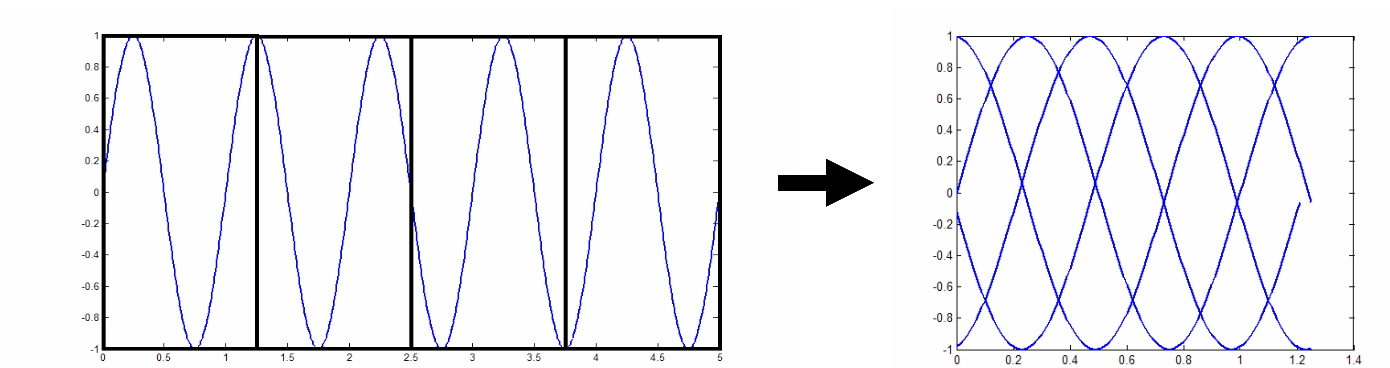
# Lecture 5 Goals:

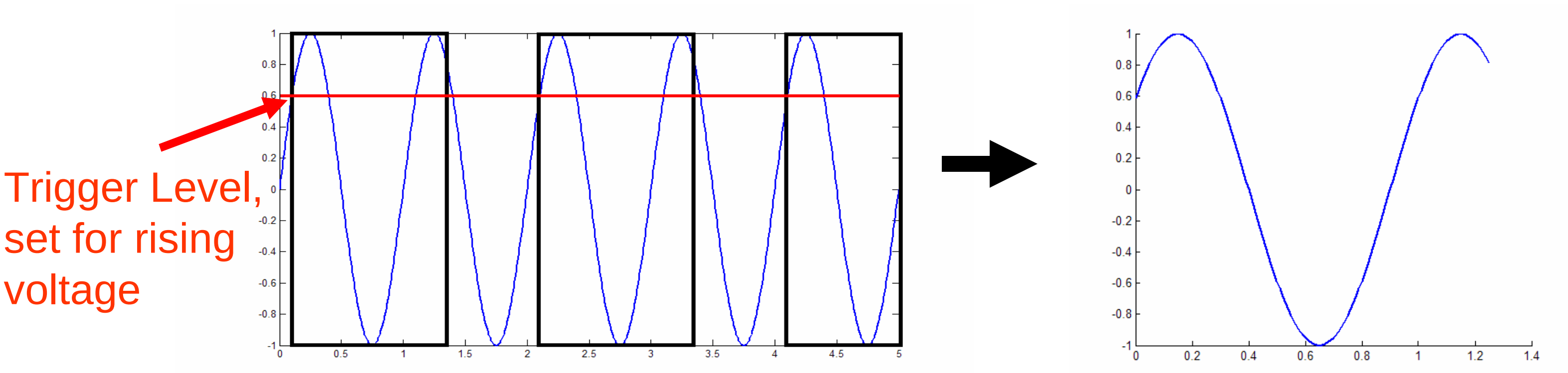
- Lab Skills
  - Oscilloscope Triggering
- Analyze the Step response of a RC Circuit
  - PSpice: Placing the Cursor at a specific point
- Design a Timer Circuit
- Design a Integrating Op-Amp

# Oscilloscope Triggering

- The trigger level tells the oscilloscope when to start sweeping out the trace

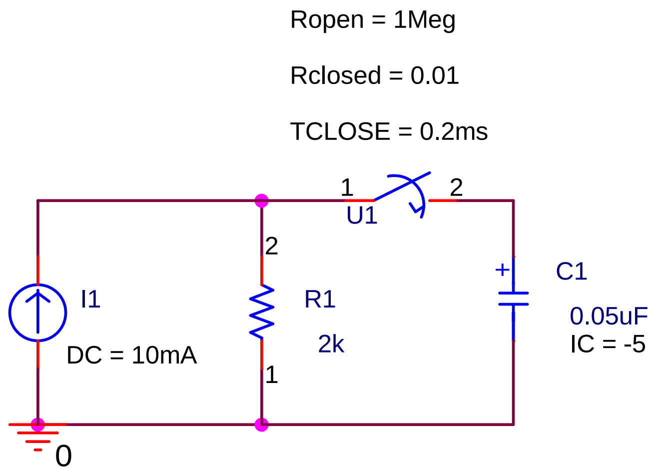


- Without a trigger, the signal would look like this on the O-scope



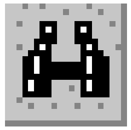

- A trigger level makes the graph look more consistent.
- The trigger can be CH1, CH2, or an external source.
- The level can be adjusted,  and set for either rising or falling voltage.

