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Report on 2011 Time and Frequency Activities of the Standards and Calibration Laboratory of Hong Kong

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SCL's
Time and Frequency Standards

- At present, the Caesium Beam Frequency Standard (Symmetricom 5071A Opt001), denoted as SCL8, is used as the master clock. Fine adjustments is introduced by a Microphase Stepper (Trak 6490). The 5 MHz output of the Trak6490, after buffered by a distribution amplifier, is used to drive a Time Scale Generator (Trak 6460).

- It is backed up by another Caesium Beam Frequency Standard (Symmetricom 5071A Opt001), denoted as SCL7, with fine adjustments introduced by another Microphase Stepper (Trak 6490).

SCL's Time and Frequency Standards

- The laboratory time scale UTC(SCL) is defined as the rising edge of the 1PPS signal at output port A of the Master Time Scale Generator (Trak 6460).

- The time difference UTC(SCL) - GPS is monitored continually by tracking GPS satellites using a TFS128 multi-channel GPS system. There are normally more than 400 successful trackings everyday.

- The GPS tracking schedule is programmed to follow the GPS Common View Tracking Schedule for time comparison as coordinated by BIPM Time Section.

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The Caesium Beam Frequency Standard, Microphase Stepper, Time Scale Generator and Multi-channel GPS System at SCL

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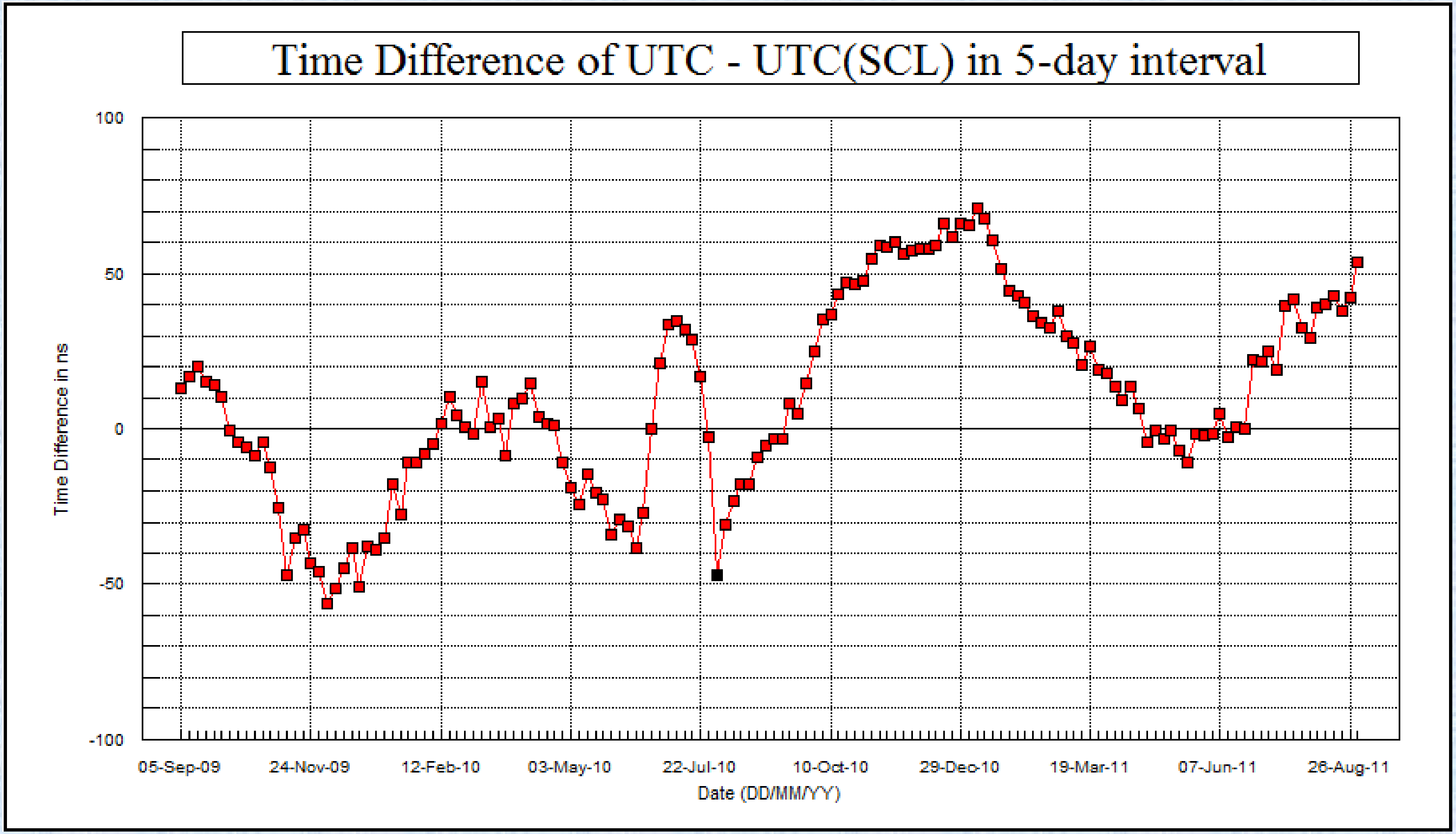

