White Paper: The KCC Scientific Model 1900S

Ken Reindel, KCC Scientific

The purpose of this White Paper is to help provide some information on Self Winding Clock synchronization, what a Model 1900S Clock Synchronizer does, and how it works. Let's start with a historic background and a general explanation of Self Winding Clock synchronization.

Historical Perspective. At the turn of the century (around 1900), a developing transportation industry combined with the Industrial Revolution meant that people needed a way to know exactly what time it was across the miles in order to accurately coordinate critical activities. In response to this, Self Winding Clock Co. working with Western Union devised an innovative system for precise time synchronization for clocks all over the US. Clocks were produced that ran on a pair of the new No. 6 Dry Cells. This was done by taking a high-quality Seth Thomas mechanical movement equipped with a special rotary or vibratory motor, using the batteries to wind it every hour. This eliminated the need to wind these clocks on a regular basis, preventing problems caused by lack of attention to them.

Synchronization involved sending out a signal to clocks all around the country simultaneously, at exactly the top of the hour. The Western Union Telegraph system had already established a network of wires interconnecting businesses, railroads, etc. for communication purposes. These same wires were adapted to synchronize clocks at these locations. Within a few minutes of the hour, telegraph activity was ceased and a series of synchronization signals were sent out. Inside the Self Winding Clock Co. models, a mechanism connected to an electromagnetic coil would react to this Western Union signal by "pulling" the hands to exactly the hour. This method survived to provide the nation with synchronized, precise time for a good part of 60 years!

In the early 1960's, most of these self winding clocks were decommissioned and the Western Union service was discontinued, obsoleted by newer methods of communicating accurate time. Collectors began to recognize the historic contribution and value of these clocks. These clocks were (and still are) procured at Marts, antique stores, Ebay, and other sources. Savvy collectors also recognize the significant value of resurrecting the synchronizing mechanisms on these clocks for improved timekeeping—and of course the historic nostalgia.

The Model 1900S. The Model 1900S is a way to drive the synchronizer coils, just like the Western Union signal did for decades. Instead of relying on an outside signal brought in with telegraph wires, the Model 1900S acts as an internal timepiece with the ability to send the proper signal to the synchronizer coils at exactly the top of every hour. The device is connected to the synchronizer coils with the supplied wires. A button on the top of the 1900S is depressed and released at exactly the top of the hour. Thereafter, the 1900S will supply this signal on its own, every hour thereafter. This corrects any deviation in the clock's timekeeping to accuracy levels that are unachievable in a mechanical clock by itself.

The beauty of a 1900S Kit (composed of a battery to power the clock and the 1900S) is that it looks exactly like a pair of vintage No. 6 batteries. You can power the clock and synchronize it with a pair of batteries that look like they belong in the vintage clock—and add to the charm by bringing back the nostalgia of regular synchronization.

Technical Discussion. Here is a brief Q and A on the highly technical aspects of the 1900S.

1. How does a 1900S work?

Inside the 1900S is a microprocessor and a precise watch crystal that work together to create a super-accurate timepiece. This timepiece controls circuitry that connects a voltage source to the terminals at the exact time so that the synchronizer solenoids located in the clock can be driven at that exact time. The unit runs on three AA cells, and they will last for over 3 years. At that time they can be easily changed.

2. How do you achieve "super accuracy"?

The practical issues in designing an accurate quartz-based timepiece (synchronizer, clock, watch, etc.) are related to:

- Crystal initial calibration
- Crystal loading
- Temperature Drift
- Time Drift

The biggest problem by far is crystal initial calibration. Most crystals are cut to 20ppm accuracy. This is equivalent to 10 minutes per year. Many manufacturers of watches and other timepieces use crystals with this specification in their devices, directly, with the accompanying inaccuracy. Others hand pick and sort the best ones to use in their products using a test fixture. This is difficult because when the crystal is installed in the actual timepiece, parameters are different than they were in the test fixture. Crystals are very sensitive to this "loading" change and behave differently as a result. Further, the soldering processes involved in assembling the crystal into the product subjects the delicate crystal to extreme temperatures, causing further shifts. These factors, in combination, result in poor timekeeping.

3. So what do you do differently?

We first optimize crystal "loading" with a microprocessor which is programmed to load the crystal optimally. We then calibrate the crystal after it is in-circuit, where it will spend the rest of its life. To do this, we developed a LabVIEW-based software algorithm that allows initial calibration to 0.2ppm (parts per million)—the equivalent of a fraction of a minute per year.

