Tough 5G Timing Requires MEMS Clock Sources

If you've been involved in the design of cellular technology, you know what complexity looks like. Protocols and standards stacked atop each other like so many wobbly building blocks. That it all works together is a testament to careful specs, careful design, and careful timing.

Today, 5G is all the rage, and this time it will be no different – in fact, it's going to be even tougher. 5G promises to be the go-to solution for many more applications compared to prior generations. So expectations are high – meaning that, yet again, specs, designs, and timing will have to be carefully planned and implemented for the promises of 5G to be met.

5G is All about Tougher Timing

5G technology will put pressure on the timing solution far more than in the past, and for a number of reasons.

- Higher frequencies will mean shorter periods – more work has to be done in less time.
- Bandwidth will be more carefully used; channels will be tighter. That means less timing slop can be tolerated.
- Higher frequencies mean shorter ranges and less ability to go around corners. That means more radios, each covering a smaller area. Expect somewhere on the order of 10 or 20 5G radios for each current 4G radio.
- Here's the kicker: a radio-to-radio latency budget of 130 ns. That breaks down to a 10-ns budget per network node between the two radios. For perspective, GNSS timing precision is 15 ns (99.7% of the time). This means less channel-to-channel interference, contributing to better bandwidth use. You might think this isn't such a big deal to meet – at least under nominal conditions – but try making that timing stick across all conditions.

The timing needed to keep all of this ticking smoothly will place an incredible burden on the timing source. For local timing, it will require the accuracy, stability, and reliability of a MEMS clock.

Sources of Network Timing

There will be three sources of timing in a 5G system. The primary source is the network itself, using the IEEE 1588 standard for receiving timing, along with the SyncE frequency that synchronizes timing, over Ethernet. But, if the network goes down, then you can't get timing from the network. The backup is GNSS, which provides a pulse per second. Not terribly precise, but useful. But what if your equipment is somewhere without a strong GNSS signal? You will need to keep time until the network comes back up or your equipment will go down as well.

So a very important role is that of the holdover clock: a locally derived clock that keeps going until the primary source(s) of timing return. It's like a flywheel that keeps spinning at a constant speed even when it's not being actively driven. That calls for a very stable clock source, with none of the "activity dips" and sudden frequency jumps exhibited by quartz oscillators.

Exactly how long a holdover clock must keep going will depend on the network operator; there's no standard for that. Near the edge devices, the holdover clock should drift no more than 1 µs in 2 or 4 hours. Meanwhile, closer to the backend, the clock shouldn't drift by more than 1 µs in 8 or 12 or 24 hours. The specific duration is selected by the network operator. You might find that in India for example, the network operators require a tighter spec – specifically because other parts of the infrastructure aren't as robust.

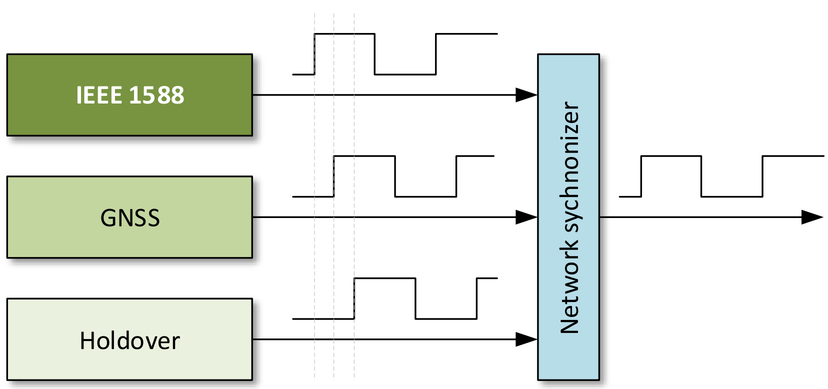

Figure 1. One of three timing sources is selected by the network synchronizer, with no phase jumps during switching.

Of course, you can't just have a simple switch that selects between these sources. Because they're completely independent of each other, they're not phase-aligned. If you simply switched from one to another, you'd get a phase jump that could cause significant downstream issues. So the network synchronizer is responsible for performing "hidden" switching – selecting a source with no disruption in the outgoing clock signal's phase.

What Makes Timing Tough?

Take already-tight 4G timing, make it tighter, and then put equipment in harsh locations where it didn't go before. That's 5G in a nutshell, and it raises a number of challenges for any local clock source.

Vibration

The first issue is vibration. With more radios in more places – like on telephone poles next to a road – you'll have more equipment in tough environments. Imagine when a heavy truck drives by and rattles everything nearby.

The timing source must be immune to such vibration. Quartz oscillators can be easily rattled, and they go out of specification, potentially for as long as the vibration continues. That can be minutes for a long freight train nearby, or even longer on a windy day. MEMS oscillators, by contrast, won't go out of spec due to vibration.

