



Worldwide Combined Semiconductor Timing

CY2017 – Q1 2018

*Industry Market Intelligence Reporting
&
Analysis...*

- *Xtal's & SMD Packaged Oscillators*
- *Semi Clock & Timing devices, IC's & Modules*
- *RF Timing Components & Modules*

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Semiconductor Clock & Timing CY2017- Q1 CY2018

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PREFACE



Mark Sherwood; CEO & Principal Associate at CS & A LLC...

I can say without any doubt, that from my own unique perspective, CY2017 proved itself a pivotal year for Semiconductor Timing, and we were witness to the continuing evolution of our business; I.e.: Continuing shifts in the *Supply Chain*; I.e.: (Supplier base consolidations, Technologies maturing (MEMS, ASO's), some with new and revised Processes & Flow, Packaging, Test, in process “tuning”,

temperature and voltage compensation, and More). Now couple this with measurable changes in the *mix of technologies in play*, changes in specific product and point-solution categories (*New, Obsolete, evolutionary, disruptive – revolutionary*), Value Propositions (\$ASP's) and resulting \$\$Revenues, plus conversion rate impacts and a rationale for aggressive \$ASP erosion... Add in political, cultural, geographic, and social factors that affect and influence: I.e.: Currency valuations, trade and borders, taxes and tariffs, and new concepts like Bit Coin cryptocurrencies, gold and precious metals, and more... the stock market favored technology stocks in 2017, and we have already seen a significant correction in Mid-February that saw the largest single day loses in volume on record across all indexes... Some investors lost their shirts while others see opportunity and are buying, buying, and buying (Berkshire Hathaway as an example)...

In the traditional sense, CY2017 delivered record volume and record \$\$revenues into WW Semiconductor Overall, and it rippled to Semi Timing where we saw increases in volumes but driven by a newly defined mix...

Driven by another year of \$\$Trillion Dollar + Revenues in Consumer Electronic Systems, and in support of all the new IoT gadgetry, we see 4G running strong and while taxed, it's meeting the demand thru sheer brute force methods... Now, we have 5G coming on fast as we run short of BW and as we add devices from the IoT connected to the net at unreal numbers each year.



Some individuals have never known anything else. Like the Millennials; for them, if power fails, or the batteries die, they're in real trouble... all they have ever known is being connected! Now, all the new devices and systems connect from your computer, to the phones, to the washer/dryer, fridge and even the toilet, the demand on Communications Infrastructure and Backhaul is growing to support that bandwidth and speed.

What does that mean for Semiconductor Timing? Where are we heading; long term as well as what is driving growth and value for Semi Timing Short-term? That's what this report is about as we embark on a new format and style for our reporting and Analysis. As you read and review deeper into this report, make careful note of questions, concerns, and issues you think about as you digest the information and intelligence... list them and send them onto me at info@timing-is-everything.net. We only grow by listening... 2017 demonstrated that the traditional boundaries between Oscillators, IC's and Modules (MCMs) has blurred... the fight for the coveted socket continues between the IC folks and the Oscillator base, and in terms of volume, Oscillators have the clear edge and continue as THE mainstay products in Semiconductor Timing... Single Output, Fixed Frequency, Low Power, Low Noise, and Low Cost... Precision performance at Commodity prices! The low end has become limited and confused while most complex providers are making a move into higher value Semi Timing with ASP's in \$\$dollars and not dimes... and with enough performance to hold their place for several years to come...

Many on both sides (Timing Supplier and OEM/ODM high-volume Consumers) are asking if CY2017 was a good year or a bad year for the WW Semiconductor Timing Industry? They are making inquiries regarding all of the technologies both in play now, and in development for the near-term future as they work hard to identify key inflection points associated with the technology, manufacture, assembly, test, and overall quality and reliability, Use case issues and wider applications usage are driving the definitions for new Semi Timing Products and Solutions. All the while feeling the threat and in some cases today like SmartPhones and even GPS, the reality of actually seeing 99.9% of the External to the ASIC Timing Silicon eliminated from the reference design (example of no longer needing external timing: elimination of stand-alone timing except for 1 Xtal: QUALCOMM and the loss of a high percentage of the handset business – stand-alone quartz, TOD, USB,)...

If you're a high-volume consumer of Semiconductor Timing, today you're concerned with the viability and continuity in the supply chain; no line down for need of a simple crystal or oscillator...With functions such as Time of Day, the demands on the 32KHz segment PCIe, IEEE 1588, and even RTC



(Real Time Clocks) experienced measurable upticks in volume... \$\$Revenues however, were mitigated by aggressive device \$ASP erosion...

Within the supplier bases across all three industry segments: Xtal & Oscillators, Semi Clock & Timing, and RF Timing, the solution mix, technology issues, cost models, and flow... we saw better volumes, and flat - lower REVENUES... Another year under \$5.0B is no trend, it is a new reality...

