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Design of a Synchronous Counter with Two-dimensional 10 x 10 LED array for Calibration of Timing Parameters of Video Cameras

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In 2011, the Standards and Calibration Laboratory (SCL) developed the video totalize method for calibration of stopwatches with the use of an in-house designed synchronous counter [1]. All digits of the LED display for the counter are updated synchronously with the clock input signal driven by a signal generator which in turn is phase locked to the caesium atomic clock, the primary frequency standard at SCL and is traceable to the Coordinated Universal Time (UTC). With a 10-digit display capable of counting long time period and a specially designed least-significant-digit (LSD) indicator to enhance the time discrimination for the measurement, this synchronous counter enables fast events to be accurately time-stamped by a high speed video camera. Detailed information on the circuit design of the SCL counter and calibration procedure of stopwatch has been discussed in the paper. The original purpose of the SCL counter is to calibrate the relative correction of a specific time interval measured by a stopwatch. With its unique features, the SCL counter can be extended to other applications, like measuring the flashing time interval of LED Lights in Toys [2], finding skipped frames in a recorded video [3], and leveraging the stroboscopic effect to calibrate the frame rate of a digital camera [4]. Through these applications, it was felt that to further improve the accuracy and extend the application areas, the function of the LSD indicator should be enhanced such as increasing the number of LEDs.

The authors noticed that the Home Office of the UK had designed a Frame Interval Timer called Lightboard for use by the UK Police to calibrate CCTV timing parameters for law enforcement applications [5]. The LEDs of Lightboard are arranged in a two-dimension 4 x 10 array. Inspired by this idea, SCL has enhanced the design of the LSD indicator of the synchronous counter from a 10 LED circular display to a two dimensional 10 x 10 LED array. Each LED will be turned on sequentially. If the counter is driven by a 1 kHz clock, this 10 x 10 LED array will enable fast event up to 100 ms duration to be time-stamped at a resolution of 1 ms using a video camera. The potential applications of this enhanced synchronous counter include calibration of shutter speed and frame rate of digital video recorder, looking for occurrence of skipped or duplicated frames in a recorded video, and characterizing the rolling shutter performance of CMOS image sensor.

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2. Samuel CK Ko, Aaron YK Yan, Henry CK Ma, "Measuring the Flashing Time Interval of LED Lights in Toys", *NCSLI Measure J. Meas.*, **9**, 4, December 2014, pp. 36-39.

3. YK Cheng, CN Tam, CH Tao, CN Tsang and KC Poon, "Calibration of dashboard cameras to reveal frame skipping in video recordings," *Proceedings of the 12th International Conference of the Institute of Traffic Accident Investigators*, 2017, pp. 131-1433.

4. H. W. Lai, Michael W. K. Chow and C. K. Ma, "Calibration of the Frame Rate of High Speed Digital Video Recorders by Stationary Counting Method: Application of the Stroboscopic Effect," NCSLI 2017.

5. https://www.fcir.co.uk/case-studies/cctv-analysis