Instruments for the Measurement & Recording of Flows Under Ice

- Ice Detection and Under-Ice Flow Monitoring
- Discharge and Current Profiles Under the Ice
- Flood Forecasting and Warning Systems
- Sensors and Data Logging Options for Temperature, Flow and Water Level
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Ice Detection and Under-Ice Flow Monitoring
Using a SonTek Argonaut-SW

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Abstract—The Argonaut-SW is an acoustic Doppler current meter designed for water level, velocity and flow monitoring in rivers and channels. When working in ice affected rivers, some means of determining if ice is present is required to provide accurate flow data. Using data collected with an Argonaut-SW in the Chateauguay River in Quebec, Canada in 2004, algorithms were developed that allow the Argonaut-SW to detect the presence or absence of ice on a river in real-time. These algorithms were developed using data collected during winter and ice break up in the spring of 2004. The new algorithms have been tested at a number of sites during the freeze up and winter of 2004-2005. The ice detection algorithms provide a reliable and highly efficient means of detecting ice formation on the river. The Argonaut-SW also provides reliable stage, velocity and flow data while operating under ice. Combined with the ice detection data, this allows for substantial improvement in flow monitoring on ice affected rivers. Data from a number of Argonaut-SW installations involving flow under ice conditions will be presented, both with respect to the ice detection algorithms and the overall flow monitoring capabilities.

I. BACKGROUND

Flow monitoring under ice cover presents a number of significant challenges. Most mechanical devices for water level or velocity measurement are highly susceptible to clogging and freezing. Many standard means of monitoring water level are not effective, as the presence of ice will affect the water pressure and produce misleading results [1]. Doppler current meters such as the SonTek/YSI Argonaut series show great promise in this application, with no moving parts and a strong immunity to fouling with ice. The vertical acoustic beam used to measure water level by instruments such as the Argonaut SL and SW detects the location of the bottom of the ice. For flow calculations under ice, depth measured to the bottom of the ice is the critical parameter to provide an accurate gauging of water level.

The velocity distribution within the water column changes significantly when ice is present. The modified velocity distribution will affect flow calculations and can have a significant impact on processes such as erosion and bridge scour. Accurate and reliable knowledge of the under ice velocity distribution is critical to the monitoring and understanding of these phenomena. Other applications that require accurate under ice measurements include hydrologic modeling, forecasting water flows to reservoirs, and optimizing power management for hydroelectric facilities.

Fig. 1 – SonTek/YSI Argonaut-SW

The Argonaut-SW (Fig 1) was a logical choice for under ice flow monitoring. The SW is a bottom mounted instrument that is specifically designed to be able to adapt to changing water level, while also providing data on the vertical structure of velocity within the water column. Since ice coverage will affect the vertical structure of velocity within the water column, knowledge of the velocity distribution is needed for accurate flow monitoring.

Given the type of data collected by the SW, it was also expected that an algorithm could be developed that would allow the SW to automatically determine whether or not ice was present on the river. No other automated method of ice detection was available, and the ability to determine in real-time when ice formed will be extremely valuable to accurately monitoring flow in the river, particularly during the freeze up period in fall/winter and the break up period in spring.

II. ARGONAUT-SW OPERATING PRINCIPLES

The Argonaut-SW is an acoustic Doppler current meter designed for water level, velocity and flow monitoring in rivers, channels and pipes [2]. The SW housing (fig 1) is 24.5 x 10.0 x 6.3 cm and contains all electronics for processing and data recording.

The SW uses three acoustic beams at an acoustic frequency of 3000 kHz to monitor water level and velocity (Fig. 2). Beams 1 and 2 are slanted 45° from the vertical and are used to measure the vertical profile of velocity. Beam 3 looks vertically up and is used to measure the range to the water surface or the bottom of the ice. Using the water level measured by beam 3, the SW automatically adjusts the size of the measurement volume and returns an integrated velocity value starting a short distance above the instrument.
In open channel conditions, the SW is able to measure velocity all the way to the water surface. When used under ice or in a full pipe, the SW ends the measurement volume some distance below the bottom of the ice or top of the pipe to avoid sidelobe interference from the ice or the wall of the pipe.

As with any acoustic Doppler device, the maximum operating range of the SW depends on conditions in the water. Typically, the SW can operate in water depths ranging from 0.2 to 5.0 m. Experience has shown that some ice-affected rivers have very clear water during winter, reducing the maximum measurement range for velocity. So in some cases, the maximum velocity measurement range may be limited to less than 5 m. In general, even if velocity measurement range is limited the SW will still provide reliable water level data and the velocity data will be sufficient for accurate flow calculations for depths up to 5 m.

In addition to the vertically integrated velocity measurement, the SW can report the profile of water velocity. The multi-cell velocity profile divides the water column and reports velocity in up to 10 equally sized cells. The size and location of the cells are fixed based on user supplied operating parameters and are not adjusted based on changing water levels. Though not essential for basic flow monitoring applications, the multi-cell velocity profile expands the capabilities of the SW for detailed flow modeling. The velocity profile is particularly valuable in ice-affected rivers, where the presence of ice will significantly change the vertical velocity profile.

III. ICE DETECTION DEPLOYMENT SITES

During the fall of 2003, two Argonaut-SW systems were deployed on the Chateauguay River in Quebec, Canada. The two systems were approximately 400 meters apart, with no inlets or outlets between them. The sites, which have notably different flow characteristics, were selected to compare instrument performance and to provide additional data for modeling of under ice flow conditions.

