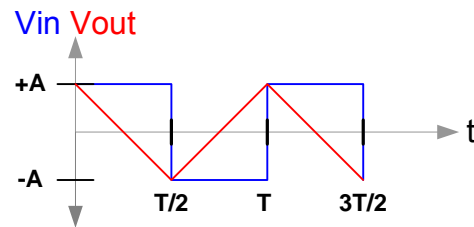


Inverting Miller Integrator

$$v_{out} = - 1/(R1 C1) \times \int v_{in} dt$$



Construct an integrator that has a time constant ( $R1C1=1\text{ms}$ ) of 1ms.

Apply a square wave to the input of the integrator  
(The TA will specify frequency and magnitude).

Does the waveform of  $V_{out}$  make sense?

Explain why or why not.

For a square wave input voltage of magnitude A and period T we can write the input voltage as piecewise function ignoring the transitions at 0, T/2, T :  $V_{in} =$

$$+A : 0 \leq t \leq T/2$$

$$-A : T/2 \leq t \leq T$$

Breaking the integral into two parts noting that the integral is that of a constant we derive that:  $0 \leq t \leq T/2$ ,  $V_{out} = -At/\tau + C1$  and  $T/2 \leq t \leq T$ ,  $V_{out} = At/\tau + C2$

Given:  $\tau = R1 \times C1 = 1\text{ms}$  and assuming that  $V_{out}(0) = A$

To determine the period T or frequency that will produce the desired output:

$V_{out}(0) = A$  and  $V_{out}(T/2) = -A$  desired.

$$V_{out}(T/2) = -A = -1000 A (T/2) + A$$

$$2A = 1000 A (T/2)$$

$$4 = 1000 T$$

$$T = 4/1000 = 4\text{ms} \text{ so } F = 250 \text{ Hz. } (T = 4\tau)$$

The initial conditions for the integration are then:

$$C1 = A \text{ and } C2 = -A$$

$$V_{out}(T/2) = -2A + A = -A$$

$$V_{out}(T) = 2A - A = A$$

Find:

1)  $V_{out}$  at  $t = T/4$  assuming  $V_{out}(0) = C1 = A$

$$V_{out}(T/4) = A - 1000 (1\text{ms}) A = 0$$

$$V_{out}(3T/4) = A - 1000 (1\text{ms}) A = 0$$

2)  $V_{out}$  at  $t = 3T/4$  assuming  $V_{out}(T/2) = C2 = -A$

$$V_{out}(3T/4) = -A + [1000 (3\text{ms}) - 1000(2\text{ms})] A = 0$$