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SCL's Development in 2010/2011

- A new method for the calibration of stopwatches, called video totalize method, has been developed at the Hong Kong Standards and Calibration Laboratory (SCL).

- A paper describing this method has been published.

C. M. Tsui, Y. K. Yan, and H. M. Chan, "Calibration of Stopwatches by Utilizing High Speed Video Recordings and a Synchronous Counter" NCSLI Measure, vol. 6, no. 3, pp. 64-71, September 2011.

SCL's Development in 2010/2011

- The method starts with the taking of two short video clips of the display of the stopwatch under test, together with the reading of an in-house designed synchronous counter, with the two clips separated by an interval of six to seven hours.

- The 10-digit synchronous counter is driven by a 1 kHz clock which is phase locked to the cesium frequency standard of SCL. The elapsed times measured by the stopwatch and the synchronous counter are obtained by viewing the recorded video to search frame-by-frame for the instant at which the reading of the stopwatch changes.

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SCL's
Development in 2010/2011

- Using this method, the measurement uncertainty is no longer constrained by the display resolution of the stopwatch, but instead is limited only by the frame rate of the video recording. Digital cameras that can record video at 420 frames per second with usable image quality are commercially available.

- SCL has designed and built a synchronous counter that allows the reference time to be read from the recorded video with a resolution of 1 ms.

- The measurement uncertainty obtainable by this calibration method is less than 2×10^{-7} for a 95 % coverage interval.

