Accurate Silicon Oscillator Reduces Overall System Power Consumption

by Albert Huntington

Introduction

Choosing a clock used to be simple: grab an off-the-shelf fixed-frequency super-accurate, low jitter quartz crystal, or cobble together a rather noisy, inaccurate RC oscillator using discrete components. Recently, though, the number of clock choices has expanded, making the decision tougher, giving rise to a number of important questions. Is crystal accuracy absolutely necessary? Are low power consumption and reliability important, suggesting an all silicon solution? What about cheap ceramic resonators—are they up to the task?

Each of these solutions has strengths and weaknesses. Power consumption, accuracy, noise and durability must all come into consideration when choosing a clock. The LTC6930 is a self-contained, fully integrated all silicon oscillator that occupies a unique space within the world of clock solutions, providing a combination of accuracy and low power features that is hard to beat.

The LTC6930, which requires no additional external components, can accurately provide fixed frequencies between 32.768kHz and 8.192MHz over a wide supply range of 1.7V–5.5V (Table 1). It typically dissipates between 100µA and 500µA depending on frequency and load, and is available in both 8-lead 2mm × 3mm DFN and standard MS8 packages.

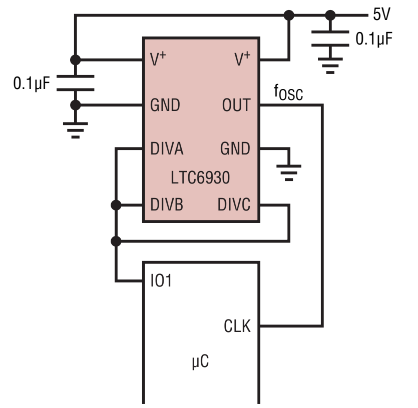

Figure 1. The LTC6930 clock configured as a 2-speed clock, slow and fast clock speeds are set via one I/O pin on a microprocessor

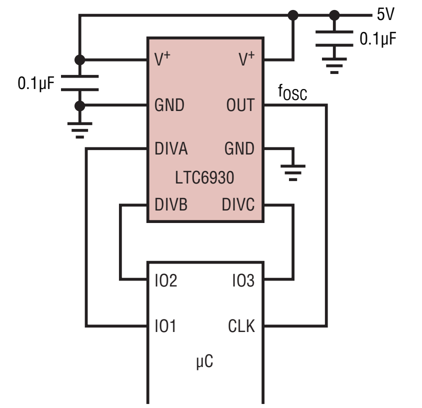

Figure 2. Fine control of the the LTC6930's frequency via three microprocessor I/O pins

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Smart Power Savings

Many electronic devices, especially battery powered portable applications, use low power sleep mode to conserve power during times of low activity. The depth and effectiveness of sleep modes is limited by recovery requirements—namely, how fast must the system come back up to full power. A standard crystal oscillator can be a major contributor to recovery delays.

Crystal oscillators can take tens of milliseconds to produce an accurate output when recovering from

Table 1. LTC6930 available frequencies and settings

	÷1	÷2	÷4	÷8	÷16	÷32	÷64	÷128
DIV Pin Settings [DIVC][DIVB][DIVA]	000	001	010	011	100	101	110	111
LTC6930-4.19	4.194304MHz	2.097152MHz	1.048576MHz	524.288kHz	262.144kHz	131.072kHz	65.536kHz	32.768kHz
LTC6930-5.00	5.000MHz	2.500MHz	1.250MHz	625.0kHz	312.5kHz	156.25kHz	78.125kHz	39.0625kHz
LTC6930-7.37	7.3728MHz	3.6864MHz	1.8432MHz	921.6kHz	460.8kHz	230.4kHz	115.2kHz	57.6kHZ
LTC6930-8.00	8.000MHz	4.000MHz	2.000MHz	1000kHz	500.0kHz	250.0kHz	125.0kHz	62.5kHz
LTC6930-8.19	8.192MHz	4.096MHZ	2.048MHz	1024kHz	512.0kHz	256.0kHz	128.0kHz	64.0kHz

a shutdown. The technique of using two clocks, a fast clock for full power operation and a slower sleep mode clock, can degrade the accuracy and recovery performance of the system—where clock switching generates runt pulses and slivers that can sabotage sleep recovery times.

In contrast, the LTC6930 easily and accurately transitions between fast clock mode and a slower sleep mode. The transition from one clock frequency to another takes less than a single clock cycle, and no runt pulses or slivers are generated. The LTC6930 also features a fast 100µs start-up time and the first clock-out is guaranteed to be clean. This makes it possible for the designer to apply sleep mode liberally, without worrying about clock recovery, thus saving significant overall system power.