The upstream site (Fig. 3) is approximately 85 m wide and has depths ranging from 2 to 5 meters at the location the SW is installed. The downstream site is approximately 40 meters wide and has depths ranging from 1.5 to 4 meters at the location the SW is installed. The water velocity at the downstream site is significantly higher than at the upstream site. The downstream site forms ice later, and ice breaks up earlier, than the upstream site.

During the fall of 2004, an SW was also installed at a remote location on the Necopastic River in Quebec, Canada and at another site in Saskatchewan, Canada. These four sites have provided the bulk of data used to develop and evaluate the ice detection capabilities of the SW. Additional SWs have been installed and are operating at a number of sites in ice-affected rivers, although the data from these other sites has not been analyzed in detail as part of this project.

IV. ICE DETECTION

Water velocity, level and flow data have been collected continuously with both systems on the Chateauguay River since installation in 2003. During the winter of 2003/2004, additional debugging data was collected from both sensors and was monitored closely to evaluate and modify system performance under ice.

Data collected from these two sites during the spring 2004 break up were used to develop the algorithm to determine if ice is present. The details of the ice detection algorithm are proprietary to SonTek/YSI and will not be presented here. The ice detection algorithm uses the profile of signal strength and velocity to calculate an ice detection score; the ice score is a unit-less parameter with values ranging from 0 to 200.

The ice detection algorithm also uses water temperature as a threshold check; if temperature is less than 5°C, the SW will look for the presence of ice. If temperature is greater than 5°C, the SW assumes no ice is present (it returns an ice detection score of 0). The temperature threshold level was higher than expected, and is based on observations during the spring break up when ice can be present (albeit for a short period of time) during the first warmer water runoff.

The ice score is interpreted as follows. A value from 0 to 50 indicates little evidence of ice, and the SW operates as if there is no ice present. A completely frozen river typically gives ice scores of 150 to 200. Ice scores between 50 and 150 are seen during freeze and break up periods, and have been correlated to a variety of conditions such as partial ice coverage, floating ice moving downstream, and warm periods while ice coverage is still thin (assumed to indicate partial melting of the ice).
V. FIELD TESTS AND RESULTS

The ice detection algorithm was developed using data from both sites on the Chateauguay River during break up in the spring of 2004. Of particular interest is the ability of the SW to recognize changes in ice conditions, and thus determine the precise time at which freeze up and break up occurs. Fig. 4 shows a plot of the ice detection score from the upstream site on the Chateauguay River during break up in 2004.

The plot covers a time span of 20 days starting on March 21 (plotted as day 80 of the year 2004); break up occurred on March 24 (day 84). The ice detection score indicates a change from complete ice coverage (with ice detection score between 160 and 200) to minimal ice coverage (ice detection score near 0) in the span of 1-2 hours. The approximate time of the break up has been confirmed with an automated camera taking photographs of the site.

While analyzing the data from this period, we observe a period of relatively low ice scores (values up to 80) starting about 5 days after the spring break up (day 89-90). This corresponds with independent observations of ice that has broken apart further upstream and was drifting past both SW installation sites. Thus, the lower ice detection score appears to indicate partial ice coverage.

Results from the downstream site during the break up in spring 2004 were similar to those seen at the upstream site. Breakup at the downstream site occurred on March 5, and took place in two stages over the span of about 12 hours. The ice score quickly dropped from near 200 to near 100, remained there for several hours, and then dropped to near 0. The downstream site also showed several periods of low ice scores (50 to 100) in the days and weeks after break up, likely indicating ice floating down from upstream.

Since the data used to develop the ice detection algorithms were collected during the spring break up from these sites, a more rigorous test of the algorithm is how it responds to the formation of ice during the freeze up period in the fall and winter. The new algorithms were enabled for freeze up at both sites on the Chateauguay River, and at the site on the Necopastic River. Unfortunately the new algorithms were not installed on the site in Saskatchewan until after the river was frozen; the site has been operating with the new algorithms since a few weeks after freeze up.

Both sites on the Chateauguay River and the site on the Necopastic River showed similar results during the freeze up. In each case, the SW was able to clearly and reliably report when significant ice coverage was formed on the river. In all cases, the SW indicated periods of partial ice coverage in the time leading up to the complete ice coverage. The downstream site on the Chateauguay River froze much later than the upstream site (January 22 compared with December 6), with the final ice coverage forming over a period of 3-4 hours. The site on the Necopastic River froze on November 12, with complete ice coverage forming in 4-5 hours.

There is another interesting feature from the upstream site on the Chateauguay River. These data are an excellent example of the type of information that may be obtained with this instrument that would likely be unavailable with any other device, and provide insight into the river dynamics. Fig. 6 shows a plot of the ice detection score and the measured water level for a period of 2 days around the freeze up process in 2004.
The transition from open water to ice coverage can be seen more clearly (as the ice detection score gradually increases from near 0 to near 200 around day 340). At roughly the middle of the freeze up period, the water level shows a rapid drop. The change is stage was approximately 0.25 m out of a total water depth of less than 3 m. The change occurs in the span of less than 15 minutes. Likewise at the same time, a small but noticeable increase in velocity occurs. This gives an idea of the effect that the ice coverage can have on the flow conditions within the river.

We did not observe a similar change in stage at either the downstream Chateauguay site or on the Necopastic River during the freeze up process. At this time, we cannot offer any conclusive explanation, but it does point out some intriguing characteristics of the river during the freeze up process.

