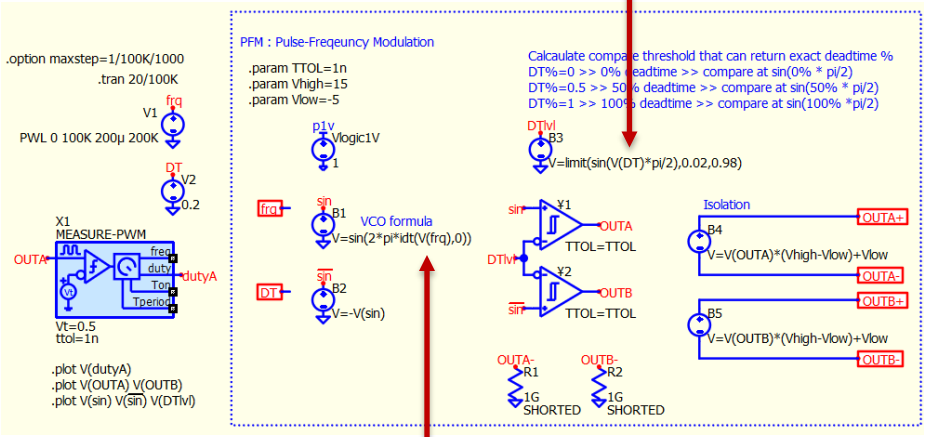
Qspice : concept.PFM-Bridge-DeadTime.qsch

$$\text{threshold} = \sin\left(\frac{Deadtime\%}{100\%} \times \frac{\pi}{2}\right) = \sin\left(\text{DT} \times \frac{\pi}{2}\right)$$



$$\sin\left(2\pi \int_0^t f(\tau)\, d\tau\right)$$