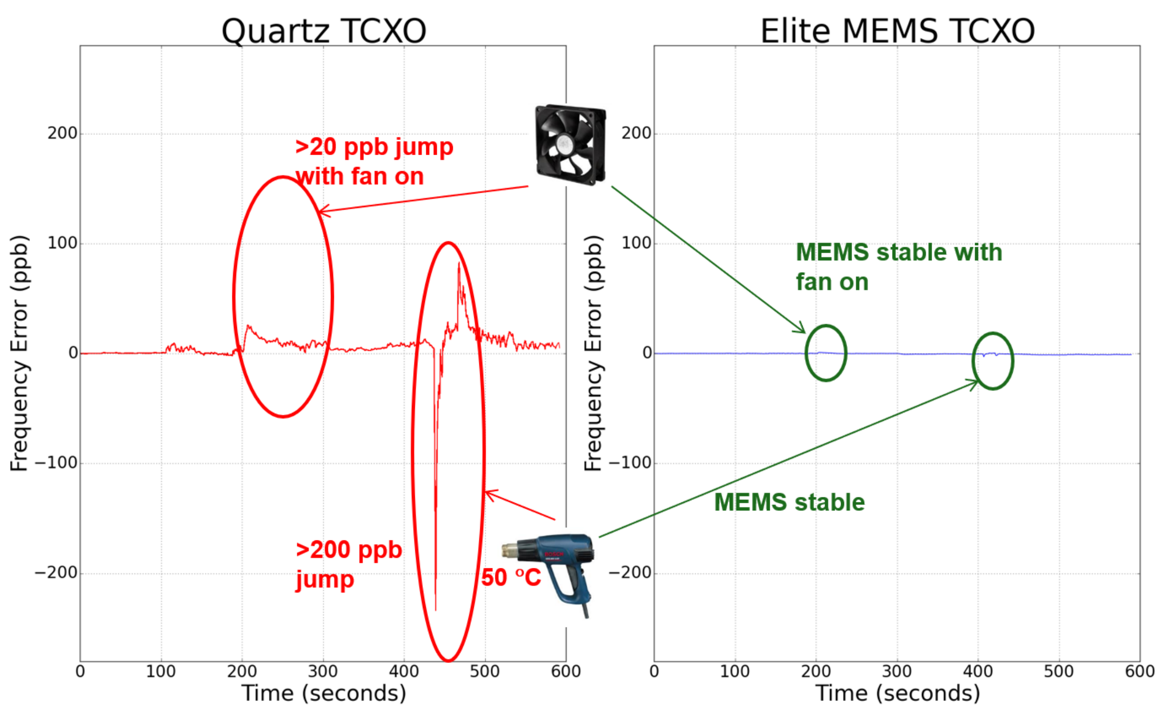

Figure 2. Quartz TCXOs are sensitive to heat, airflow, and rapid temperature shifts, exhibiting significant frequency variations, while MEMS TCXOs are extremely stable under these conditions.

Heat

5G equipment will be placed in every conceivable environment. That means that some equipment will get exceedingly hot; others will operate under very cold conditions. The same equipment in, say, Minneapolis may have to handle extreme temperatures in the summer and in the winter. And, because fans are prone to failure, designers are trying to leave them out, meaning 5G equipment won't have cooling built in.

Keeping timing accurate under all temperatures is extremely tough. But keeping the network up is essential. That means that even under extreme temperature conditions, the network has to keep going. High-performance MEMS oscillators can operate cleanly up to 125 °C with very high stability.

Rapid Temperature Shifts

As if it weren't enough to have to operate in the blazing sun and in icy conditions, you can make conditions even harder where rapid temperature changes occur. If you've been in the Southwest, for example, where colliding fronts and a moving jet stream bring hot and cold air masses together, the ambient temperature can change by 20 °C in minutes. That places a further strain on the clock source, since it's exposed to sharp temperature gradients as things heat up or cool down.

Quartz has a hard time dealing with rapid temperature changes. The frequency can jump by hundreds of ppb (parts per billion), going way out of spec, and then take minutes to recover the desired frequency. MEMS timing devices, by contrast, have no problem keeping up.

5G Timing Needs MEMS Oscillators

With 5G designs, timing will matter more than ever. Without tight, precise clock sources, the 5G promise will remain only so much hype. That hype turns to reality with MEMS oscillators; it's how network operators can be assured that their network won't go down due to the timing function.

MEMS oscillators from companies like SiTime can operate unperturbed under the wide range of conditions that 5G equipment will be exposed to. As compared to quartz, MEMS oscillators:

- Have temp ratings up to 125 °C
- Have 10 times the vibration immunity of quartz
- Suffer no micro-phase-jumps, reducing the number of dropped calls
- Have 100 times the reliability of quartz, minimizing truck rolls (for example, SiTime has had zero field failures out of over a billion shipped units).

The fact that MEMS oscillators can do all of this with one-fifth the energy consumption means that, unusually, there really isn't a tradeoff. MEMS is well poised to be the clock source of choice for the many 5G designs scheduled to roll into use in just a few years.

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