VI. LIMITATIONS

There are some limitations of the ice detection algorithm that should be noted. Since the algorithm uses the profile of acoustic signal strength and velocity, the SW needs a certain minimum depth to have sufficient data for these calculations. When depth drops below about 0.7 m, the performance of the ice detection algorithm changes and the scores are typically lower than would be expected in deeper water. When depth is less than 0.3 m, there is insufficient data and the SW does not perform the ice detection algorithm at all (it reports an ice detection score of 0).

When ice is present the SW cannot measure velocity all the way up to the bottom of the ice. Because of the acoustic reflection from the bottom of the ice, the SW sees sidelobe interference in the upper 20% of the water column (a similar effect is seen for measurements in pipes [2]). This is different than performance in open water, where the SW can measure all the way to the surface. To avoid this interference, the SW will automatically pull back the measurement volume the appropriate distance when the ice detection score is greater than 50.

VII. CONCLUSIONS

The ability to detect ice on the surface of a river has been added as a standard part of the Argonaut-SW firmware; ice detection must be enabled by the user as part of the standard deployment procedure. The Argonaut-SW has been shown to provide reliable velocity and stage data in both open water and under ice conditions. The ice detection algorithms provide reliable detection of the ice presence, both during freeze up and break up periods. The ice detection score can also indicate partial ice coverage.

The ice detection score is available in real time to improve the accuracy and reliability of flow monitoring in ice affected rivers. The ability to detect the presence of ice provides a powerful tool not available with any other flow monitoring device. This capability is extremely valuable when monitoring rivers in ice affected regions, and should greatly expand the accuracy and reliability of these measurements. It should also increase the knowledge of the dynamics of ice affected rivers.

VIII. ACKNOWLEDGMENTS

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IX. REFERENCES

Discharge and Current Profiles Under the Ice

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Abstract - In 2004 SonTek developed, in conjunction with Environment Canada, a new methodology for measuring current flow under ice cover. Mini-Acoustic Doppler Profilers (ADP) were deployed from above the ice cover and water velocity data were collected with SonTek’s new Stationary Measurement Software. These initial field tests were made on the Mackenzie River at Fort Simpson, North West Territories, Canada.

The original field site was chosen for its demanding environment conditions. At Fort Simpson, the Mackenzie River was over 1 km wide, with approximately thick 1 m of fast ice, areas with up to 80 cm of frazzle ice and currents of about 1 m/s. Temperatures dropped to below -20ºC during part of the February field tests. A full set of Mini-ADPs (3.0 MHz, 1.5 MHz and PC-ADP) were utilized at various locations to generate velocity profiles from the water-ice boundary layer to the bottom boundary layer. SonTek’s Stationary Software was used to stitch various velocity profiles into a single discharge summary.

Further refinements to the methodology and software have been ongoing in Canada and Asia. In March 2005 data was collected from a new field location at Heihe, Heilongjiang province in Northern China. The Heilongjiang River borders northern China and Siberia. It was about 700 m wide, with a maximum velocity of about 0.7 m/s and a total flow in winter of approximately 600 m$^3$/s. In spring, the flow rates increase and the maximum velocities can get to 2 m/s.

I. INTRODUCTION

Understanding environmental impacts on river systems of global change and water quality requires a baseline understanding of river flows in all seasons. However, under ice velocity surveys in winter conditions are logistically challenging. Temperature extremes, ice thickness, the lack of open water, the presence of frazzle ice and sometimes the remoteness of the location are often beyond the capability of environmental instrumentation that are designed for low-latitude use. SonTek has developed and tested its acoustic Doppler equipment to work in these extremes.

Acoustic Doppler profilers (ADP) remotely measure water movement with the use of acoustic pulses or pings. ADPs are found in various housing configurations and frequencies. The relatively new Mini-ADP is as fully functional as a standard, full-sized ADP; the only significant difference is its small 10 cm probe diameter. This smaller, low-flow disturbance design has simpler deployment requirements than a standard ADP.

II. MINI-ADP AND PC-ADP

The ADP was first developed by SonTek back in 1994. It has two different modes of operation, narrow-band and pulse coherent. Narrow-band acoustic processing has the greatest velocity and profiling range of any processing technique but has limited resolution. The pulse coherent processing technique has the highest spatial and temporal resolution of any acoustic processing technique but has limited velocity and profiling ranges.

Fig. 1. Mini-ADP linked to its autonomous black box, which has a wireless connection to a remote computer. The probe head was mounted to a wooden pole that was graduated to determine the water depth of the probe head.

The ADP works with multiple transducers transmitting acoustic pulses along narrow acoustic beams within the water. For narrow-band processing, these pulses reflect off scatterers within the water and the backscattered signal is received by the transducers. The speed of the scatterers moving towards or away from the transducers, and thus the speed of the water they are in, is directly proportional to the Doppler shift of the returning signal. The method is robust and has a large operational velocity range.
with no intrinsic bias. Measurable velocities can be as great as 10 m/s and remote sensing of velocities can happen 10’s and 100’s of meters away from the acoustic transducers. However, the pulses have to be relatively long (a large number of wavelengths) in order to acquire high precision measurements of the Doppler shift and thus the velocity. These long acoustic pulses limit the vertical resolution of the velocity profile.