Think about the now accepted standard of being connected with almost everything, coupled with TOD (Time Of Day) needs across most ALL Market segments and Applications for 32KHz-1MHz Quartz and now MEMS in use as the reference resonator in the supplier specific oscillator and / or stand-alone Quartz, the volumes are in the billions of units for some products like 32KHz... Indeed, T.O.D. needs in the world of the IoT is pushing volumes for 32KHz and as noted, generated good response for highly integrated RTC's. CS &A is forecasting that we will continue to see an exodus of suppliers out of the low-end arena due to the very low ASP's and not caring too much about gaining economy of scale – they want out of the commodity end and into the value portion. This means moving from commodity and complex-commodity, single output, single frequency; fixed or programmable / frequency generators to multiple output, multi frequency mixed I/O buffer type MacroTiming.

In looking at the life cycles for new products making up that IoT, the traditional life curves are changing... While time to market and time to money have always been the number one input for the design, next came the cost reduction exercise, and in time; legacy... no more is this the hard rule as companies are still driven by time to money and time to market, cost reduction is an up front and ongoing effort. The life cycle itself for these products is shorter too. OEM's want you wanting that new model and anticipating on its feature sets while trying to be careful and not do an Osborne" (*too early announcing the new model and killing sales on the current one as they wait for the new one!*). The decision to integrate some or all the Timing Domain circuitry into the device/system ASIC/ASSP/Processor continues to make significant impact on our industry. Remember that there are virtually no technology inflection points to inhibit this kind of action, only common-sense business decisions... OEM/ODM's would still rather integrate some function or feature that differentiates them from the competition and provides compelling demand, while the benefit of integration of the timing functions hits real estate, cost, and performance. There is nothing there they can charge the end user for! So, for the time being, in my opinion: for at least for the next 3-5 years, volumes will continue to trend up, \$ASP's will continue



the erosion albeit at a lower rate as the competition becomes limited and volumes go up...and revenues will continue to decline...

Over the last 5 years, our markets served have fractured in terms of value added and value appreciation (*where we price the solution, and what the customer will actually pay for the product*) for Semi Timing... We see requirements for single output Oscillators/Synthesizer/Frequency Generators, and increasing volume for Multiple output and multi frequency solutions hitting the market now (*these fall into the **MacroTiming** Product Category where we see the heaviest levels of integration of semi timing critical path functional blocks in a single Macro Level device – today, this level of integration can run the full length of the clock tree from resonator to output buffers and with waveform integrity to limit bandwidth and/or key in programmable Jitter Attenuation to the input of the PLL*).

Applications Drivers

Use cases are dominated by the need for a highly stable, low noise, low power, small form factor Timing Solution utilized as a frequency reference. Other downstream and embedded PLL's are using this output for their input. First thing done in the ASIC/ASSP is to buffer this input and voltage convert it down typically ~1v pp). Now this down converted clock signal is fed to a PLL circuit for multiplication. For SERDES Physical Layer and MAC timing, the multiplier is either x10 or x16 to match and determine the specified DataRate. Example: Gb Ethernet running a 1.25

This is double edge clocking at its best, so Duty Cycle joins the Specification group that can be addressed to differentiate and improve the quality of the offering... Spec is typically 45/55 in percentage, so the impact of an improved offering with a Duty Cycle of 48% / 52% would be a significant improvement and have a potential for positive effect on Bit Error Rate (BER) as well as good / better PSRR numbers IF DC regulation and isolation are clean...

Wired and Wireless Communications Timing combined remains a key driver for many Semi Timing Suppliers as they modify their respective mix and vie for the business. Politically, that's a tough road, and one result is to expand the business thru MnA and buy the channel along with more revenue and volumes that add in the supplier economy of scale goals and objectives... Murata bought TEW, MegaChips buys SiTime, Analog devices, IDT, Pericom, and more, are all evidence to that fact, and now at the beginning of the 2nd Quarter, it's a big action – Microsemi and Microchip for \$8.5B+.



Crystal and Oscillator Market Summary

2016 marked a turnaround in the market and 2017 offered signs of real growth. The total market for Crystals and Oscillators increased 4% in 2017 to \$3.27 billion. Revenue is forecasted to increase 1.1% to \$3.38 billion in 2020.

The rebound in the market came from mobile handset shipments, newer consumer devices, such as IoT devices and wearables, and networking and telecom equipment.

However, with this positive news, the story remains the same for the Crystal and Oscillator market – the reduction of discrete clocking components and the integration of the clocking functions into ASICs/ASSPs/SoCs. PCs have eliminated multiple XOs and Crystals, and instead, we see more clock distribution ICs, some with multiple PLLs and only one Crystal. Mobile handsets are eliminating TCXOs, and are instead using MHz Crystals, with the temperature compensation blocks integrated into the RF transceiver. CS &A is seeing more and more of this kind of loss of market in applications today and it has, and will continue to have more of an impact on the Crystal and Oscillator market.