# PART 1: Response of an RC circuit to a Step Input

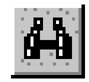



| **PSPICE:** | |
|---|---|
| ***Analysis Type:*** | *Time Domain (Transient)* |
| ***Run to time:*** | *1ms* |
| ***Maximum step size:*** | *1us* |
| ***New Parts:*** | ***Parameters:*** |
| *Sw_tClose/EVAL* | *TCLOSE, Rclosed, Ropen* |
| *C/CLASS* | *IC* |

- Find: V(t), $I_C$(t), and $I_R$(t) for t ≤ $t_0$- and t ≥ $t_0$+ in terms of {I, R, C, $V_0$, $t_0$}. Use the FIFE equation.
- Run a Time Domain (Transient). Plot V(t), $I_C$(t), and $I_R$(t), and mark the curves at t = 0.3ms.
- Calculate your equations for t = 0.3ms. Troubleshoot if you values do not match PSpice (i.e. adjust switch parameters, check ckt, TI-89…)
- Based on how capacitors behave ( effective characteristics), justify the results of V(t), $I_C$(t), and $I_R$(t) at t = $t_0$+ and t = infinity .



# Search Commands

- The cursor can be positioned to a specific x value,  or a specific y value using cursor search.
- First click the cursor search button 
- Select a cursor to move.

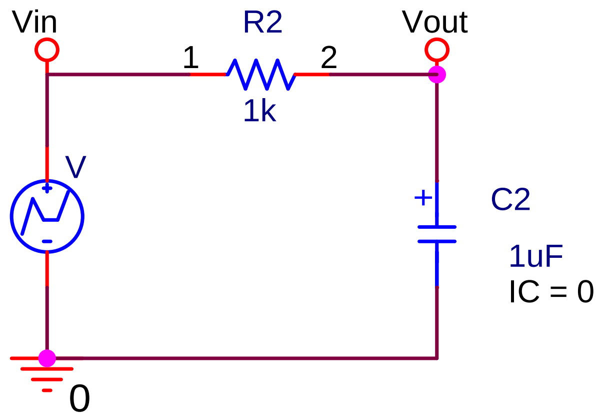
For a specific x value:


For a specific y value:


NOTE: the search starts from the current position and moves forward (by default ) additional commands can change the search direction:

***search [forward/backward] [xvalue/level] [(value)]***

# PART 2: Response of an RC circuit to a Pulse Input




**PSPICE:**

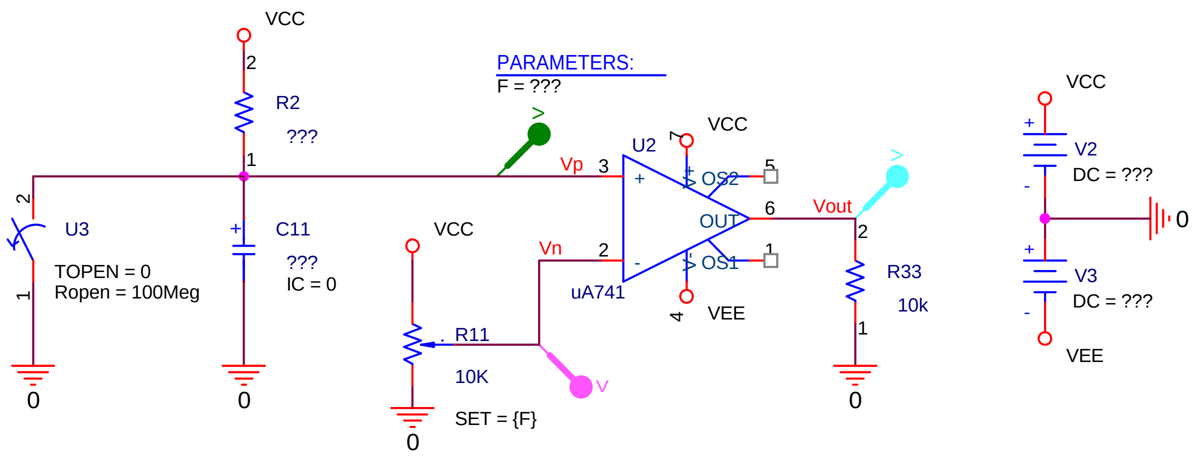
| | | |
|---|---|---|
| ***Analysis Type:*** | *Time Domain (Transient)* | |
| ***Case:*** | $3\tau$ | $5\tau$ |
| ***Run to time:*** | *9ms* | *15ms* |
| ***Maximum step size:*** | *1ms* | *1ms* |
| ***New Parts:*** | ***Parameters:*** | |
| *VPWL/SOURCE* | *t1, t2, t3, t4, t5, v1, v2, v3, v4, v5* | |
| *-OR- VPULSE/SOURCE* | *V1, V2, TD, TR, TF, PW, PER* | |

- Run a Time Domain (Transient) with the voltage source setup to have a pulse width of 3 ms. Make sure initial cap voltage is 0V. Add a trace to the plot for Vin and Vout. Mark Vout at 6ms. Print 2 copies and keep one for the lab experiment.