Shifting the Clock Frequency

The output frequency of the LTC6930 is set by three DIV pins, which control an internal clock divider. The factory set master oscillator frequency may be divided by a factor of up to 128, and switching between these division modes is accomplished within a single clock period and without slivers or runt pulses. All three pins may be tied together to enable a simple digital signal from a microcontroller to shift the clock down by a factor of 128 as shown in Figure 1. This is enough to bring an 8MHz clock down to 64kHz.

The DIV pins can be addressed in various combinations for smaller frequency shifts or independently for complex power modulating systems where a microcontroller has fine control over its own clock speed, as shown in Figure 2.

Although there are some power savings within the LTC6930 when the output frequency is lowered (Figure 3), far greater savings are realized in the overall system. Power consumption in CMOS devices such as microcontrollers is roughly proportional to their operating clock speed. Slowing down the clock by a factor of 128 during a sleep condition can reduce the system power by a factor of 100—very important in a system that spends significant time in sleep mode.

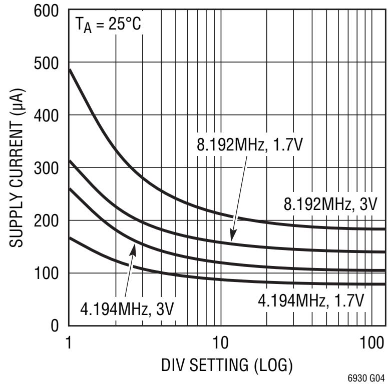

Figure 3. The LTC6930 supply current at different divide ratios

Power Savings from Fast Start-Up

Many systems are designed to sleep most of the time and wake up briefly on occasion to perform some task. If a task requires particularly little time, the total power dissipated for the task may be dominated not by the awake time, but by the time it takes for the oscillator and associated sensory electronics to power up. The guaranteed fast start-up time of the LTC6930 allows system designers to budget minimal recovery time and thus save power in start-up settling time.

Crystal oscillators often specify start-up times of up to 20ms, if they specify them at all, and the first clocks out may be of low amplitude and otherwise out of spec. The designers task is further complicated by the fact that start-up time may vary randomly. See Figures 4 and 5 to see how a crystal oscillator start-up time compares quite unfavorably to the LTC6930 start-up. A system that needs to wake up occasionally for a millisecond to take a single measurement may end up spending 100ms waiting for its clock to come up without a clean signal and then settle in order to take that single measurement. The fast and clean 100µs start-up of the LTC6930 allows the designer of such a system to reduce wake time, and therefore power dissipation, again by a factor of around 100.

A Word on Accuracy

The big question when moving from a quartz crystal to a silicon oscillator will always be one of accuracy. If crystal oscillators do anything well, it is provide a stable and accurate frequency source, but accuracy is just one concern out of many.

While each individual application is different, Linear's years of experience with silicon oscillators allows us to make some general recommendations based on actual customer applications. With an initial accuracy of better than 0.09% and a commercial grade accuracy over temperature of better than 0.45%, the LTC6930 does not compete with crystal oscillators in all areas, but does provide a clock accurate enough for the most applications.

Of course, there are applications that require either accuracy or jitter characteristics out of the reach of the LTC6930, such as clocking high speed analog-to-digital converters such as the LTC2242 series, clocking jitter sensitive high speed serial communications systems such as Ethernet, and long term timekeeping functions such as a digital alarm clocks. Nevertheless, silicon oscillators like the LTC6930 perform far better than crystal oscillators when power consumption is a

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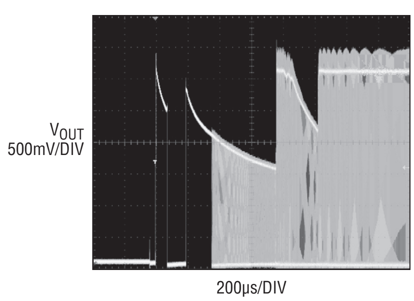

