All solid-state lighting, generally speaking, is powered by an AC power source. Of course there are some LED lights that are battery operated. The AC source has a 50Hz or 60Hz line frequency that must be rectified to be used for LEDs. There are LEDs that can be powered directly by the AC line, but most products in the market have LED drivers that convert the AC line to the proper LED voltage and current.

The AC LED, or so-called driverless LED, incorporates the line frequency component that turns the LED light on and off at the rate of 50 or 60Hz. All of these LED driver solutions, including some of the more sophisticated LED drivers exhibit some degree of this line frequency sine wave artifact. Many LED drivers introduce low-frequency flicker at two times the line frequency: 100Hz flicker for a 50Hz line frequency or 120Hz for a 60Hz line frequency.

An LED is a semiconductor component, and like any other semiconductor it responds very fast to the input. Any current or voltage fluctuation at the input is immediately reflected to the output, which in this case is light. When the input variation is the line frequency modulation, the light produced will be modulated as well and that modulation (or variation) in the light produces flicker.

The human eye and brain process the light from LEDs within a finite time, so most of us will not notice or "see" the flicker. This is especially the case when the light is exceedingly bright, which makes the pupil opening very small, further "filtering" the flicker effect. Our eyes and brain are more sensitive to low ambient light because the pupil opens very wide to capture all the available light.

In either case (bright or low light), it has been assumed that, because the flicker is largely imperceptible, it is acceptable. However, studies have linked flicker to health problems. So, even though flicker at these frequencies may not be visible to the naked eye, there is evidence that the human brain can detect light flicker frequencies as high as 200Hz. Potential problems include headaches, eye strain, impaired visual performance or, in extreme cases, epileptic seizure.

Even incandescent and fluorescent lighting produces flicker. Incandescent bulbs are made of tungsten that heats up when connected to the AC power source to produce light. The heating process actually follows the input line frequency, so it heats up and down at the line frequency. However, heat has a long thermal constant, so it cannot cool down fast. Therefore it has somewhat of a built-in filter that averages out. Because of this, standard incandescent bulbs do not produce much flicker. Instrumentation can demonstrate that the incandescent bulb does have flicker but it cannot be seen by the naked eye.

Fluorescent lamps glow and produce light when the electrons traveling inside the tube collide on the internal phosphor coating. Similar to incandescent bulbs, the phosphor has good persistence properties that maintain the glow for a short period of time. This reduces the flicker effect, but,
again, with instrumentation we still can show the flicker, even though it cannot be seen by the human eye.

Several industry groups are researching the effects of flicker in LED lighting, including the IEEE (see http://grouper.ieee.org/groups/1789/public.html). The IEEE "Flicker Technical Report" indicates that our brain does respond to light at frequencies up to, and beyond 120Hz.

The Epilepsy Action website (http://www.epilepsy.org.uk) states that "Most people with photosensitive epilepsy are sensitive to 16-25 Hz, although some people may be sensitive to rates as low as 3 Hz and as high as 60 Hz." Because of the brain activity that is stimulated by both visible light flicker (3 to 70Hz range) and invisible flicker, many now believe both types of flicker can induce medical issues, including headaches, eyestrain and epileptic episodes.

Aside from the important health issues, LED flicker also causes non-health related annoyances and problems. For example, everyday we use our mobile phone to snap spur-of-the-moment photos and videos. We enjoy the high-quality pictures and videos we take outdoors in the sunshine and expect the same result when shooting indoor events.

However, if you are shooting under indoor SSL lighting that is equipped with poorly designed LEDs, the photos and videos will produce results like the picture shown below - with dark bar lines across the picture. This results from invisible flicker produced by the LED bulb, which the human eye cannot see.

A direct photo taken of an LED bulb (below) also dramatically shows this flicker phenomenon.
So we need to question ourselves again, does flicker really matter? From health concerns to ruining your digital videos and photos, flicker absolutely matters!

But wait! There is yet another source of flicker in solid-state lighting. This one comes from dimmable LED bulbs, which can also interact with, and produce undesired flicker when connected to a dimmer. This is due to the analog method of dimming, where the LED drivers allow modulation of the LED current at double the line frequency. The IEEE Standard PAR1789 “Flicker Technical Report” discusses low-frequency flicker (~3Hz to 70Hz) caused by residential dimmer switches in detail ([http://grouper.ieee.org/groups/1789/FlickerTR1_2_26_10.pdf](http://grouper.ieee.org/groups/1789/FlickerTR1_2_26_10.pdf)).

One solution to eliminate the ripple that results from the 2X line frequency modulation is to use a proven high-quality, high-performance two-stage digital LED driver design to eliminate the line frequency component. In this topology, the first stage is dedicated to power factor correction (PFC), which mimics the input as a resistive load so the dimmer is happy and at the same time produces an intermediate voltage that has minimum line frequency ripple. The second stage is a flyback converter that provides safety isolation and also filters and delivers the DC current to the LED without any ripple.

In addition to high power factor correction, other factors to consider when choosing an LED driver include low total harmonic distortion (THD) to meet stringent global power standards, as well as ensuring the driver can meet other standards, like the NEMA SSL 6 dimming standard for incandescent, screw-base lighting retrofit applications, and the Zhaga consortium’s hot-plug LED module requirements for LED light interchangeability and compatibility between lighting products made by diverse manufacturers.

Oh yes, and then there are issues such as cost, which can be managed by reducing the BOM (look for devices that don’t require a lot of components for EMI filtering and that use smaller, lower-cost E-capacitors). And then there’s compatibility with a wide range of dimmers and, of course, quality of light – you need to make sure you’ve got temperature protection (high temperatures degrade SSL bulb lifetime). Two digital LED drivers from iWatt (iW3616, iW3617) are third-generation parts that tick most all of these boxes, including thermal protection that de-rates the output LED current when the temperature reaches the maximum setting.