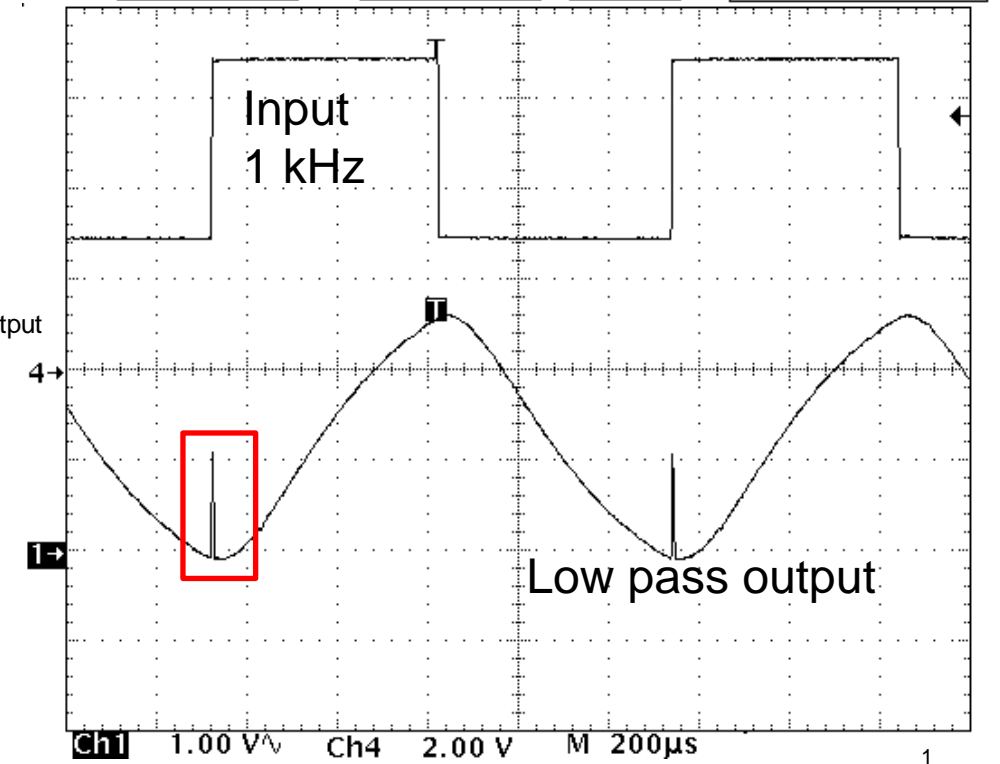
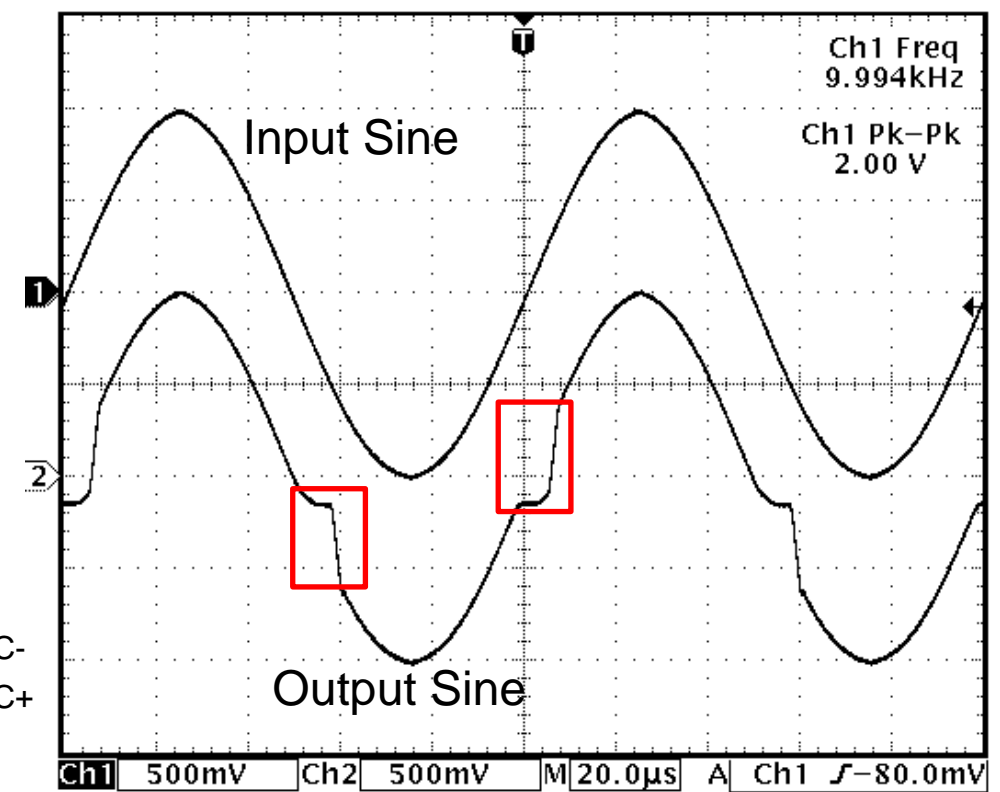
