An LED's intrinsic capacitance works in a 650-mV LRC circuit

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You can use the inherent capacitance of an LED to make a series resonant boost circuit that can create a voltage large enough to light the LED. Depending on the color of the LED, you need a voltage higher than 1.6V to turn it on. The threshold, or knee, voltage rises higher as the LED wavelength becomes shorter. All PN-junction diodes, including LEDs, have capacitance due to depletion and diffusion profiles.

You can light an LED using its capacitance in a series LRC (inductance/resistance/capacitance) resonant circuit. In such a circuit, the Q factor determines the multiple of the generator voltage that appears across LC. If you fashion a circuit with a high enough Q factor, you boost the generator voltage enough to light the LED. The Q factor of the resonant circuit is a function of the resistance, inductance, and capacitance, as the following equation shows:

\[ Q = \left( \frac{1}{R} \right) \sqrt{\frac{L}{C}} \]

You can verify this calculation with a simple circuit using a blue LED in series with an inductor (Figure 1). The knee voltage of the LED is 2.45V, and the signal generator has an internal resistance of 50Ω. An inductance of 100 μH and the 50-pF capacitance of a typical LED yield a Q of 28. The amplitude of the sinusoidal signal generator is set at 650 mV p-p. You can then vary the generator’s output frequency until you see the circuit’s resonant point. As the circuit approaches the resonant frequency, the voltage across the LED starts to increase. The resonant point manifests itself as a small jump in voltage, rather than a smooth progression, due to a positive feedback at resonance. The positive feedback happens because the capacitance of any PN-junction device is not linear (Figure 2). As the circuit approaches the resonant frequency, the LED voltage increases, which also increases the LED capacitance, resulting in lower resonant frequency.
For a blue LED, the voltage waveform as the circuit approaches resonance is 1.55 MHz. The circuit settles at 1.69 MHz (Figure 3). The forward-biased LED is thus emitting light, clipping the positive parts of the boosted waveform. Using the same 650-mV-p-p generator amplitude on other colors of LEDs produces different resonant frequencies. You can see a similar effect with a square-wave generator because it also contains the fundamental components of the resonant frequency.