The pulse coherent technique gives ADPs almost the opposite features. Pulse coherent processing uses the phase change between pulse pairs rather than the frequency change of a single pulse. The time between the two pulses, $\tau$, and the speed of the water determine how far the scatterers move between pulses. The correlation method of pulse coherent processing is the correlation technique of pulse coherent processing is restricted in detecting the distances to within $\pm \lambda/2$, where $\lambda$ is the acoustic wavelength of the pulse (in the case of the 1.5 MHz PC-ADP and a sound speed of 1500 m/s, $\lambda = 1$mm). Therefore, the maximum resolvable velocities are limited to $\pm \lambda/(2\tau)$. The time between pulses also determines the maximum profiling range, $\tau \times \text{Sound Speed} / 2$. Hence, an increase in the time lag between pulses reduces the maximum resolvable velocities but increases the profiling range.

The pulse coherent technique has the advantages of greater spatial and temporal resolution than other acoustic processing techniques. With appropriately chosen time lags, the phase change between pulses is large and easily resolved, even with short acoustic pulses. Thus, fewer acoustic pulses are required relative to other processing techniques to attain the same level of velocity precision. Also, the short acoustic pulses allow for smaller cell sizes and better vertical resolution. The smallest cell of a 1.5 MHz ADP using narrow-band mode is 25 cm, while the cell can be as small as 1.6 cm with pulse coherent processing.

ADPs are built with two different housing formats. The standard ADP is in a single robust housing that has space for transducers and electronics. This all-in-one design is typically used on lower frequency ADPs and those meant for deep ocean deployments. The Mini-ADP is the mating of an electronics housing with a small Delrin transducer head via a high frequency cable. The design allows for a much smaller probe than other acoustic profilers (Fig. 1). The small size reduces any flow disturbance near the profiler.

The Mini-ADP comes in complete packages with internal batteries, compact flash recorder, compass, tilt and temperature sensors. The measured temperature and user input salinity are utilized to estimate the in-situ sound speed. This assures that the accuracy of the ADP’s measured velocities is within 1% because the velocities depend on the sound speed. The electronics housing can take compact flashes of up to 1 GB, for long-term autonomous deployments. The compact design used during the field work in the NWT and northern China (Fig. 1) was the perfect balance of portability and operational modes for working on the ice.

Other optional sensors can be integrated with the ADP. Druck’s piezoresistance and high precision RPT pressure sensor can be installed inside the probe head. Paroscientific DigiQuartz pressure sensors are available for external integration. Temperature and conductivity can be measured by an external SeaBird MicroCat, while turbidity can be resolved by a D&A OBS sensor.

The PC-ADP is the only ADP designed specifically to take advantage of the pulse coherent technique. The PC-ADP combines the Mini-ADP design with unique 15° slant angle beams. Because an ADP is only sensitive to velocities along the beam, the 15° angles allow for greater resolvable horizontal velocities than other ADPs with slant angles of 25°. The reduced flow disturbance within the sample volume of the profiler makes the Mini-ADP design the obvious choice to use with the PC-ADP.

### III. FIELD LOCATIONS

In February 2004, SonTek joined members of Environment Canada (EC) in the North West Territories of Canada. The field work was to develop the equipment, software and procedures necessary to meet the challenges of monitoring under-ice water velocities. A location was chosen on the Mackenzie River that was within line-of-sight of the EC office in Fort Simpson, NWT.

The Mackenzie River is the fourth largest of the river systems that empty into the Arctic Ocean. The river at the field site was over 1 km wide and up 15 m deep. The ice at the site was deformed with pressure ridges. Outside the pressure ridges, the ice thickness was approximately 0.8 to 1.0 m thick. Below this layer of non-moving ice were patches of mobile frazzle ice (slush). These patches of frazzle could be over 0.5 m thick.

The existence of the patches of frazzle ice makes velocity measurements difficult. Traditional measurements with mechanical current meters are problematic. The measurements begin by making a hole in the ice with a motorized ice-auger and the mechanical current meter is then deployed through the hole. Unfortunately, frazzle ice can quickly fill the hole, making recovery of the mechanical current meter uncertain (Fig. 2). The
mechanical meter also needs a special “hot box” to prevent freeze up, especially when moving between holes.

The use of standard ADPs in the same application would have been logistically difficult. The probe-head of a standard ADP has a 20 cm diameter, but a Mini-ADP’s probe is only 10 cm. The smaller probe fits within the same size ice-hole as the mechanical current meter (Fig. 1). The placement of the probe at the ice-water interface provided partial coverage of the hole and impeded frazzle ice from filling and blocking the hole.

Further field tests in 2005 were conducted near Winnipeg, Manitoba, Canada and Heihe, Heilongjiang, P. R. China (Fig. 4). The Heilongjiang River is an international river that defines part of the border between P. R. China and Russia. It is the first field location outside of Canada that SonTek has used for testing under ice velocity measurements. The river has a water shed area of 1.6 million km² and is one of the eight longest rivers in the world. At our chosen field site near Heihe, the river was about 700 m wide and 4 m deep in March 2005.

IV. ADP AND PC-ADP DATA

Three different Mini-ADPs have been deployed at the various field sites. At Fort Simpson, two regular Mini-ADPs, 1.5 MHz and 3.0 MHz were used in their narrow-band modes. Their respective nominal ranges of 25 m and 6 m provided velocity profiles from near the ice water interface to the bottom boundary layer. At Heihe, a 1.5 MHz Mini-ADP was used across the entire river’s width, but it had a new feature for 2005 that allowed it to profile in shallower water depths. The system could automatically acquire narrow-band and pulse-coherent data at the same time.

