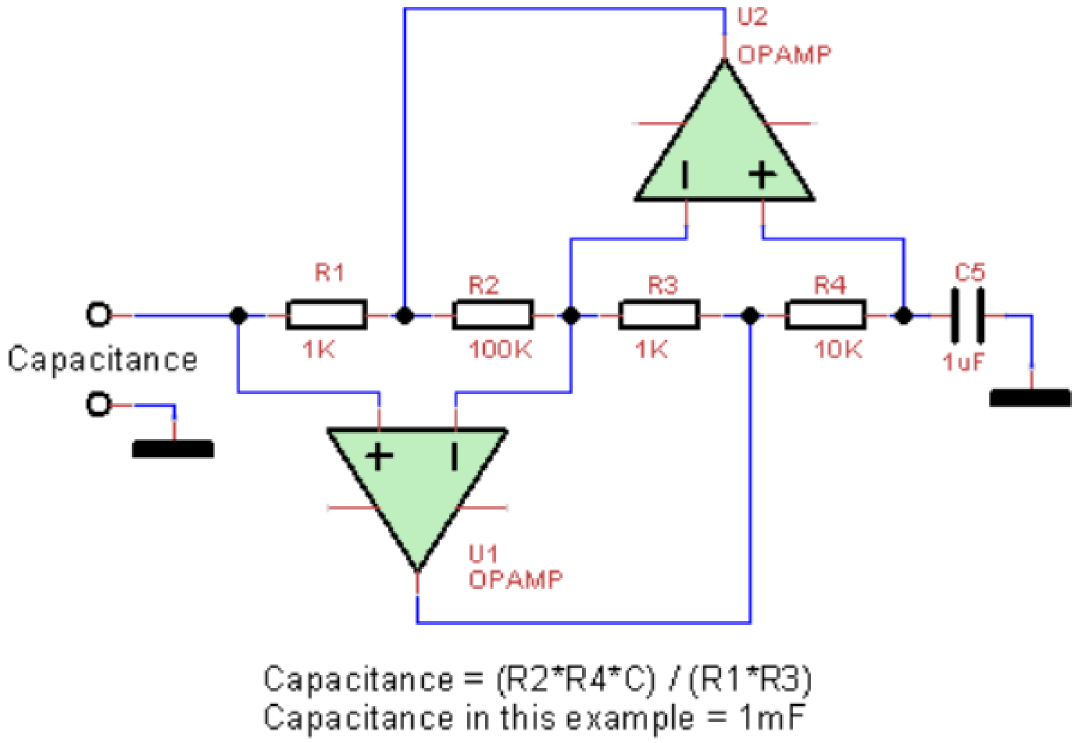
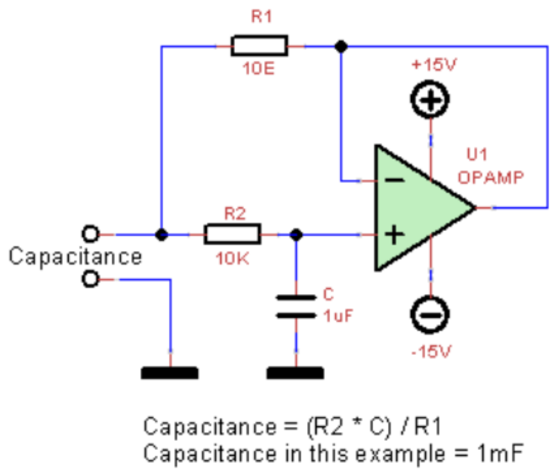
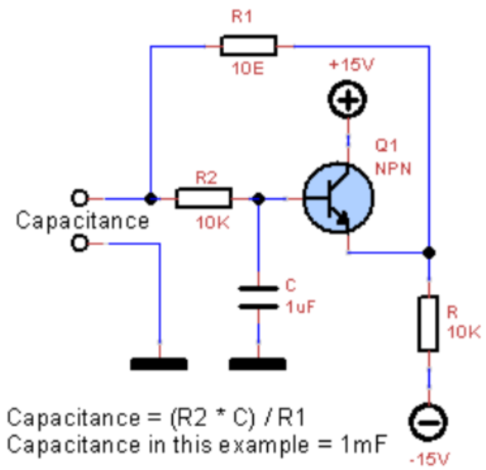
Grounded scaled capacitors

Capacitance multiplier based on the Antoniou gyrator



Capacitance multiplier using an RC integrator and buffer





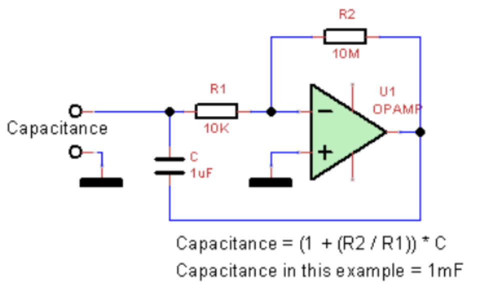
Left figure above : R2 and C form an integrator. The OPAMP U1 is configured as a voltage follower, so the capacitor voltage at the non-inverting input also appears on the non-inverting input. This means that the voltage over R1 is equal to the voltage over R2. But because R1 is 1000 times lower than R2, R1 will draw extra current away from the input. Because of this extra current, the input feels like being loaded with a much bigger capacitor (1000x bigger in this case).

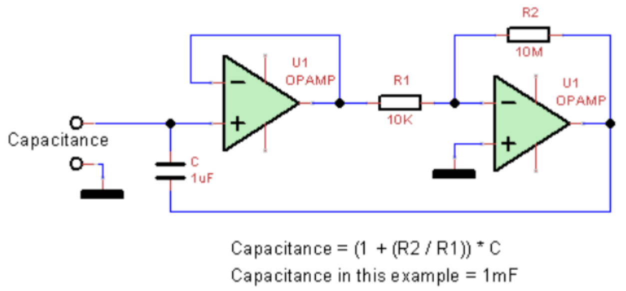
- **Note :** *The OPAMP can only deliver a limited current, so there is a lower limit to the value of R1 (10E).*

Right figure above : Here the transistor is an emitter follower that will copy the voltage on it's base, which is the voltage over C, to the emitter, connected to R1.

- **Note** :*Because the transistor does not make an exact copy but looses 0,7V (base-emitter voltage) on the way, the circuit is not as accurate as the OPAMP circuit on the left.*
- **Note :** *The transistor has a limited Hfe (current amplification factor, so there is a lower limit to the value of R1. More emitter current means more base current, means more load on the capacitor C.*

Capacitance multiplier using bootstrapping





In the circuits above, a bootstrapping technique (like pulling yourself up from the floor by your bootstraps) is used to make the capacitor at the input feel like a much bigger capacitor. The bootstrapping lies in the fact that the lower node of the capacitor is not connected to ground, but is connected to the output of an inverting amplifier that amplifies and inverts the voltage at the upper node of the capacitor. So the lower node of the capacitor is pulled down additionally, so more current is needed to charge the capacitor, making it look like a much bigger capacitor is connected to the input.

The right circuit above is an improvement over the left circuit, because the capacitor voltage is first buffered by an OPAMP U1, that is connected as a voltage follower. This prevents that input impedance of the inverting amplifier influences the voltage on the capacitor C.

Capacitance multiplier using an integrator