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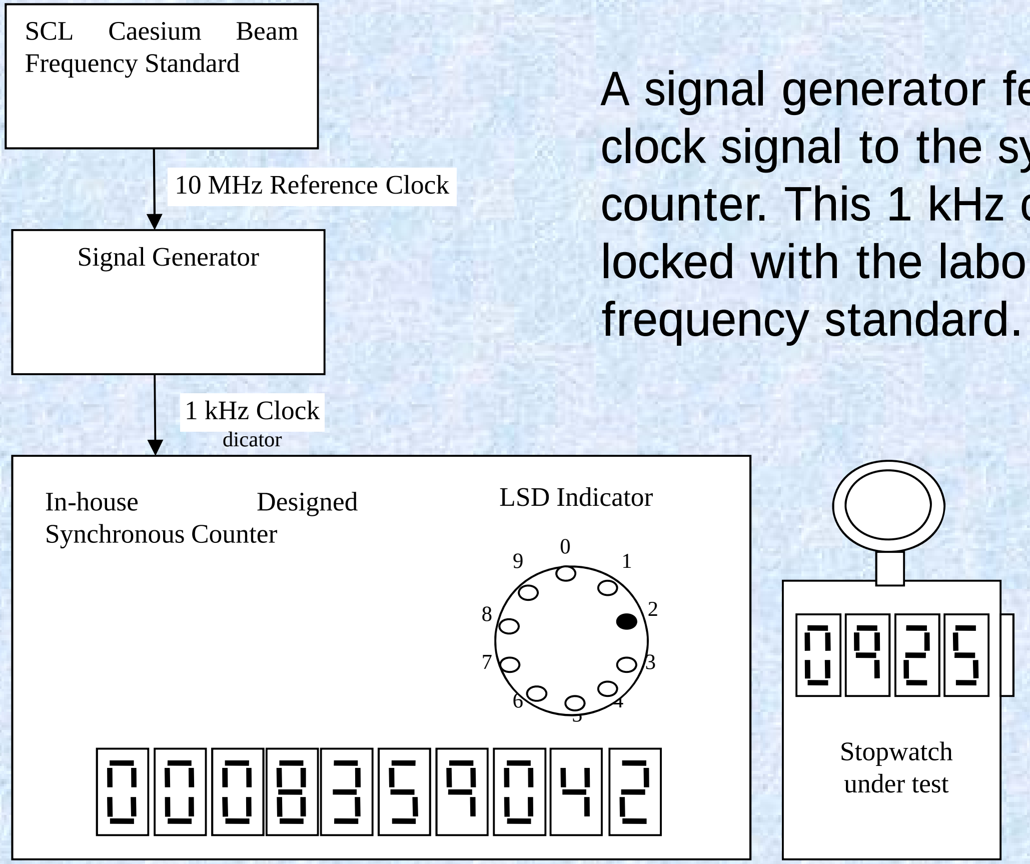

A signal generator feeds a 1 kHz clock signal to the synchronous counter. This 1 kHz clock is phase locked with the laboratory caesium frequency standard.

A high speed digital camera is used to record a 10 second video clip at 240 fps or 420 fps for the stopwatch and the synchronous counter when they are both counting.

