Report on SASO – NMCC Time and Frequency activities to the 20th meeting of the Consultative Committee for Time and Frequency, September 2015

SASO Time and Frequency Laboratory is a responsible for national time scale generation and dissemination on Saudi Arabia. Recently at SASO NMCC the Time and Frequency Laboratory was developed using primary 5 Cs atomic clocks, 2 GNSS receivers and high technology modern equipments, The national time scale was generated with an uncertainty better than $2x10^{-14}$ and disseminated through the internet for industrial applications using an NTP time dissemination system with an uncertainty less than 50 ms. The fully automatic time and frequency calibration system that was developed is traceable to the national time scale and has the capability for frequency generation and measurement in the DC – 50 GHz range including signal analysis and phase noise measurements. Currently SASO is a member of BIPM Atomic Time Club in order to contribute to the Universal Coordinated Time (UTC) time scale and the realization of the international traceability of the SASO time scale.

1. Time Scale Generation and Traceability

SASO time scale generated by using 5 Cs atomic clocks with high performance tubes (5071) and calibrated 2 multichannel GNSS receivers (TTS-4). The block diagram and photograph of the time keeping system Figure 1. Time signals from the GPS, GLONASS and GALILEO systems are received using 2 GNSS antennas which are installed on the metrology (NMCC) building. The time signals from the antenna are received by a TTS-4 model multi-channel GNSS receiver using a 35 m low noise cables. The reference one pulse per second (PPS) time signal from the reference atomic clock is also sent to GNSS receivers and these receivers measures the time difference between satellite clocks and reference SASO Cs atomic clocks in accordance with the BIPM satellite tracing schedule. Time difference between atomic clocks is measured by computer controlled counter trough switch box. All cables delay is measured by counter and 50 GHz oscilloscope with an uncertainty less than 100 ps. SASO time scale was compared by GPS common view with UME and MTC scale with an uncertainty less than 5 ns. In additionally for uncertainty evaluation 2 Cs clock in SASO same time interval compared trough counter and 2 GNSS receiver using GPS common view method. Currently SASO time scale generated with type A uncertainty 0.7 ns and with type B uncertainty 7.3 ns.

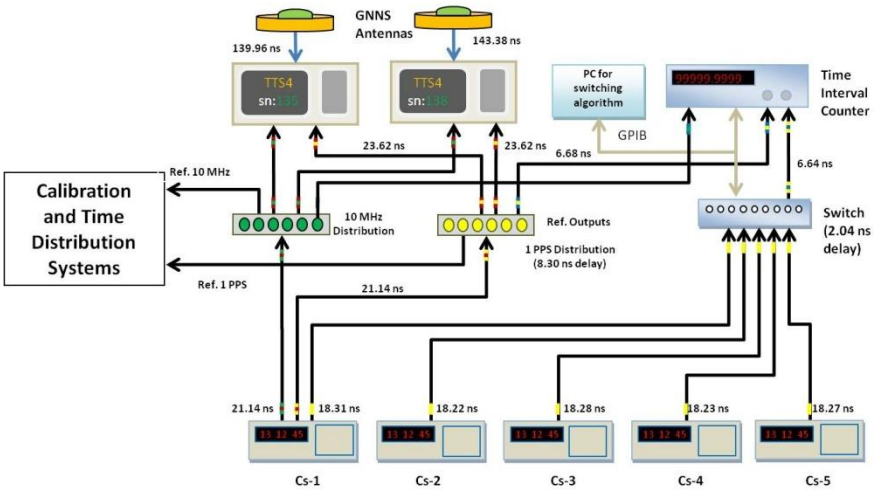

Figure 1. Block diagram of SASO time and frequency system

The photograph of the developed time and frequency system is shon on the figure 2. On right site of the picture shown time keeping and dissemination system and on the left site calibration system is presented.

Figure 2. Photograph of SASO time and frequency system

2. NTP Time Dissemination

The NTP Time Dissemination System was developed for the distribution of time generated from a Cs atomic clock or a local Rb frequency standard among local area networks (LANs), wide area networks (WANs), and the internet/intranet by using a network time protocol (NTP) at stratum - 1 level. The Time Dissemination System includes 3 NTP Stratum-1 Servers, a Rb Frequency Standard, a Time Coder and a UPS (Fig.3). With this system, time dissemination is realized with an uncertainty better than 5 ms for LAN and better than 50 ms for WAN. The block diagram of the NTP Time Dissemination System including the local Rb frequency standard and simple GPS receiver for initial time synchronization is given in Fig. 3.

