Getting the best from your Stanford SR620 timer

Roger Wood, Philip Gibbs, David Walters & Christopher Potter

NERC Space Geodesy Facility, Herstmonceux, UK

Preamble:

These notes were compiled following the EUROLAS workshop held at Herstmonceux in 2002 March. They are presented here with the aim of propagating standard "good practice" throughout the global network. It is intended that this material will be placed on the ILRS website as the first of a number of similar documents devoted to instruments widely used in the ranging community. It is hoped that other users will share their experience of these instruments and will add to this information, and to the list of references, for the benefit of all.

Manufacturer's information:

Stanford Research System's web page http://www.srsys.com/html/sr620.html contains a general description of the time interval/frequency counter and offers downloads of the detailed specifications for the instrument, and also the *Operating Manual And Programming Reference* handbook (395kB, revision 2.2 dated 1999 November at the time of writing and can be viewed at ftp://ftp.thinksrs.com/PDFs/Manuals/SR620m.pdf).

Introduction:

There are now many stations in the global network using Stanford SR620 time interval counters as their primary range-measuring instrument, and others that have access to them. After the EUROLAS workshop on "*Detecting and eliminating errors in the EUROLAS network*" (Wood & Appleby 2002) it was suggested that it would be valuable to gather together and share the experience of users in order to propagate useful tips and matters of established good practice. The following paragraphs offer some of this collected wisdom and should help SR620 users to get the best possible performance from their instrument.

Hints and tips for best practice:

1. **Power supply:**
   - The best policy is "**never switch off**";
   - Use a **stable mains voltage** supply (for this and many other instruments it is useful to **monitor** the mains voltage regularly and warn when it falls);
   - Use a **transient suppressor** to prevent voltage "spikes" reaching the timer.

2. *Switching on:*
   - If the timer has been switched off for any reason, allow **at least one hour** for it to warm up before any operational use (see Gibbs 2002 for warm-up tests).

3. *Working environment:*
   - Maintain a stable working environment around the timer;
   - Keeping the **temperature constant** is particularly important;
   - Monitoring the temperatures of air at the timer air inlet and air outlet will give quick feedback of potential problems;
   - Maintain a **good airflow** round/through the instrument.
   - Be aware that nearby air-conditioning units, cycling on and off, can substantially alter the temperature of the air in the vicinity of the timer, even in a supposedly temperature stabilised room.

4. *External frequency ("Clock source"):*
   - Supply each timer with a separate, **high quality 10 MHz sine wave**;
   - Make sure that the timer is set up to take an **external "clock source"**:
     - On the front panel, select the Calibration menu ("*cAL*");
     - Set "*cLoc SourcE rear*";
     - Specify the frequency by "*cLoc Fr 10000000*".
   - Keep it **permanently connected** to the timer;
   - Make sure that the input is properly **terminated with a 50Ω impedance** via a standard BNC T–connector (since timer inputs are >1KΩ).

5. *Multiple timers:*
   - If you use more than one timer, try to use **identical cable lengths** to feed:
     - All start channels;
     - All stop channels;
     - All external frequency inputs (UR43 co-ax).
   - This arrangement is recommended in order to minimise any possible phase effects.

6. *Timer calibration:*
   - The manual says that the timer "*has a sophisticated, built-in, auto-calibration routine that nulls insertion delays between start and stop channels, and compensates for the differential non-linearities inherent in analogue time-measurement circuitry. The auto-calibration routine takes about two minutes to perform and should be run every 1000 hours of operation.*" It is therefore recommended that users regularly (every 8 weeks or so) perform an Autocal (handbook, version 2.2, page 68) to optimise timer performance;
   - Regularly (annually) optimise the amplitude of the internal 90 MHz counting frequency of the timer (see handbook, version 2.2, page 69).

7. *Jitter:*
   - Regularly (annually say) **monitor the jitter** of the timer.
   - A simple experiment to do this consists of splitting a single pulse (generated from detector noise or a pulse generator) and feeding one pulse directly into the start channel and the other via a long cable into the stop channel. Many hundreds, or even thousands, of measurements of the time differences between the two will show a jitter dependent only on the performance of the timer. Typical results are about 25-30ps.

8. *Non-linearity:*
   - If you have more than one timer regularly monitor the range dependence of time interval measurements;
   - A simple experiment to do this would be to inter-compare the timer readings, shot by shot, as a function of satellite range. Examine the data for many passes and all satellites to display any range dependence of the timers;
   - As an independent check data may be collected over the full range of satellite ranges by exposing the detector to (reduced) daylight and successively gating at different ranges using a time delay generator (see Washington paper).

9. *Level settings:*
   - It is found that setting the discriminator levels for input pulses using the hand controls on the front panel does not give consistent or reproducible values for these settings;
   - Best results are obtained by using the hand controls to set values *very different* from (preferably with the opposite sign) those required for the inputs actually to be used, and then **setting the required values from software**;
   - This approach has three advantages:
     - Superior, long-term consistency of setting;
     - Simple visual inspection of the front panel immediately reveals any setting failures;
     - If the software fails to set the thresholds, the timers will not collect any (erroneous) data.

10. *Useful References on SR620 timers:*

Gibbs, P. & Sinclair, A.T., 1994, "*Investigation of a small range-dependent bias of two SR620 Time Interval counters*", Proceedings of 9th International Workshop on Laser Ranging Instrumentation, pp 274-276.

Appleby, G.M., Gibbs, P., Sherwood, R.A., & Wood, R., 1999, "*Achieving and maintaining sub-centimetre accuracy for the Herstmonceux single-photon SLR Facility*", Proceedings of , Florence.

Gibbs, P., 2002, "*Results of the SR620 timer comparisons made at the Herstmonceux Workshop*", to appear in proceedings of the 13th International Laser Ranging Workshop, Washington, 2002. See also http://nercslr.nmt.ac.uk/current_rnd/workshop_sr.html

Samain, E., 1994, "*Use of the Stanford SR620 interval counter as a time measuring device with 10 picosecond accuracy*".

Wood, R. & Appleby, G.M., 2002, Report of the EUROLAS Workshop "*Detecting and Eliminating Errors in the EUROLAS Network*" , held at Herstmonceux, 2002 March 11 to 13, http://ilrs.gsfc.nasa.gov/reports/special_reports/eurolas_workshop.html.