SonTek’s Stationary Measurement software was used to collect the data from the Mini-ADPs. The software is designed to perform current and discharge surveys by stitching together velocity profiles from various discrete stationary locations. This differs from traditional current surveys with an ADP where the ADP has to stay submerged for the entire time of the survey and its position is determined by bottom-tracking or DGPS. This new capability is immediately applicable to surveying velocities through ice cover where a series of discrete ice-holes is the only available method to access the water.

Profiles from the ADPs were sufficient to resolve most of the average flow. The profile from the 1.5 MHz ADP (Fig. 5) clearly indicates the existence of two boundary layers; one near the top of the profile at the ice-water interface and one near the bottom of the profile at the bottom-water interface. The tests run at Fort Simpson, showed that the ADPs were able to function in some of the most demanding conditions (frazzle ice and cold) that were proving problematic for mechanical current meters. These tests were run at only a few positions across the Mackenzie River and no complete discharge measurement was done.
While the tests run in NWT were for developing procedures and testing equipment on only part of the river, in Heilongjiang the idea was to do a complete discharge for the river from the Chinese side to the Russian side of the river. At a traditional gauging station where mechanical current meter measurements have been made, we deployed an ADP using the same ice holes that had been cut for the mechanical current meter. Data was collected remotely at the Chinese gauging station (Fig. 6).

A 1.5 MHz Mini-ADP was deployed with a new capability to automatically mix narrow-band and pulse coherent processing. This allowed for a greater operational depth range than had previously been available in a completely automated operation. Thus, we could operate in shallower depths than had been possible in the 2004 tests.

The ADPs operated successfully in one of the harshest environments of Northern Canada and Northern China. Temperatures ranging from -5ºC to -25ºC did not affect the systems when protected by a modest amount of insulation. Layers of frazzle ice did not prove to be an impediment in either collecting velocity profiles or recovering instruments.

The third type of Mini-ADP that has been deployed, the PC-ADP, was used during the first tests at Fort Simpson NWT. Because of the relatively high current speeds (> 1m/s), the time lag between acoustic pulses had to be set relatively short and this resulted in a maximum profiling range of only 0.5 m. However, it was possible to setup the PC-ADP for very high-resolution profiles. Sample rates of 20 times a minute, with vertical profiles of 27 × 1.6 cm cells provided velocity precisions of about 0.1 cm/s. This combination of temporal and spatial resolution allowed for a detailed study the ice-water boundary layer.

The PC-ADP probe was mounted in a hole in the ice with its transducer surface placed flush with the ice-water interface. The region of disturbed flow was minimized because of the probe placement, the small size of the hole and the probe size and shape. With the first cell starting only 7 cm from the head, we had a unique opportunity to measure the boundary dynamics. The near ice boundary layer proved to be more variable and complex than anticipated.

The mean velocity profiles (Fig. 8) approximately follow the Law of the Wall. The mean speed follows a nearly logarithmic profile from 20 cm to the end of the profile at 51 cm. The typical derivation for a logarithmic boundary layer over a rough surface [3] is

\[
U = \frac{1}{u_*} \ln \frac{z}{z_0}
\]

where \( U \) is the mean speed, \( u_* \) is the friction velocity, the von Karman constant \( \kappa = 0.4, z \) is the distance from the boundary and \( z_0 \) is length scale of the roughness elements. Hence, the friction velocity and roughness length given the profile in Fig. 8 are approximately 0.1 m/s and 0.7 m respectively. The large roughness length suggests that flow past pressure ridges upstream of the PC-ADP generated the turbulent boundary layer dynamics observed.

The PC-ADP profiles also indicate a high degree of temporal variability. This was apparent during the field test because large horizontal forcing changes were observed when holding onto the aluminum pole upon which the PC-ADP was attached. Standard deviations of the velocity profile (Fig. 8) indicate that the current variability was 15% to 30% of the mean velocities. Within 10 cm of the ice, the velocities and their standard deviations are relatively low. At distances of over 20 cm, where the Log Layer is well developed, the standard deviations are nearly constant with depth, and there is only a small trend of decreased standard deviation (turbulence).

\[ U = \frac{1}{u_*} \ln \frac{z}{z_0} \]

V. SUMMARY

SonTek’s Mini-ADPs proved to be the right tool for measuring velocity profiles under ice:

- The small size of the Mini-ADP makes it logistically easy to deploy through the ice using existing equipment.
- The ADPs operated successfully in one of the harshest environments of Northern Canada and Northern China. Temperatures ranging from -5ºC to -25ºC did not affect the systems when protected by a modest amount of insulation. Layers of frazzle ice did not prove to be an impediment in either collecting velocity profiles or recovering instruments.
- High-resolution velocity profiles of the ice-water boundary layer with the PC-ADP proved to be highly dynamic and complex. Much of the boundary dynamics appear to be generated from upstream pressure ridges.
TRCA FLOOD FORECASTING & WARNING SYSTEM

SCALEABLE FLOOD WARNING SYSTEM INCLUDING WEB-BASED DATA & VIDEO FOR THE TORONTO & REGION CONSERVATION AUTHORITY'S NINE WATERSHEDS

SUMMARY

Sutron designed, manufactured, and integrated into an existing system a web-based, scalable, 100% reliable Flood Warning System for TRCA to deliver data using a cellular communication-based network (where service is available) from five Pilot Locations to a Base Station computer at TRCA headquarters.