Figure 4. Typical crystal oscillator start-up transients

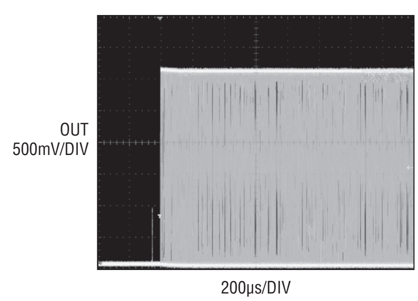

Figure 5. Typical LTC6930 start-up

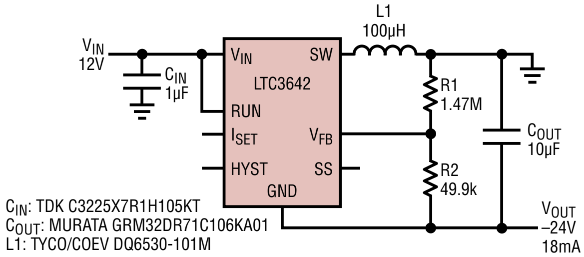

Figure 5. Generating a negative 24V output voltage from a positive 12V input voltage

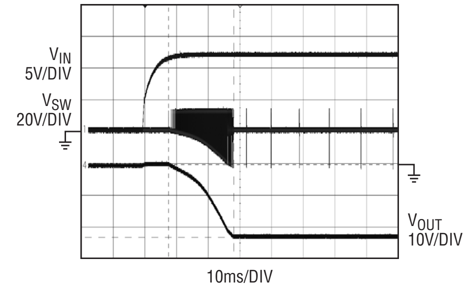

Figure 6. The LTC3642's wide input voltage swing makes it suitable for generating a negative output from positive input voltage.

portable medical instruments and certain automotive applications.

Positive-to-Negative Converter

The LTC3642 can produce a negative output voltage from a positive input voltage without the use of transformers (see Figure 5). In this configuration, the LTC3642 actually operates in an inverting buck-boost mode. Its wide input voltage range, up to 45V, provides sufficient headroom to generate any negative voltage between –0.8V and –40.5V. Figure 6 shows LTC3642 producing a –24V output from a 12V input supply from start-up. The LTC3642 is inherently stable in this configuration with no external compensation components required.

Conclusion

The LTC3642, LTC3631 and LTC3632 are a rugged DC/DC converters for use in applications where a stable voltage output must be produced from poorly regulated high voltage rails. Their compact size and high efficiency make them easy to use in a wide variety of low power applications, including mobile and battery powered devices.

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concern, and extreme accuracy is not paramount. Such applications include clocking microprocessors and microcontrollers, acting as a time base for low speed serial communication protocols such as USB and RS232, digital audio applications, clocking switching power supplies and anywhere a general purpose clock is needed.

Conclusion

When comparing clock power dissipation it is important to consider not just the dissipation of the oscillator itself, but also how the oscillator's features and start-up times effect the dissipation of the entire system. Crystal oscillators not only dissipate more current than other solutions, but can have other start-up and control characteristics that lead to power waste. When the LTC6930's on-the-fly frequency programmability and one-clock-cycle settling time are considered, it is clear that it conserves much more system power than its dissipation specification would indicate

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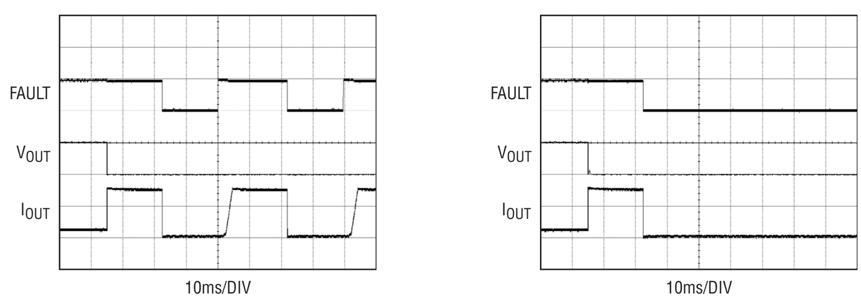
on a pin-selectable setting, the IC can be configured to either periodically attempt to power up (RST pin high, Figure 4a), or remain shut down until power is cycled to the device (RST pin low, Figure 4b). The waveform indicating the fault condition is seen at the Fault pin and is produced by an internal open-drain device whose input is pulled high in the event of a fault. The Fault pin can either be connected to a microprocessor or drive an LED.



4a. RST high: converter attempts power-up every 15ms.

4b. RST low: converter remains shut down until power is cycled.

Figure 4. A fault detection mechanism powers down the converter, providing robustness to output shorts

Conclusion

High conversion efficiency and the ability to detect and handle output shorts make the LTC3529 an ideal solution for either peer-to-peer portable applications or point-of-load board power with robust fault handling. The 1.5MHz switching frequency and highly integrated design of the LTC3529 yield compact solutions with minimal design effort.