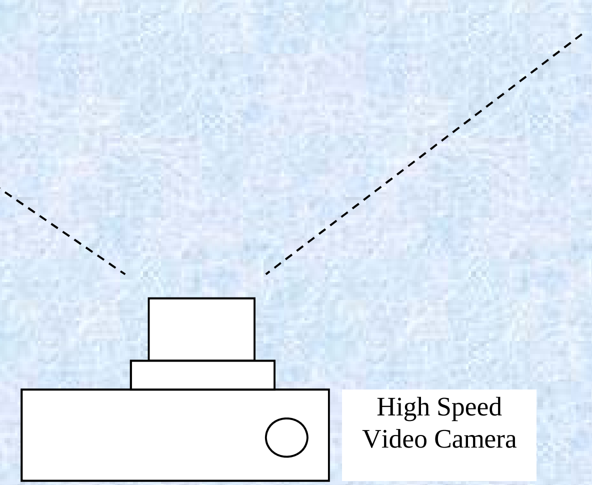

Figure 1

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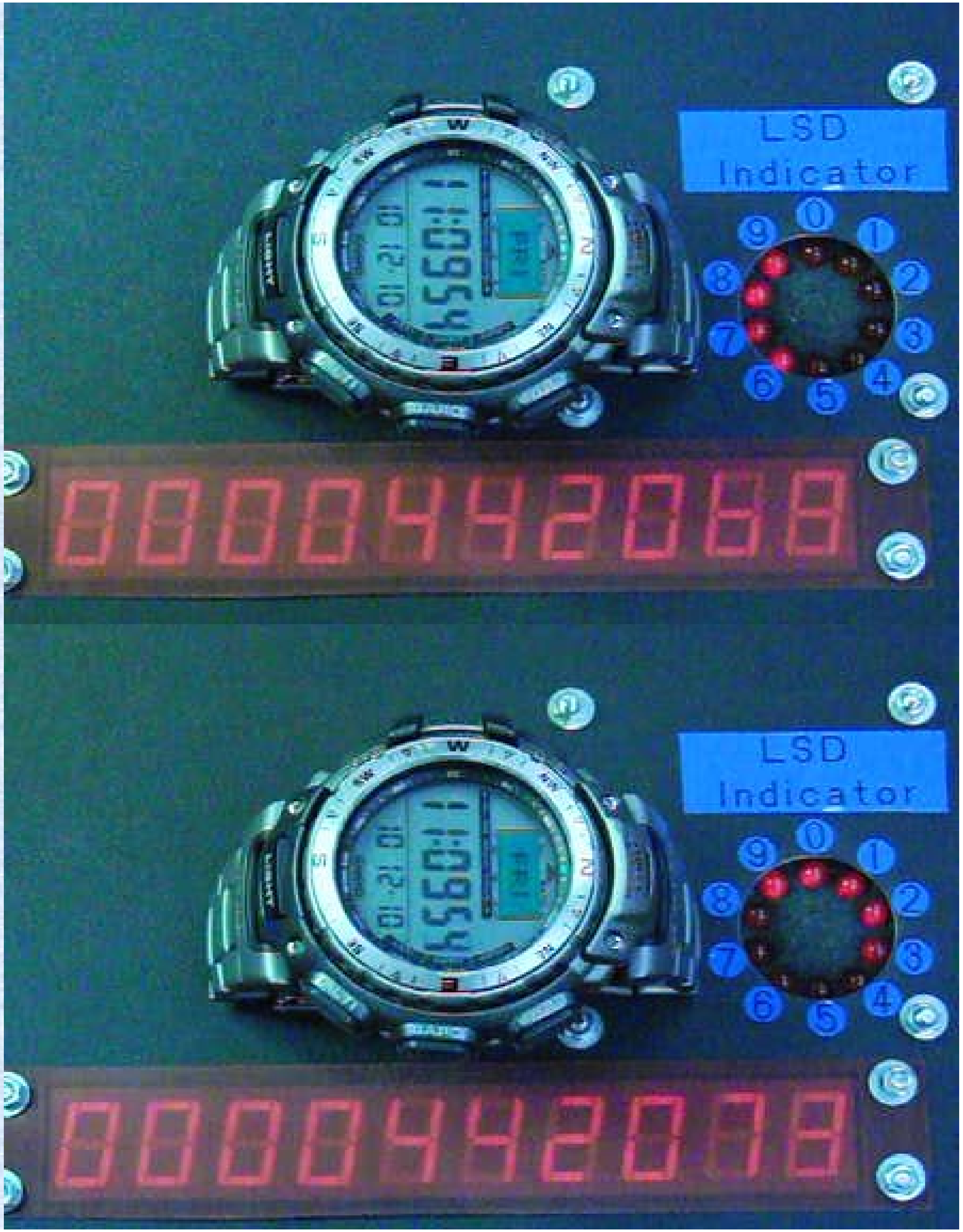
Synchronous counter reading is 442.069s. (442.06 from the 7-segment LED display. The most clockwise LED that lights up in the circular indicator is “9”, hence the LSD is 9) The reading of the digital watch is 11:09:54

Synchronous counter reading is 442.073 s. The LSD of the digital watch reading starts to change from “4” to “5”. The lowest segment of the digit “5” is noticeable in this picture.



Example of two frames from a video clip

Why an In-house Designed Synchronous Counter is Needed

- The display readings of many commercial universal counters **did not update synchronously** with the input clock signal.
- In the next figure, the time between frames is about 2.38 ms. If the display of the universal counter was truly synchronous, the counter reading should increment by 2 or 3 with each new frame.
- However, we can only observe three readings during this 76.2 ms period: 11490, 11539 and 11588. The universal counter seems to only update its display about once every 49 ms

