

## **NIST SRP Electronics Upgrade 2021**

The NIST Standard Reference Photometer (SRP) which has been in existence since 1983 has required several upgrades of its electronics system over the years due to changing technologies and obsolete components. Until now, the most recent upgrade of the SRP electronics system was performed back in 1999 and since this time several of the components are no longer available. As in the past this drives NIST to develop an upgrade of all or portions of the SRP electronics systems and control software to keep all SRPs in operation based on current technologies. In 2015, NIST developed a new electronics system based on the National Instruments (NI) CompactRIO hardware and has a working prototype. This system was deemed too expensive and required excessive software development. During this time a new SRP control software package called “O3 Conductor” was developed based on NI LabVIEW. Since then, in collaboration with the International Bureau of Weights and Measures (BIPM) a more reasonable SRP electronics system based on NI cDAQ components has been developed. The O3 Conductor software has been modified to work with the cDAQ based electronics system and development of a complete rewrite with improved structure has begun. This collaboration has brought us to what we now have available as the next SRP electronics upgrade. Below are the specific options that are available.

It should be clear that NIST is not forcing any SRP owner to perform any upgrade, it is completely voluntary. We are merely providing these upgrades to make sure each SRP can continued to be used well into the future. NIST will do its best to continue to help maintain the existing systems when possible. Additional information will be sent by the BIPM to BIPM.QM-K1 participants regarding the possibility to perform the upgrade and its validation during a comparison performed at the BIPM.

### **Option 1: Control software and interface hardware**

The existing “SRP Control” program which was written using Microsoft Visual BASIC is no longer supported by Microsoft and will not be modified by NIST. Additionally, the Measurement Computing Corporation hardware used to communicate with the SRP electronics using SRP Control is obsolete and only works in a 32-bit PC. As mentioned above a new NI LabVIEW based SRP control software called “O3 Conductor” has been developed and been in use for about 5 years. This program works on any 32 or 64-bit PC and recent Windows operating system. The hardware necessary to use the O3 Conductor program is an NI USB 6212 DIO card with SCSI output and cable and an updated NIST signal distribution module. Purchase of the current O3 Conductor version will allow any updated version at no additional cost.

Upgrade Package Costs (shipping or installation not included):

1. O3 Conductor software: \$2500 U.S.
2. NI USB 6212 with SCSI output and cable: \$2241 U.S.
3. Updated signal distribution module: \$500 U.S.

Install Cost at NIST: Included with Official SRP Validation.

*Notes: This option will not solve the problem of obsolete components in the electronics module thus is not considered a long-term solution.*

*Comparisons to another SRP are recommended before and after software change.*

*The NI USB 6212 with SCSI output and Cable can be purchased directly from NI.*

*An updated signal distribution module is only available from NIST.*

## **Option 2: New electronics module and 4 temperature sensors.**

This is the basis for the upgrade and consists of a completely new electronics module and 4 new temperature sensors. Much of the components inside this new electronics module are the same with the major difference being the replacement of the timing and signal distribution circuit board by an NI cDAQ chassis and associated plug in modules. The new electronics module enclosure is custom made as the company used for the past enclosures went out of business. It was designed to be similar and is the exact same size but is slightly different from the original. It will be black in color so those with the brown modules will obviously see a more distinct difference. Additionally, the cover is removed by lifting straight up rather than sliding in from the rear. The existing SRP J1, J2, J3, Pressure (now P1), Detector, Scaler 1, Scaler 2, and the ground wire cable connectors will plug directly into the new electronics module. There will now be 4 temperature sensors labeled T1 (cell 1 in), T2 (cell 1 out), T3 (cell 2 in), and T4 (cell 2 out) respectively. These custom-made 100-ohm Platinum RTD surface probes will need to be adhered to the appropriate positions on the cells and will provide a more accurate measurement by averaging the inlet and outlet temperature of each cell. Measurements are currently being taken to assess this improvement. The new surface mount temperature probes will need to be calibrated by comparison to a traceable temperature standard in some type of chamber. A drywell unit with precise temperature setting and control is the preferred choice. The recommended time interval for this calibration is also currently being assessed but is believed to be on every 6 months to 1-year interval.

Additionally, a second pressure transducer for cell 2 pressure measurement which is optional can be used so a P1 and P2 socket is present. A final socket called J5 is available for an optional automatic pump control feature.

Upgrade Package Costs (shipping or installation not included): \$19,595 U.S.

Provided: Fully Tested Electronics Module and 4 Calibrated Temperature Sensors.

Installation Cost at NIST: Included with Official SRP Validation.