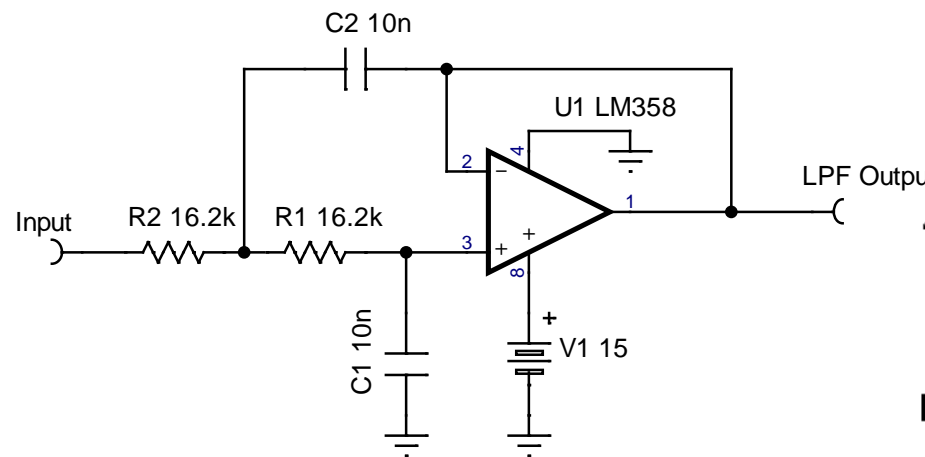
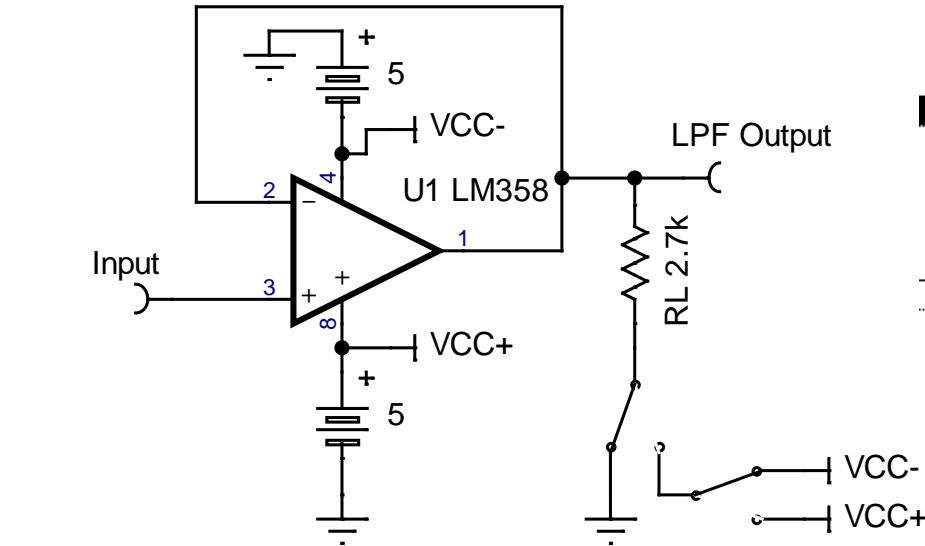