The System includes the following:

- State-of-the-art automated remote water level measuring equipment
- Integrate existing TRCA rain gauges and submersible pressure sensors at the five sites into the new Real-Time Monitoring and Warning System.
- Datalogging and real-time communications using cellular IP-based modems
- Real-time data collection and data-processing software to access real-time and logged data
- Remote and direct access to the datalogger
- A real-time, web-based decision support system and dynamic real-time web-reports using graphical and tabular formats
- A warning or call-out system based on sensor and station attributes
- A real-time live video camera system
- Comprehensive system documentation
- Hands-on and class-room training in the operation and maintenance of the entire system as well as each station and its components.

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HIGHLIGHTS

- Direct Access via PC or PDA and Full Remote Access over the Internet as if connected directly
- Complete Remote Diagnostics and Configuration Capabilities
- Datalogging available to multiple LOG files so data can be shared by different agencies
- Alarm Call-Out facility
- Windows™-based Real-Time Central Data Processing Software – Sutron’s XConnect
- Data Transfer Speeds of up to 115 kbps
- Central Software that supports RDBMs, such as MS Access, SQL or ORACLE
- Automated Dial-Out or Notification via Pagers, Email, Printer, etc – XConnect’s XCALARM
- Dynamic Real-time WEB Output using XML reports – XConnect’s XCWEB OUTPUT
- Provide Base Station Software with a RDBMS Interface that automatically collects and processes rainfall and water level data at pre-defined intervals, generates reports and, when appropriate, produces alarms.
- Provide 100% reliable Call-Out or Alarm Notification System.
- Provide Dynamic Real-Time Web Reports detailing a range of real-time rainfall/water level data, trends, alarm status, datalogger health, etc. (see specifications).

XConnect supports a variety of relational databases:

- Access - Microsoft Access database.
- Oracle - Oracle 8i and higher databases.
- SQL Server - Microsoft SQL Server.
- HDB (CADSWES) - Special database schema created by CADSWES Corporation.
- INSQNL (Wonderware) - Special implementation of XConnect tables and Wonderwares INSQNL database.
Other Great Products From SonTek:

**FlowTracker**
Handheld Doppler current meter easily attaches to wading rods and features a built-in discharge measurement algorithm.

**RiverCAT**
Complete integrated catamaran system for open channel discharge measurement with optional DGPS for bathymetric surveying.

**Argonaut-SL**

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**Argonaut-SW**
Shallow Water Flow, Level, and Velocity Measurement.

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**IRRIGATION**

**PIPES AND CULVERTS**

**NATURAL STREAMS AND CANALS**

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SonTek

THE WORLD LEADER FOR WATER VELOCITY MEASUREMENT

www.sontek.com

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Flow Monitoring

Monitoring flow in natural streams, concrete lined channels and pipes could never be easier than with the Argonaut-SW. This lightweight and compact system uses SonTek's proven Doppler technology to measure the flow, velocity and water level. The system is designed to account for velocity variations within the channel to produce the most accurate flow calculation possible.

Easily installed onto the bottom of an open channel, the Argonaut-SW measures water velocity, water level, and total flow.
**Features**
- Operates in depths from 0.2 to 5.0 meters (0.7 to 16 ft.)
- Water level measurement
- Automatically adjusts for optimal performance with changing water level.
- Windows + PDA software

**Applications**
- Open Channels
- Pipes
- Natural Streams
- Shallow Water Conditions
- Water Level Monitoring
- Velocity Indexing

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**View Argonaut**
Every Argonaut-SW comes with user-friendly Windows software for setting up your system and analyzing data. A flow configuration utility makes flow measurement simple.
**Argonaut-SW**

**Specifications**

**Velocity Profiling Range**
- Maximum depth 5.0m (16ft)
- Minimum depth 0.3m (1ft) *

*Can operate in shallower depths down to 0.2m (0.7ft) with performance limitations

**Water Level Measurement**
- Minimum depth:
  - Above transducer 0.10 m (0.3 ft)
  - Total water depth 0.20 m (0.6 ft)
- Maximum depth 5.0m (16ft)
- Accuracy ±0.1% of measured level, ±0.3 cm (0.01ft)

**Water Velocity**
- Range ±5 m/s (16 ft/s)
- Resolution 0.1 cm/s (0.003 ft/s)
- Accuracy ±1% of measured velocity, ±0.5 cm/s (0.015ft/s)

**Standard Features**
- 2-D velocity measurement (using 2 acoustic beams) - along channel and vertical velocity components
- Water level measurement using vertical acoustic beam
- Automatically adjusts sampling volume location to measure the maximum possible portion of the water column
- RS232/SDI-12 communication protocol
- Real-time flow calculations using user-supplied channel geometry
- 4 MB Recorder capacity (over 50,000 samples)
- Temperature sensor (Resolution ±0.1 °C, Accuracy ±0.5 °C)
- ViewArgonaut Windows 95/98/NT/2000/XP software for instrument setup, data collection, and post processing
- PDA software (SonUtils and deployment module)
- Polycarbonate mounting plate

**Optional Features**
- 4-20 mA and 0-5VDC output modules; possible variables are X velocity, y velocity, velocity magnitude, temperature, signal strength, water level, and flow
- MultiCell current profiling

**Physical Parameters**
- Dimensions: 24.5 cm (9.7 in) long by 10.0 cm (4.0 in) wide by 6.3 cm (2.5 in) high
- Weight - in air: 1.2 kg (2.6 lb), in water: 0.15 kg (0.3 lb)
- Pressure rating: 25 m (80 ft)
- Operating temperature: -5 °C to 60°C (23°F to 140°F)
- Storage temperature: -10 °C to 70°C (14°F to 158°F)

**Power Requirements**
- Input power 5-15 VDC
- Power consumption 500 mW - 700 mW nominal

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**Argonaut-SW**

**How it Works**

The SW is mounted on the bottom of the channel or pipe and uses two angled acoustic beams to measure a profile of water velocity. A third vertical acoustic beam measures the water level. Velocity and water level data are combined with user supplied channel geometry to compute total flow in real-time.
Simple. Sleek. Superior.

