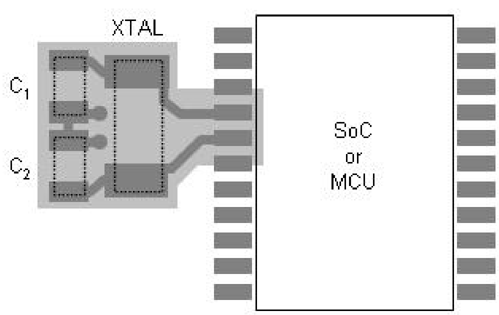
Silicon MEMS Oscillators Provide Benefits for LED Lighting

Over the last decade LED lighting has evolved from concept to mass production and is now replacing traditional lighting solutions at a rapid pace. LED lighting offers various benefits such as energy efficiency, extreme shock and vibration resistance, compact size, long life and effective dimming. LEDs are also environmental friendly since they do not contain hazardous substances such as mercury in fluorescent bulbs. Many LED lighting systems are built like a computer network and consist of a control unit, automatic motion detector/timer units, dimmers and other modules that communicate to each other through a wired serial interface, like DALI or through low speed wireless interfaces. This functionality requires microcontrollers (MCUs) or specialized IC chipsets that often require an external clock. There are various types of timing devices available today. Silicon MEMS-based oscillators offer high performance, reliability and flexibility, along with supply chain benefits and are the preferred solution for many lighting systems.

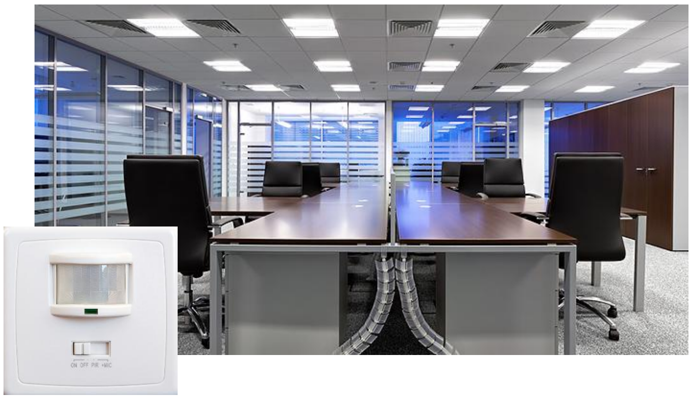
MEMS oscillator performance benefits LED systems

Most MCUs can use a crystal (XTAL), a built-in low-stability oscillator, or an external clock for the timing reference. A built-in oscillator saves space and cost, but has very poor performance that limits its application. XTALs have layout restrictions and must be placed very close to the XTAL inputs of the MCU, as shown in Figure 1. This can make component placement difficult in some designs. Since oscillators have standard CMOS outputs they can drive longer traces and therefore are more flexible in their location.

Figure 1: XTAL component placement

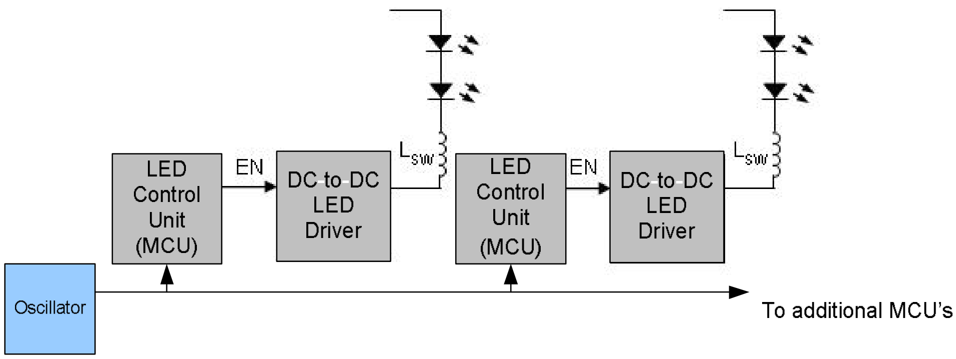


The lack of drive capability is another example of the limitations of XTALs. An XTAL cannot be used in multi-drop applications where two devices require the same reference clock (phase and frequency). SiTime MEMS oscillators offer flexible output drive strength options that allow driving up to 60 pF capacitive loads, so 3 or 4 ICs can be clocked with a single device, which serves not only synchronization purpose, but also saves space and cost.



LED lighting used in commercial buildings and offices is an application example in which an XO is preferred. Some locations have building codes that require at least two LED drivers with separate on/off switch controls for each room or area within a large room, as shown in Figure 2. A single MEMS oscillator can provide a reference clock for multiple LED control units.