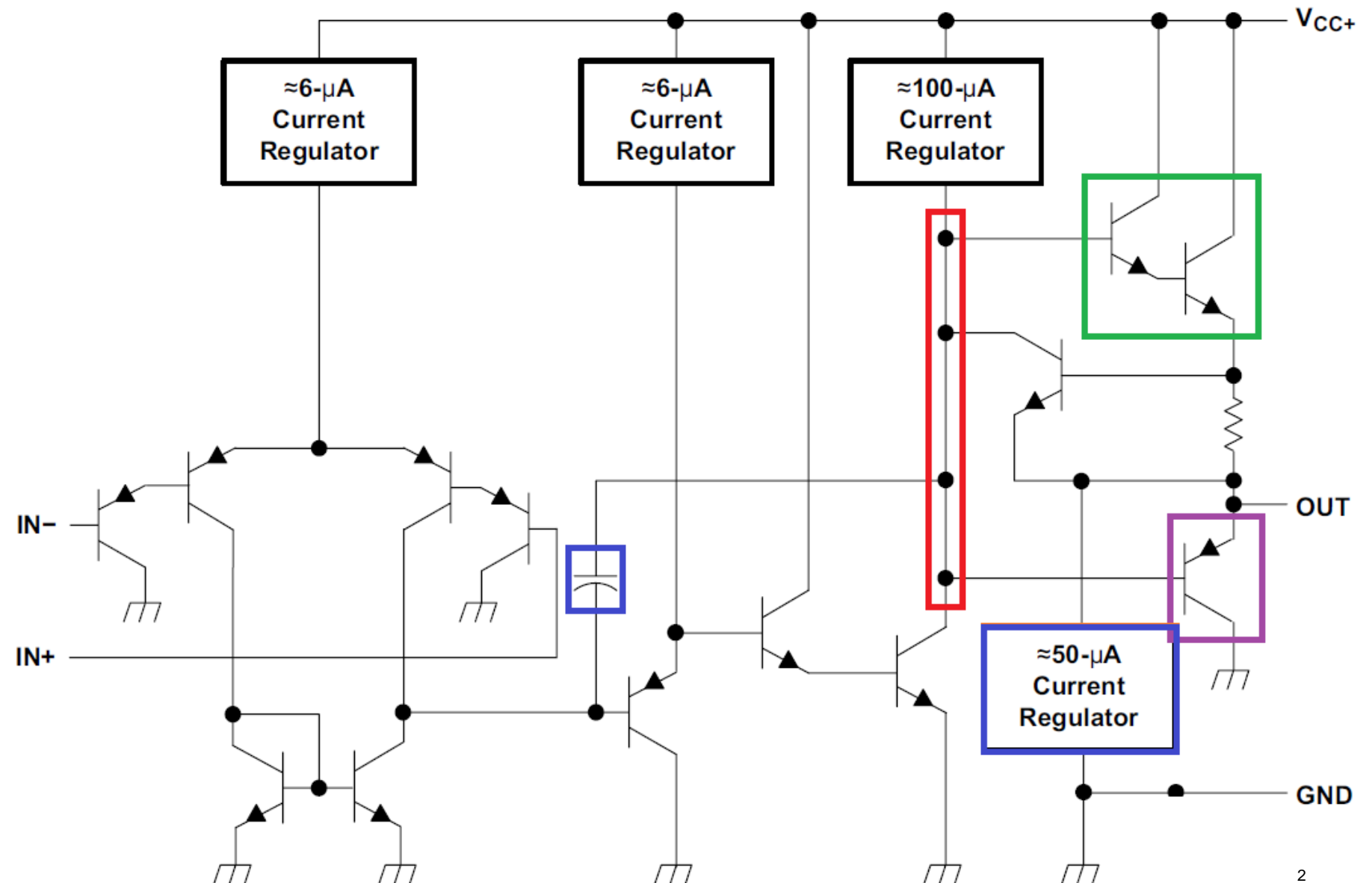
TS321, LM358, LM324 Family crossover delay