- What % of its final value does Vout rise to?

- Adjust your voltage source for a pulse width of 5 time constants ( 5ms ). Repeat transient and find % final value.

# PART 3: RC Timing Circuit with Comparator




- Design the circuit such that at t = 10 seconds Vout changes from 0 V to 5 V.
- First find the capacitor voltage as a function of time. Set the time constant to an appropriate value using standard capacitors and resistors
- Adjust the pot setting F such that Vn = Vp at t = 10 seconds.
- Make sure TOPEN is at least 100 MΩ. Run a Time Domain (Transient) with voltage probes at Vp, Vn, and Vout. Adjust Vcc and Vee such that Vout is as close to 0 and 5 V as possible. Mark Vout at the 0 V case, 5 V case, and the 12 second transition

**PSPICE:**

***Analysis Type:***

*Time Domain (Transient)*

***Run to time:***

*15s*

***Maximum step size:***

*10ms (Increase to shorten simulation time)*

***New Part:***

*Sw_tOpen/EVAL*

***Parameters:***

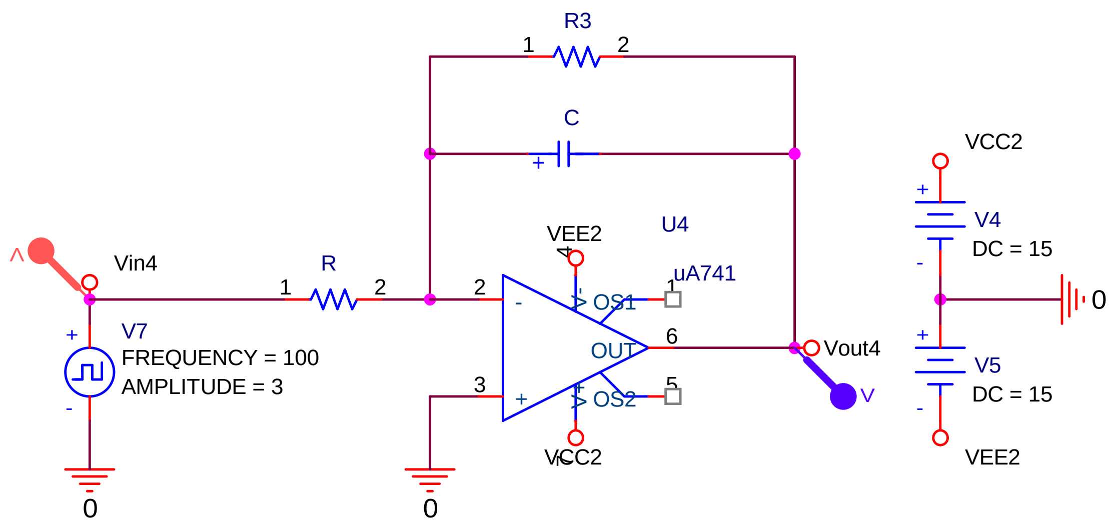
*TOPEN, Rclosed, Ropen*

**Design Specs:**

| | |
|---|---|
| $V_{OUT}$ = 0 +/- 0.1 V | for t < 10 sec |
| $V_{OUT}$ = 5 +/- 0.1 V | for t ≥ 10 sec |
| *Transition time:* | *10+/-0.1 sec* |

NOTE: PSpice ver. 15.7 will complain that too many components are being used. Removing the switch, and setting the CAP IC = 0 will fix the problem

# PART 4: Integrating Op-Amp Circuit




**PSPICE:**

***Analysis Type:***

*Time Domain (Transient)*

***Run to time:***

*20 cycles of output*

***Maximum step size:***

*1us (Increase to shorten simulation time)*

*Check "Skip initial transient solution"*

***New Part:***

*Vsq/CLASS*

***Parameters:***

*FREQUENCY, AMPLITUDE*

- Design R and C such that Vout has a peak to peak voltage of 6 $V_{P\text{-}P}$. Use standard values.
- Figure out how long to run a transient such that 20 cycles of Vout is shown.
- Find a value for $R_f$ that effectively removes the drift while keeping Vout within 200mV of 6 $V_{P\text{-}P}$.
- Run another transient long enough to see the drift settle down, mark this settling down time ( $t_s$ ) and its corresponding $V_{P\text{-}P}$.

**Design Specs:**

*$V_{OUT}$ = 6 +/- 0.2 $V_{P\text{-}P}$ Sawtooth Wave*

*Remove drift after a settling down time*