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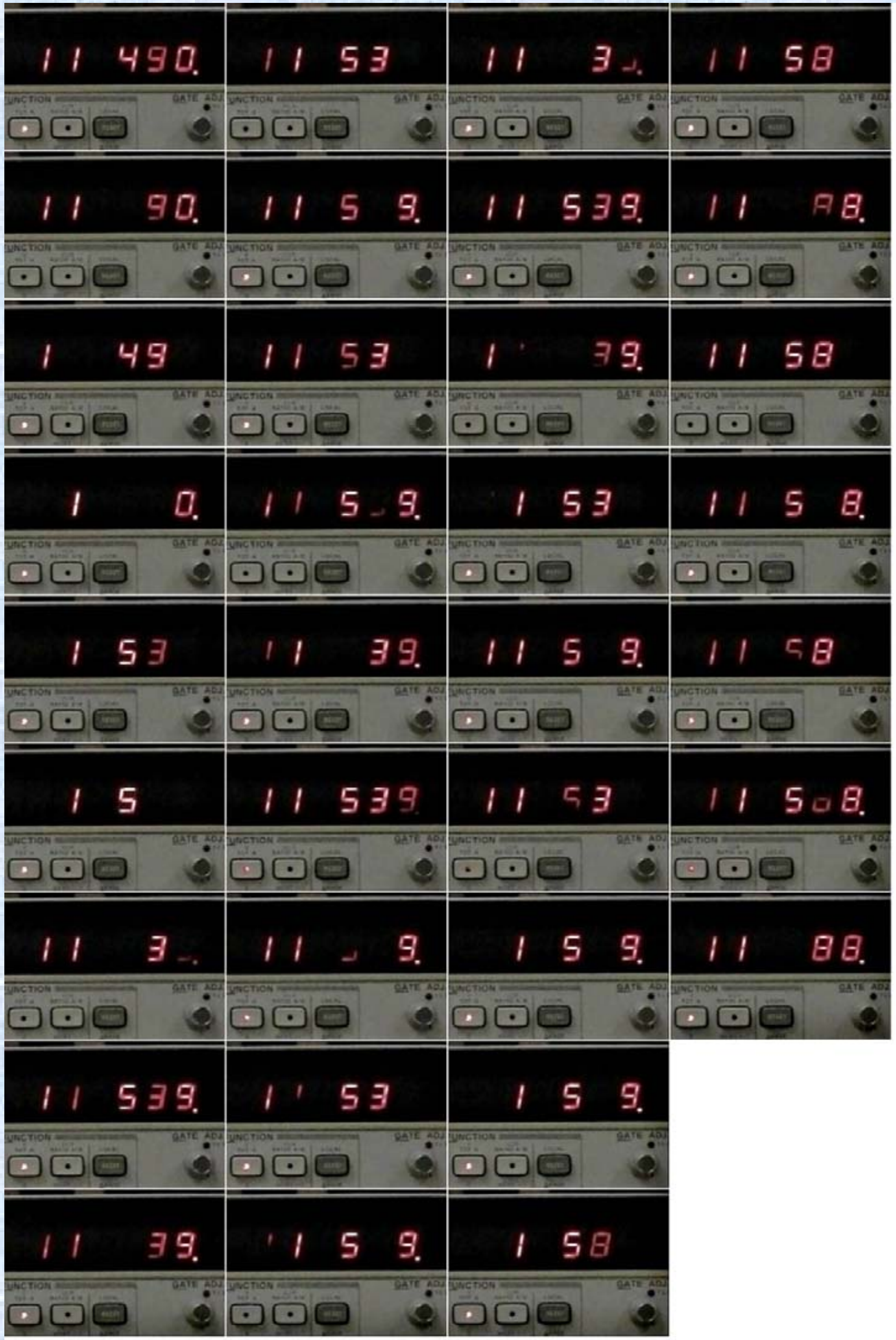
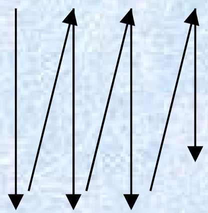


Display of a commercial universal counter captured by a high speed digital camera at 420 fps. The universal counter is driven by a 1 kHz clock input.



Progress of frame sequence

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Why an In-house Designed Synchronous Counter is Needed

- There are severe limitations when the video totalize method is employed with some commercial universal counters.

- The synchronous counter designed by SCL was built with **logic circuits** that ensure its 10-digit LED display will be updated synchronously with the input clock.

- It is driven by a 1 kHz clock generated by a signal generator phase locked to the laboratory cesium frequency standard. It has a **resolution of 1 ms**.

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END

Thank you