APPLICATION BRIEF

Better Undersea Sensing with the Quantum™ SA.45s Chip Scale Atomic Clock (CSAC)

Key Features

- No access to GPS means undersea sensors must get time internally, usually from an OCXO
- The SA.45s CSAC's much lower power consumption can result in big cost savings on batteries and sensors
- The SA.45s CSAC's better aging means sensors can be left unattended longer and still be accurate
- The SA.45s CSAC's much smaller temperature coefficient means CSAC performs better despite wide ambient temperature swings

Microsemi invented portable atomic timekeeping with QUANTUM™, the world's first family of miniature and chip scale atomic clocks.

Choose QUANTUM™ class for best-in-class stability, size, weight and power consumption.

Sensors employed in undersea applications rely on precise timing to be effective. However, because time from GPS is unavailable underwater, these sensors have generally relied on OCXOs for stable and accurate time stamping within the sensor. Now those applications have a better option—The SA.45s Chip Scale Atomic Clock (CSAC) from Microsemi. Compared to OCXOs, the SA.45s CSAC maintains far higher accuracy for far longer periods, uses much less power and maintains a much more stable frequency despite the wide variations in temperature these sensors encounter.

Why Precise Timing Matters

One such undersea application is reflection seismology (or simply "seismic"). In seismic, oil exploration firms place a grid of geophysical sensors (Figure 1) on the ocean floor to help determine likely spots where oil will be located. The sensors can be dropped over the side of a ship or laid down by a remotely piloted vehicle. The sensors can be independent or a cable can connect a row of sensors. Each sensor typically includes a hydrophone, a geophone and an OCXO or a TCXO that is used to time stamp the data received by the two other devices. Once the sensors are in place, a powerful air gun or array of airguns launches a sonic pulse from a ship. The ship moves in a pattern that allows the airgun to be fired from many different angles relative to the sensor grid. Some of the pulse's energy reflects off the ocean floor and back to the surface, but the rest penetrates the ocean floor, travels through the layers of rock and eventually reflects back to the sensors on the ocean floor where it is detected and time stamped. Once the ship has finished its predetermined pattern, the sensors are retrieved along with the time stamped data.

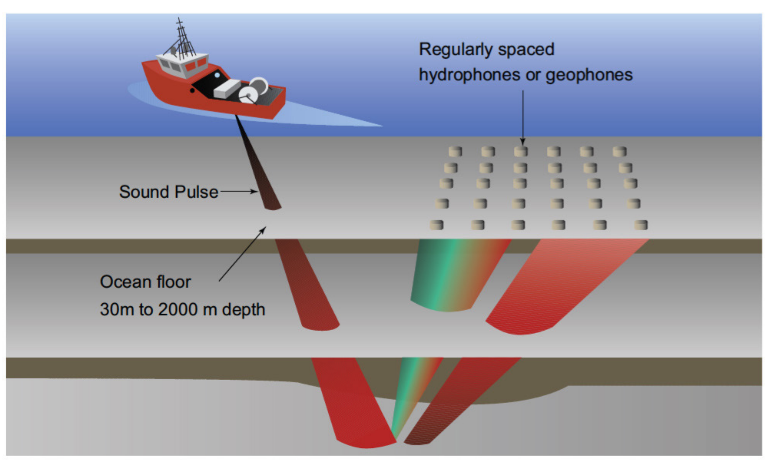

Figure 1. Since reflections of sonic pulses off undersea layers travel at different speeds through oil, gas, rocks and sediment, precise timing of these "bouncebacks" can indicate oil or gas.

Better Undersea Sensing with the Quantum™ SA.45s Chip Scale Atomic Clock (CSAC)

Figure 2. At only 16cm^3, and with <120mW of power consumption, the SA.45s CSAC brings the benefits of an atomic clock to portable applications for the first time.

Because the sonic pulse travels at different speeds in different materials, the time it takes to reflect back to the sensors off the various rock layers is different depending on which materials the pulse traverses. When this timing data is post-processed,

it creates a picture of the layers of rock and sediment beneath the ocean floor, showing which locations likely hold oil or gas deposits. The more precise the timing, the more accurate the pictures of where oil and gas actually exist.

CSAC's Performance Advantages

The Microsemi SA.45s CSAC (Figure2) can greatly improve the accuracy and reduce the cost of sensor systems, while maintaining a much more constant frequency over time and over wide shifts in temperature. With a volume of only 16cm^3, it is smaller than most OCXOs. In addition, the CSAC's power consumption of <120mW is a reduction of approximately 10x to 20x compared to most OCXOs, which typically consume 1.5W to 2W steady state.

As a true atomic clock, the SA.45s CSAC has an aging rate of 3.0E-10/month. The unit can also be programmed through an RS-232 serial interface for control, calibration and status monitoring.

User Benefits

These performance advantages translate into key benefits for companies involved in seismic exploration:

- **Improved accuracy over longer deployments**
  During a typical deployment, sensors can be underwater for several weeks at a time. This is because the ships and crews needed to deploy the sensors, take the measurements and retrieve the sensors cannot always be optimally scheduled. Bad weather can also cause delays. Throughout the deployment, the OCXOs in the sensors are aging, producing a time stamping error that varies as the square of the time underwater. The CSAC's low aging rate—which can be 1/100th of even a good OCXO—greatly reduces these time stamping errors as sensors are deployed for longer periods.
- **Reduced power lowers battery and sensor costs.**
  Batteries are typically the biggest expense in these underwater sensors—and the number of sensors in a typical grid is increasing. Because the SA.45s CSAC consumes one-tenth to one-twentieth (or even less, in some cases) of the power of an OCXO, it requires much less battery power—so sensors can be smaller and cost less. Alternatively, sensor manufacturers can choose to retain the existing battery capacity and use the CSAC to create sensors for much longer missions.

  For even less power consumption, the SA.45s can also be programmed to operate in an ultra low power mode. In this mode, the CSAC's physics package is turned off and the unit operates as a free-running TCXO. In the ocean bottom's isothermal environment, the TCXO's drift will be almost entirely due to aging.

  The physics package is then periodically (also programmatically) turned back on and after warm-up (<100sec) it redisciplines the TCXO. This mode enables average average power consumption levels well below 50mW.
- **Reduced effects from wide temperature swings.**

  Today most marine geophysical sensors are calibrated to GPS on the deck of the boat before being dropped into the ocean. Because the water at the bottom of the ocean is often just a few degrees above freezing, the sensor can see a temperature change of 30°C or more from its calibration temperature, causing a shift in frequency and a linear error in time. Some sensors use software models to correct for this error, but the best approach is to minimize the error to begin with. With a temperature coefficient of $\pm 5.0 \times 10^{-10}$ over its entire temperature range, the SA.45s CSAC can offer a 10x to 1000x improvement over OCXO or TCXO alternatives.

Why Microsemi

Microsemi is the world's leading source of highly precise timekeeping technologies, instruments and solutions. We provide timekeeping in GPS satellites, national time references and national power grids as well as in critical military and civilian networks, including those that enable next generation data, voice, mobile and video networks and services. Our products include atomic clocks, hydrogen masers, timescale systems, GPS instrumentation, synchronous supply units, standards-based clients and servers, performance measurement and management tools, and embedded subsystems that generate, distribute and apply precise frequency and time.

Microsemi Corporate Headquarters
One Enterprise, Aliso Viejo CA 92656 USA
Within the USA: +1 (800) 713-4113
Outside the USA: +1 (949) 380-6100
Sales: +1 (949) 380-6136
Fax: +1 (949) 215-4996
E-mail: sales.support@microsemi.com