Here's how the program works. The buffered crystal output from the microprocessor-based crystal oscillator is measured against a stabilized NI PXI-6608 which uses internal OCXO accurate to under 50 parts per billion. Once the actual frequency is precisely known, LabVIEW calculates the calibration constants which are stored on board the 1900S microprocessor. These constants are used to correct the timekeeping error of the individual crystal, in-circuit. The result is better accuracy than most quartz watches available today. It takes extra time to calibrate it up front, and every unit must be calibrated and verified individually. But if accurate timekeeping is important, it's the only way.

A feature of our design which greatly helps keep the unit accurate is electronic voltage regulation. As the internal battery is depleted, the voltage naturally decreases. To avoid errors caused by a constantly changing battery voltage, there is a special circuit on board to regulate the voltage applied to the crystal circuit. This keeps it very stable over the life of the battery.

4. Do you offer a TCXO option?

A TCXO is a Temperature Compensated Xtal Oscillator. Its claim to fame is that it is internally compensated for temperature drift over a very wide temperature range. The fact is most watch crystals are designed to be amazingly stable around room temperature (about 30 seconds per year from 65°F to 83°F), which is where we operate most of our clocks. They just need to be calibrated to achieve this. We do indeed calibrate them, so accuracy is assured—at room temperature conditions stated above.

Most of our customers don't operate their clocks at freezing temperatures or in the hot sun, where a TCXO would excel. But, if you do, we now have a version of our Model 1900S, called the Model 1900STC, which uses a temperature compensating device (available March 1, 2009). It is somewhat more expensive, but unbeatable if you are using your clock in an unconditioned workshop, garage, observatory, or other area where the temperature varies substantially from typical room conditions. Please ask us about the Model 1900STC if you are interested.

5. How does the 1900S hold over time?

The last crystal characteristic to deal with is time drift. This is one that no one can predict. We use devices which have a maximum specification of around 3ppm per year (90 seconds). Typically they are much, much better but without a time machine no one can predict the future. We do know that as any crystal ages, it actually becomes more stable. For this reason the best we can offer is to recalibrate your synchronizer after the first year at a 50% discount from our standard calibration charge (you pay postage). After that, our standard charge is $40 for a recalibration—but only if needed, which is not very likely!

6. How do you verify your synchronizer's accuracy and calibration?

Each 1900S is test run for over 1 week. They are referenced to an "atomic" timepiece synchronized to NIST Boulder via WWVB to validate accuracy. Only those synchronizers which achieve under 0.75 seconds per week are shipped (which is practically all of them, after calibration).

In the end, we routinely see accuracy levels on the order of between 1 to 3 seconds per month with this approach (some are better!). If you own a quartz watch, you will find yourself setting your watch to your self winding clock synchronized with the 1900S. Come to think of it, that's the way Western Union intended it back in the day when the Self Winding Clock Co. ran the railroads!

7. Can you program your device to be used in any Self Winding Clock Co. model?

We packaged the 1900S to optimize its fit and function for all Self Winding Clock Co. models. This greatly simplifies installation and use of the product for these clocks. The output voltage provided and its output drive impedance is a good match for 3 volt clocks. This is the great majority of the clocks out there. Instructions are provided for use with 24 volt clocks (or anything between 3 volts and 24 volts for that matter).

The 1900S is also a great companion product to our line of vintage battery replicas which are available in any voltage you might need. There is something very charming about having a product which looks like it belongs in the clock, like you're back in 1905, yet offers 21st century technology and performance!

8. Are there competitive products to consider?

We're biased, so obviously we think that the Model 1900S is unique. But customers routinely compliment us on the product family calling it "amazing." There are two competitive products that act as timing products for vintage self winding clocks and slaves. One is the Neonixie timer. The other is made by Piexx. They're nice products and they work. But, neither of these suppliers offers the product packaged in a vintage container. Neither offers a battery companion for the product. Neither offers setup assistance or self winding clock restoration services. Neither provides vintage wire and everything you need. Neither can be installed without tools or extra hartware. The Piexx requires a separate power supply (battery, wall wart). You need to be a little knowledgeable about electricity and electronics to use the competitive products. In particular, the Piexx is very complex to set up and use. I am still not sure how to set it up for hourly synchronization. The Neonixie is much easier to set up, but again you'll need to have some knowledge of electricity to do it. For example you'll have to select pulse duration (which can seriously impact battery life if you choose wrong). You'll also have to choose between multiple wiring configurations. Price between all 3 models is similar (Piexx is a little more).