Figure 2: XO supplies synchronous clock source for multiple LED control units

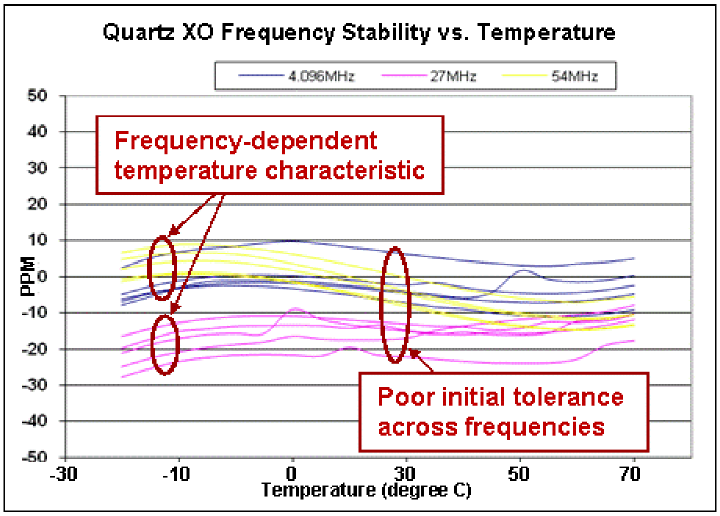


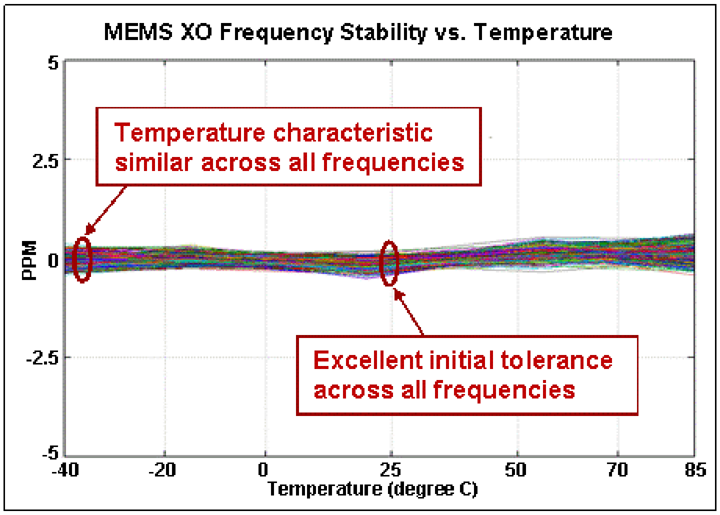
LED lighting systems don't contain glass parts and are very robust against shock and vibration. This advantage can't be used to its full extent with quartz-based references since they are inherently sensitive to shock and vibration. MEMS-based oscillators have more than 10 times better shock and vibration performance and are the preferable choice for harsh mechanical environments.

Another performance benefit of MEMS oscillators is better frequency stability over temperature. This factor has become very important as lighting installations have transformed from simple power networks into complex distributed systems linked with communication interfaces including power line communication (PLC) and wireless interfaces such as ZigBee, WPAN, and Bluetooth that require a stable low noise reference clock. Quartz oscillators have difficulty in achieving better than ±25 PPM stability over the industrial temperature range, have poor initial tolerance and require additional testing that increases cost. Figure 3a shows the disadvantages of quartz oscillators over a wide temperature range. MEMS oscillators, such as those from SiTime, can easily offer ±10 to 50 PPM stability at any temperature, supply voltage and output frequency. Figure 3b illustrates a SiTime MEMS XO that guarantees < ±10 PPM frequency stability over -40°C to +85°C. SiTime has MEMS oscillators with ±25 PPM frequency stability over the automotive temperature range from -40°C to 125°C offering benefits for industrial and automotive lighting applications, and outdoor lighting systems. Better frequency stability translates into better system timing margin and reliability.

LED lighting systems typically use DC-DC switching drivers that inject a high level of noise into the power supply network. This noise translates into jitter on the oscillator clock output and may affect performance of the system, especially communication interfaces. SiTime MEMS oscillators use internal voltage regulators and have much lower power supply noise sensitivity than quartz oscillators.

Figures 3a and 3b: Quartz stability vs. MEMS stability (Note the scale on Fig. 3b: ±5 PPM)





Silicon MEMS oscillators have a programmable architecture and offer superior flexibility compared to quartz-based oscillators. Output frequency, supply voltage and many other features can be programmed and this simplifies inventory and reduces lead-time. Various output drive strength options of MEMS oscillators can either be used to increase driving capability or to reduce EMI by slowing down the edges.

Another option that can be useful for reducing EMI is spread spectrum, which distributes the energy of carrier and it's harmonics over some frequency band.

MEMS technology offers better reliability with lower costs and very short lead-times

With all of the advantages of LED lighting, its high price remains as a top concern. In the total cost calculation, the long service life of LED lighting helps to offset higher initial costs, but designing reliability into the lighting system is very important for this reason. SiTime MEMS oscillators offer less than 3.5 ppm aging over 20 years which is the average predicted lifetime of an LED lighting system. There are differences in the cost and reliability between quartz- and MEMS-based oscillators. MEMS oscillators are typically less expensive than quartz and up to 40 times more resilient.

Availability is almost as important as performance and flexibility when selecting an oscillator. Many different oscillators are offered by many vendors; however less than five percent are generally held in stock because each quartz oscillator configuration has to be manufactured separately. Conversely, SiTime silicon oscillators are readily available and delivered on demand. SiTime uses batch manufacturing and semiconductor industry flow. In addition, SiTime is able to hold inventory in die bank and finished blank package form. As a result, samples can be easily configured to any frequency, voltage, PPM or package (within the range of the device) within minutes. Custom products for production will be delivered in two to four weeks.

Summary

LED lighting offers many benefits and is rapidly replacing traditional lighting solutions. LED technology has reached the critical point where mass production is profitable, driving higher volume and lower costs. Like silicon MEMS oscillators, LED lighting is a new technology that is quickly displacing legacy technologies. Both MEMS timing devices and LEDs are semiconductor devices. Both offer excellent shock and vibration performance along with other features not previously available to the industry. Lighting designers no longer need to accept and work around the many inherent limitations of crystal-based timing. Reference clocks based on new MEMS technology provide low-cost solutions with flexibility that addresses the limitations of quartz. MEMS oscillators offer the following.

- Any frequency between 1 to 220 MHz
- Low EMI output options, spread spectrum and output edge-rate control
- Very stable over temperature and long-term aging
- Excellent shock and vibration performance
- Small size

With greater performance, reliability and flexibility, SiTime MEMS oscillators provide a valuable reference clock alternative for LED lighting applications.

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