Inspired by the need for a SIMPLE way to measure water velocity and level in open channels, the Argonaut-SL, (affectionately known as the Side-Looker) has earned worldwide acceptance as a long-term monitoring solution. Fully featured with accessories, mounting options, software, and a variety of integration formats, the Argonaut-SL fits your application in the way you need it to.

Designed specifically for side mounting on bridges, canal walls, or riverbanks, the SL's SLEEK low-profile housing makes installation easy. With three models to choose from, the SL can be used in channels as small as you can jump across to rivers as wide as the Amazon.

Ultra narrow beam widths combined with unmatched side lobe suppression provide the SUPERIOR acoustic directivity necessary for achieving maximum horizontal range free of interference from surface or bottom boundaries.


Each Argonaut-SL comes complete with the industry leading Windows software packages VIEWARGONAUT and FLOWPACK. ViewArgonaut provides comprehensive data collection and processing tools and also a full range of export options and a user-friendly deployment wizard.

Integrate, store and analyze data from multiple sites with SonTek’s Velocity-Indexing discharge rating software, FlowPack. Now you can print professional reports easily and quickly with the confidence that you will produce consistent and robust results.

An entire rating analysis can be completed in a matter of minutes, with automatically developed Stage-Area relationships and selection of the best-fit Velocity-Index equation. Data can be imported from a variety of sources including all SonTek instruments, and other devices.
## Argonaut-SL in the Field

### Applications
- River Discharge Monitoring
- Irrigation Canals
- Ports and Harbors
- Shallow Streams and Estuaries
- Water Supply

### Features
- Water Velocity and Level
- MultiCell Current Profiling
- PowerPing Hi-precision Sampling
- Mounting and Display, and I/O
- Velocity-Indexing Software

### Sound Principles. Good Advice.

<table>
<thead>
<tr>
<th>SL3000</th>
<th>SL1500</th>
<th>SL500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling Range</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0.1 to 5m (0.3 to 17 ft)</td>
<td>0.2 to 20m (0.7 to 66 ft)</td>
</tr>
<tr>
<td><strong>Minimum Channel Width</strong></td>
<td>0.75m (2.5 ft)</td>
<td>1.50m (5 ft)</td>
</tr>
<tr>
<td><strong>Acoustics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Horizontal Beam Width&lt;sup&gt;2&lt;/sup&gt;</td>
<td>1.4°</td>
<td>1.4°</td>
</tr>
<tr>
<td>- Vertical Beam Width&lt;sup&gt;2&lt;/sup&gt;</td>
<td>1.4°</td>
<td>2.9°</td>
</tr>
<tr>
<td>- Side Lobe Suppression&lt;sup&gt;3&lt;/sup&gt;</td>
<td>&gt;60dB</td>
<td>&gt;60dB</td>
</tr>
<tr>
<td><strong>PowerPing Hi-Precision</strong></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>SonTek TrueCompass/Tilt</strong></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Water Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Vertical Beam Range</td>
<td>0.1 to 5.0 m (0.3 to 17 ft)</td>
<td>0.15 to 10m (0.5 to 33 ft)</td>
</tr>
<tr>
<td>- Accuracy</td>
<td>(depth &lt; 3 m): ±0.3 cm (0.01 ft)</td>
<td>(depth &lt; 3 m): ±0.3 cm (0.01 ft)</td>
</tr>
<tr>
<td>- Pressure Sensor</td>
<td>n/a</td>
<td>0.25%</td>
</tr>
<tr>
<td>- Wave Height Spectra</td>
<td>n/a</td>
<td>Optional</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Input</td>
<td>7-15 VDC</td>
<td>7-15 VDC</td>
</tr>
<tr>
<td>- Consumption&lt;sup&gt;4&lt;/sup&gt;</td>
<td>0.5 – 0.7 W</td>
<td>0.5 – 0.7 W</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Weight in Air</td>
<td>1.2 kg (2.6 lb)</td>
<td>2.4 kg (5.3 lb)</td>
</tr>
<tr>
<td>- Weight in Water</td>
<td>0.3 kg (0.7 lb)</td>
<td>0.2 kg (0.5 lb)</td>
</tr>
<tr>
<td>- Pressure Rating (Max Depth)</td>
<td>30 m (98 ft)</td>
<td>30 m (98 ft)</td>
</tr>
<tr>
<td>- Mounting Plate Dimensions</td>
<td>28 x 25 x 1 cm (11&quot; x 8&quot; x 0.4&quot;)</td>
<td>Integrated Mount</td>
</tr>
</tbody>
</table>

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<sup>1</sup> Actual Maximum range depends on environmental conditions

<sup>2</sup> Full beam width reported at half power level (-3dB)

<sup>3</sup> Side lobe suppression improves the aspect ratio of the instrument enabling greater measurement range in shallower water.