The biggest negative impact today, in terms of high volumes and revenues, is coming from mobile handsets and the new chipsets that have eliminated the need for kHz Crystals and TCXOs. Chipset companies, such as Qualcomm, now have chipsets for mobile handsets that can use a MHz Crystal with an integrated temperature sensor, which in conjunction with temperature compensation in the RF transceiver, totally eliminates the need for a TCXO. Additionally, the MHz Crystal can generate the sleep mode timing clock that had formerly been generated by a kHz Crystal. Depending on the handset, you may find just a MHz Crystal with an integrated temperature sensor, or a TCXO, or a TCXO and a MHz Crystal. In some handsets, even with the MHz crystal driving the RF cellular transceiver, you will find the GPS function driven by TCXO. This has had a major impact on the TCXO and kHz Crystal forecasts given that mobile handsets have the largest volume for electronic products.

In 2017, we saw enough volume in mobile handsets even with the battle for sockets between TCXOs and MHz Crystals, TCXOs had growth. Certain suppliers of TCXOs, such as KCD, have been able to sustain and grow a TCXO business and still have some margin.

As we have already noted, kHz Crystals are suffering given the described changes in mobile handset architectures. However, there are some positives from wearables and IoT devices, which need kHz Crystals for RTC and sleep mode timing.



Not totally gone, there will still be kHz Crystals present in mobile handsets as smartphones may still need an additional sleep mode clock for the application processor. Additionally, kHz Crystals are still used in almost every electronic systems as there is a need for real time clocking and/or sleep mode timing.

SiTime is clearly taking market share away from traditional kHz Crystal suppliers with its kHz TCMO. This TCMO is smaller in size, has lower power consumption, and is a plug and play oscillator. Its price point is right and it is winning sockets, mainly in wearable and IoT devices, such as the Apple Watch. CS &A has categorized this device in the TCXO/TCMO product category, as this is the type of device it is, and SiTime has leaped into the top 10 of TCXO/TCMO suppliers with this device.

Crystals Back to Growth

Both kHz and MHz Crystals will have unit growth through the forecast period, and ASP erosion will still allow for revenue increases.

kHz Crystals did better than expected with unit growth of 6%. With ASPs declining 1.6%, revenue increased 4.3% to \$669 million. CS &A forecasts units to increase 3% in 2018, with revenue tapering off at 1.5% growth given ASP erosion. Long-term, units will continue to increase, and with ASP erosion, revenue will also grow with 2020 forecasted at \$692 million.

MHz Crystal units grew 5% in 2017, and with 1.1% ASP decline, revenue increase 3.8% to \$1.17 billion. There will be continued unit growth, and with ASP pressure, revenue is forecasted to increase mildly, forecasted at \$1.2 billion in 2020.

Continued Gains for XOs/MOs

XO/MO unit shipments continued to increase in 2017 by 5%. This increase was fueled by the overall growth in the general purpose electronics market, in addition to growth in the networking and telecom space. With the 2% ASP decline, revenue increased 2.9% to \$450 million. Revenue will increase through 2020 to \$463 million.

MOs have successfully taken sockets and garnered large volume in the MO category. CS &A sees wins in both general purpose as well as networking and telecom references. It appears electronics OEMs/ODMs have embraced a non-quartz alternative even though MOs still don't differentiate much in terms of performance, package, or price. It should be noted that MO growth in 2017 was minimal,



which may indicate that MOs are having a harder time competing given the lack of differentiation versus XO's.

ASOs are not getting any traction. IDT had a discrete ASO offering that they have now discontinued. CS &A understands that the IDT technology (original acquired from Mobius Microsystems) still had issues with stability and reliability when packaged, and ultimately, they still did not have a reliable, yielding, and cost effective solution. SiLabs is still offering its ASO solution, but it has not made improvements in performance since it originally launched the product and as such still have stabilities exceeding $\pm 100\text{ppm}$, which limits the application usage. Si-Ware has been quiet about its ASO solution and it does not appear that it will have a solution in the near future.

High Performance Oscillators Riding Networking and Telecom Momentum

TCXOs/TCMOs, VCXOs, and OCXOs are all benefiting from growth in networking and telecom equipment.

In 2017, TCXO units increased 7.5%. This increase came from mobile handset volumes, even with the changing dynamic of TCXOs being pushed out by MHz Crystals. Certain suppliers, such as KCD, have been able to offer competitive and cost effective solutions, while still maintaining some margin. ASPs declined 1.4%, which lifted revenue 6% to \$575 million. CS &A does not see this as a major turn around long-term. Units will have a modest increase over the forecast period, and with some standard ASP erosion, revenue in 2020 will be \$600 million.