*Notes: Requires Option 1 (O3 Conductor software only).*

*Electronics Module will be completely assembled and fully tested at NIST.*

*Tests included*

- 1. Temperature Controller function*

- 2. Shutter control function*

- 3. Scaler test function*

- 4. Valve control function*

- 5. Ozone measurement function*

*Temperature Sensors will be calibrated at NIST traceable to NIST Temperature Standards.*

*Estimated Delivery time 2-6 months from accepted order (workload dependent).*

### **Option 3: Second pressure transducer for cell 2.**

All existing SRPs have only one pressure transducer which measures the pressure at the outlet of cell 1. Selection and adjustment of the solenoid valves has always been done to minimize the pressure difference between cell 1 and cell 2. Until SRP 27, this difference allowed was up to 1.0 hPa. From SRP 27 forward this difference was reduced to 0.6 hPa and became difficult to achieve. Originally, the SRPs used a 0.125-inch orifice valve, then at some point a 0.188-inch valve began being used. Beginning with SRP 47, larger 0.250-inch orifice valves have been used which has helped keep this cell pressure difference below 0.6 hPa. The cell pressure difference has not been checked on most SRPs since production, so it is impossible to know what these values are currently. Additionally, the flow rate used in the sample and reference manifolds can vary causing different pressures. As each cell alternates measuring sample and reference gas depending on which valve is energized, additional uncertainty in the cell pressure occurs. Adding a second pressure transducer allows for accurate and independent measurements of the pressure in each cell avoiding any worry of a cell pressure difference. This also lowers the overall SRP measurement uncertainty by a small amount as the added cell pressure difference uncertainty is removed. It should be noted that the uncertainty due to temperature and pressure are the lowest values of all the combined SRP uncertainties.

The easiest way to add the second pressure transducer is to have it placed on the lab bench just below the end of the cells. A stand will be provided and a simple connection using a Swagelok fitting to a tee at the exit of cell 2, plus a direct electrical connection to the P2 connector on the electronics module rear panel makes for an easy install. If desired a completely new optical bench can be purchased which has the mounting hole for the second pressure transducer next to the cell 1 pressure transducer. This however requires hours of labor to make the change and should only be performed by an appropriate person.

Upgrade Package Costs (shipping or installation not included): \$3348 U.S.

Provided: New Pressure Transducer with Stand, Plumbing/Connector, and P2 Cabling.

Install Cost at NIST: Included with Official SRP Validation.

*Notes: Requires Option 1 (Software only) and Option 2 (Electronics Module and 4 Temperature Sensors). New pressure transducer will come with manufacturers original calibration certificate but will require and "offset" calibration against certified lab standard along with P1 transducer.*

### **Option 4: Auto pump control.**

One of the problems SRP operators face is making sure there is enough reference air available in the reference manifold when the operating program stops, and the sample pump is still on. This is because when the program stops, both cell 1 and cell 2 valves are off, so all sampling is done from the reference manifold. This means approximately 4 liters/min. needs to be available for each SRP connected. Until now the power to operate the sample pump was only available manually. This new feature allows the control program to turn on and off the sample pump thus eliminating the worry of drawing in room air if enough reference air is not available in the reference manifold. Additionally, complete remote operation of the SRP operating program can be more easily done provided specific items are already powered on.

This feature is installed by adding a new J5 connector on the rear of the pneumatics module and replacing the current pump switch with a new one allowing for auto-off-on switch selections. This does require drilling a hole in the rear panel of the pneumatics module, installing the connector and wiring, then removing the existing pump switch and installing the new one by soldering each connection. This does require some labor and should only be performed by an appropriate person.

Upgrade Package Costs (shipping or installation not included): \$166 U.S.

Provided: J5 Cable, J5 Connector and wiring, 3-way Switch.

Install Cost at NIST: \$600

*Note: Requires Option 1 (Software Only) and Option 2 (Electronics Module and 4 Temperature Sensors).*

#### **Option 5: Optical bench replacement to allow for second pressure transducer.**

As mentioned in Option 3, the existing optical bench can be replaced by a completely new one allowing for the mounting of the second pressure transducer. This option is not strongly recommended due to the labor time and experience necessary to perform it but is available if desired. This would involve removing all components from the existing optical bench and re mounting them on the new optical bench, also including the second pressure transducer. At this time alignment of the light beam would be checked and adjusted if necessary and any additional updates could be made.

Upgrade Package Costs (shipping or installation not included): \$1266 U.S.

Provided: New Optical Bench with 14 position Terminal Strip.

Install Cost at NIST: \$1200

*Note: Requires Option 1 (Software Only), Option 2 (Electronics Module and 4 Temperature Sensors), and Option 3 (Second Pressure Transducer).*