- Signal artifacts can occur internally as seen in unity gain amp (top) when load is terminated to mid-supply-rail.
- Signal artifacts can occur externally as seen in low pass filter amp (bottom) when input step current is capacitively coupled to output.
- In both cases, the root cause is the same. The output becomes high impedance (not open) while output stage switches between high current sink and high current source drivers.
- In both cases the solution is to ensure unidirectional output current. In top schematic terminate load to VCC+ or VCC-. In bottom schematic add pullup or pull down resistor.
- Next slide covers reason for the delay.



TS321, LM358, LM324 Family crossover delay

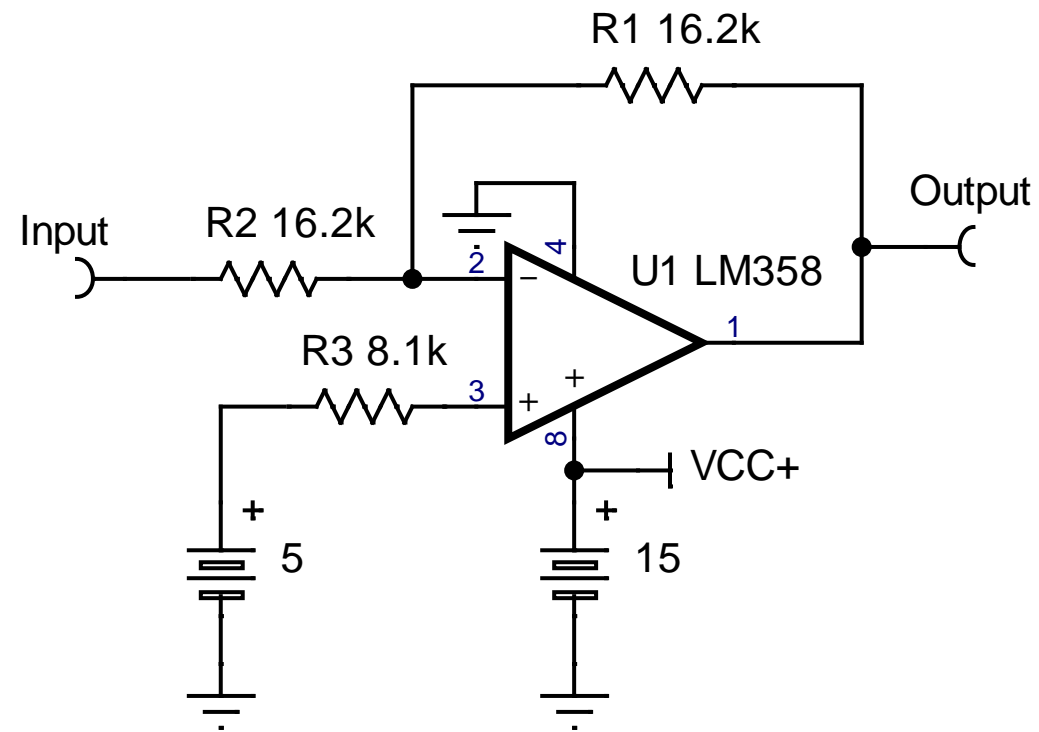
- The crossover delay is a side effect of the unique output structure.
- There is a low impedance Darlington NPN source current driver (green) with a 1.5V to 2V headroom requirement. This limits VOH level.
- There is emitter follower sink current driver (purple) with a 0.7V headroom requirement. So it can't provide sink current when OUT is near GND.
- There is a 2nd weaker constant current sink driver (blue) that has a high impedance, and low VOL at light load.
- The red node controls the main source and sink drivers and has a 3-diode-drop dead-band between source and sink drive. The slew rate capacitor limits the slew rate of the red node.



TS321, LM358, LM324 Family dual sink driver

- This inverting amplifier can't produce a V_{OL} near zero because the current needed by the feedback resistor is $>0.2\text{mA}$.
- The load line intercepts the output curves between 0.43V and 0.77V depending on the device temperature.

If R_1 and R_2 are increased to 300k , then the load line intercepts well under 100mV at all temperatures. To cancel input bias current, change R_3 set to 150k



Data sheet minimum current at 200mV is $12\mu\text{A}$
DS maximum voltage at 10k to ground is 20mV