The VCXO market grew in 2017, with units increasing 3%, an ASP decline of 2%, resulting in a revenue increase 0.9% to \$225 million. Unit growth will increase 2% through the forecast period, with ASPs declining 1.7%, letting revenue climb ever so slightly to \$227 million.

OCXO units decreased 6% in 2017, and with ASP decline of 0.9%, revenue increased 5% to \$187 million. Unit growth will increase 2.3% through the forecast period, and with ASP erosion at 1%, revenue will gain 1.3% to \$194 million.



Market Share Happenings

The top 5 remained the same, however the only supplier to have gains was KCD, which had a significant increase driven by TCXO sales. TXC, which has been holding the 3rd spot for a number of years, dropped to 4, surpassed by KCD.

SiTime continued to show it is a real player jumping up two spots from 10th to 8th. SiTime increase came from its kHz TCMO business, which has now put the company in the 3rd spot for TCXOs.

Vectron, which had gone from a conglomerate Dover to Knowles not too long ago, was acquired by Microsemi in the November of 2017. More recently, Microchip announced in March of this year that it was acquiring Microsemi, so Vectron will now be part of Microchip. Microchip already has oscillator products via Discera (Micrel acquisition).

Semi Timing; Looking Ahead, & Noting Some Key Inflection Points

As we look ahead into 2018 and beyond, several Inflection Points have been identified in: Technologies, Expansion of in-house development processes, Design capabilities and potential, and in the Mix as we address new specs surrounding Communications at multiple levels, across multiple Timing Domains yielding changes to the Portfolio...

- Decision Point: To Embed the Timing Functions into the System ASIC/ASSP/Controller.
- Oscillator Suppliers: In House Engineering Expansion for ASIC Development for FCP – Standard Oscillators, Low Power versions, Fixed and Programmable. Standard Integer N PLL's plus Fractional N, Digital-Hybrid PLL's, Output Buffer expansion and performance improvements (*Tr/Tf, Duty Cycle, Noise, Swing...*), and more...GET More CONTROL OF COGS!
- Oscillator COGS
- Semi Timing Functional Block Integration expansion..
 - MACROTIMING:
 - Partial and FULL Clock Tree integration
 - Soup to Nuts capabilities (From the Quartz/MEMS Reference, to the Multiplier, Waveform Integrity, and buffer expansion/ fanout and Distribution...
- MEMS Based Timing Specific;
 - The Monolithic Die – a MacroTiming version in MEMS Vs Quartz or CMOS



Summing it up – Mark Sherwood

This year, in the front end of my Preface, I noted that it looks like CY2018 is shaping up to be another pivotal year for the Semi Timing Industry. We have, over these last 5-8 years, been witness to significant changes in Technologies In-play, the Mix of Solutions based upon those technologies, changes / Consolidation in the Supply Chain, and we see applications without a use case for external Semi Timing beyond simple quartz fundamentals (Qualcomm based SmartPhones) ... Challenges from many sides, and all at once. Combine this Industry level pressure with shorter life cycles for electronic systems, Socio-economic and currency valuation issues (we still see a lot of pricing in US dollars), and time to market/ Time to Money pressures, so we see many suppliers reacting instead of being responsive... one example is seeing suppliers using ASP as compelling rationale for a design win... this can and has hurt the industry in forcing movement to much lower pricing at the low end for solutions in 32KHz for example, and we see more suppliers lining up for Mid-Range and Hi-End use cases and Applications for Precision to Ultra-Precision Class solutions (they want Dollars and not Dimes...).

Now, we see Technology to the point where, in many use cases and apps, the timing functions can indeed, be integrated into the System ASIC/ASSP/Processor... not much to keep it out from a technology and layout perspective, BUT, the decision to integrate the function or not is not emotional, and is based upon costs, form factor, and feature set options and pressures... An OEM/ODM is not going to integrate the function for free, so it has costs associated. In addition, a Keep Out Area does result, and most important: does it buy the designer anything compelling that they can charge for? Why integrate timing if they can create more alarms for example, or have a bigger battery, or larger screen etc., but something with some measurable value to the end customer and that they will want in the system feature set... and, one they will pay for, giving it direct value added.

That battle for the socket I referenced early on, is THE key issue for the IC guys as they lose share in single output synthesizer/frequency generators to the SMD packaged Oscillator, and at ALL of the major Communications suppliers to include: Cisco, Juniper, Huawei, HP, IBM, Oracle, ServerWorks and more, the server line cards share the builds between Oscillators and IC's, but we see prices that are close despite the differences in required BOM / COGS... Fascinating to watch it unfold...but good to see the OEM Share the load between the two, helping to keep them viable thru higher valued Semi Timing...

As we run out our estimates, calculations and factoring, we see **growth in volume and Revenues**, modest as it is at less than 5% YoY, but growth nonetheless...