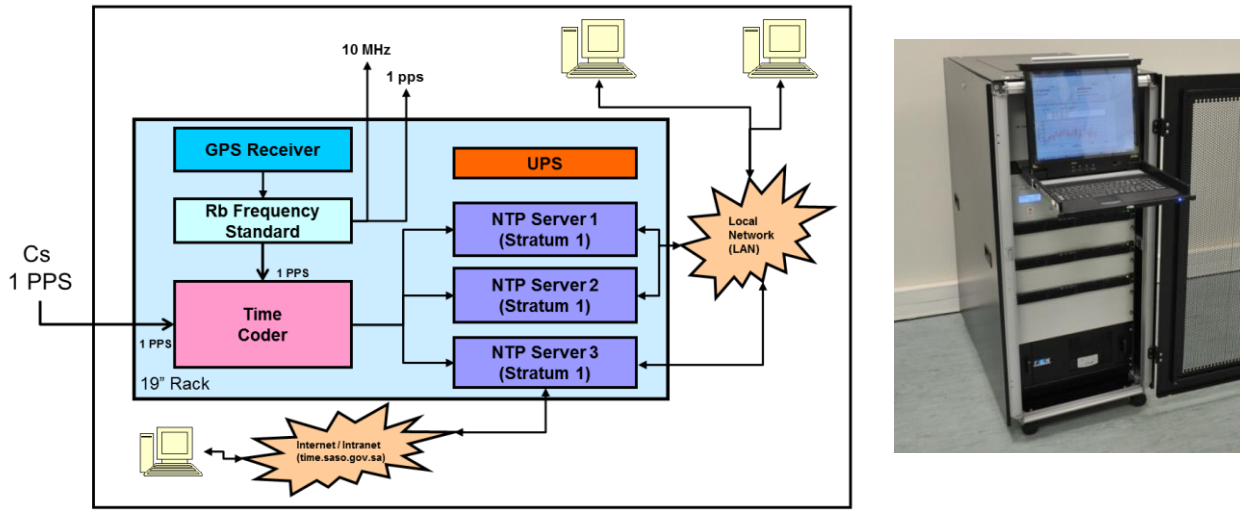

Figure 3. The block diagram and picture of the NTP Time Dissemination System

3. Time and Frequency Calibration System

The developed fully computer controlled automatic time and frequency calibration system in the DC – 50 GHz range including signal analysis and phase noise measurements was verified by manual measurement and used for atomic clock, signal generator, spectrum analyzer, counter and timer calibrations. On the left side of the figure 2 shown time and frequency calibration system. Time interval measurement with <10 ps uncertainty and high frequency oscilloscope calibration system was developed by using fs laser and 50 GHz oscilloscope system. Using the time and frequency calibration and measurement system, it is possible to calibrate the following equipment:

- Cs atomic clocks,
- Rb atomic frequency standards,
- Quartz frequency standards,
- Signal generators,
- Spectrum analyzers,
- Counters,
- Rise time of high frequency oscilloscopes
- Tachometers,
- Chronometers and Timers

The calibration and measurement capabilities of the system are as follows:

- Frequency Range :
  - DC – 50 GHz
- Frequency Measurement Uncertainty (k=2)
  - DC – 2 GHz ($1 \times 10^{-11} \times f(Hz)$)
  - 2 GHz – 50 GHz (1 Hz)
- Time Interval Measurement :
  - 0.5 ns – 10^{10} s
- Time Interval Measurement Uncertainty (k=2)
  - 100 ps
- Amplitude Range :
  - -100 dBm to +20 dBm
- Amplitude Measurement Uncertainty (k=2)
  - 2 dB (-100 dBm to -10 dBm, 30 Hz – 26.5 GHz)
  - 0.2 dB (-10 dBm to +20 dBm, 50 MHz to 40 GHz)
- Modulation Parameter Measurement
  - AM (%0 to %100), FM (1 kHz to 400 kHz), PM (0.1 rad to 10 rad)
- Phase Noise Measurement
  - Carrier Frequency Range : 100 kHz - 26.5 GHz
  - Offset Range : 1 Hz - 100 MHz
  - Noise Floor : < -165 dBc/Hz

4. EURAMET Comparison

SASO NMCC Time and Frequency laboratory attend to the ongoing EURAMET project number 1288, “Time interval comparison Pilot Study” coordinated by MIRS. Recently SASO completed first time interval measurements generated by travel standard. During EURAMET comparison, the generated time intervals measured by using time interval counter and also using 50 GHz oscilloscope which is calibrated by femtosecond erbium fiber laser.

References:

[1] Khalid S. AlDawood, Ahmed H. AlJawan, Fahed A. AlMutari, SASO Time Scale and Measurement Capability, IFCS-EFTF, Denver, USA, 2015