<sup>4</sup> Power consumption will be higher with PowerPing and/or Flow Display enabled.
Specifications

Water Velocity
- Transducer: Two-beam horizontal, 25° slant angle for 2D water velocity
- Range: ±6 m/s (20 ft/s)
- Resolution: 0.1 cm/s (0.003 ft/s)
- Accuracy: ±1% of measured velocity ±0.5 cm/s (0.015 ft/s)

Standard Features
- Vertical acoustic beam for water level
- "Multicell" velocity profiling (programmable, up to 10 equally-spaced cells)
- "Independent" velocity measurement cell. This cell can be different in size from the 10 Multicells and located anywhere within the instrument’s sampling range. This cell is used for flow calculations or other specialized functions.
- Flow computation and output, including total flow and volume
- FlowPack Velocity-Index Discharge Rating software package
- 4MB internal nonvolatile memory
- Temperature sensor
  - Resolution: ± 0.01°C
  - Accuracy: ± 0.1°C

Communications
- RS 232/SDI-12 power/communications cable (10m standard. Longer cables are also available up to 100m)
- ViewArgonaut Software (Windows 95/98/NT/2000/XP/Vista) for instrument setup, data collection, flow calculation
- SonUtils PDA software for PocketPC

Physical Parameters
- Operating temperature: -5° to 60°C (23°F to 140°F)
- Storage temperature: -10° to 70°C (14°F to 148°F)

Optional Features
- Real-time Flow Display
- External battery pack for autonomous operation (500WH)
- Wave Spectra output (SL500 and SL1500 models only)
- Analog output module (4-20mA or 0-5V)
- Modbus Interface Module (MIM)
- RS422 output for cable lengths to 1500 m
- Canal Mounting Apparatus
- YSI ECONET satellite or radio telemetry

Useful options and accessories make the Argonaut-SL a complete, turn-key solution.

Real-time Flow Display: Provides an easy-to-use interface for monitoring both output data and the system status.

Modbus Interface Module (MIM): Integrate into any Modbus-enabled system using Modbus RS-232 protocol. Acting as an RTU slave device, the MIM stores data in a series of registers so it can be reported to the master unit in real-time.

SonUtils PDA Edition: An easy answer for both set-up and analysis, SonUtils PDA software allows for quick programming and automatic downloads.

Canal Mount: An easy solution for installation in open channels.
With hundreds of satisfied users around the world, the ADP is proven, capable and versatile. Whether your application is hydrology, oceanography or harbor monitoring, there is an ADP configuration to suit your needs.

**OPTIONS AND FEATURES**

- Bottom tracking and GPS input for moving boat applications
- Windows 95/98/NT software for real-time and post-processing
- Side-looking configurations for horizontal profiling
- Water level and wave spectra
- Optional external sensors including CT and turbidity

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**PERFORMANCE SPECIFICATIONS**

**SonTek**

**ADP™ Acoustic Doppler Profiler**

**Velocity Data**
- Range: ±10 m/s
- Resolution: 0.1 cm/s
- Accuracy: ±1% of measured velocity, ±0.5 cm/s
- Up to 100 range cells

**Standard features**
- Robust, digital signal processing
- 8 bit A/D conversion
- Three-beam transducer for 3D current measurement
- Transducer shading for minimal sidelobes
- Oversize piezoelectric ceramic for narrow beams
- Recessed wet-mateable connector
- Temperature sensor

**Hardware options**
- Two-beam side-looking configuration for horizontal profiling
- Four-beam Janus configuration
- Four beam configuration with one beam oriented vertically
- Low-profile housing (DSP electronics located in a separate splash-proof box)
- Full ocean depth rating
- Internal recorder (20, 40, 85, 170 or 340 MB)
- Internal compass/two axis tilt sensor
- External battery case
- Self-contained configuration with batteries and electronics in a single housing
- Strain gage pressure sensor (0.1% accurate)
- Internal RPT pressure sensor (0.01% accurate)

**Performance options**
- Bottom tracking/DGPS interface for use from a moving boat
- SonWave wave spectrum package
- Pulse-coherent mode for high resolution profiling (contact SonTek for details)

**Windows 95/98/NT Software options**
- RiverSurveyor package for real-time river discharge measurements from moving boats
- CurrentSurveyor for velocity profiling from a moving vessel
- CurrentMonitor for fixed installations
- ViewADP for post-processing

**External sensor options**
- SeaBird MicroCat CT
- D&A OBS turbidity
- Paroscientific quartz pressure sensor
- Other sensor interfaces are available, please contact SonTek

**Power Consumption (Typical Continuous Operation)**
- 12-24 VDC
- 2.0-2.5 W Operating mode
- Less than 1 mW Sleeping mode
- Total battery capacity (3 packs at 5°C): Alkaline 1800 Wh

**Compass/Tilt Sensor**
- Resolution: Heading, Pitch, Roll 0.1°
- Accuracy: Heading ±2°
- Accuracy: Pitch, Roll ±1°

SonTek’s customer support is unsurpassed in the industry. Our experienced and professional staff is ready to assist you with the use and application of the ADP.

**Canadian Distributor**

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Fax: (604) 872-0281
e-mail: salesv@hoskin.ca
website: www.hoskin.ca

**MADE IN U.S.A.**

SonTek & ADP are registered trademarks of SonTek, Inc., San Diego, CA, USA.
Specifications subject to change without notice.
ADP v.3 • 2/00

Exceed your expectations both during and after the measurement with RiverSurveyor Live software, a Windows XP/Vista® compatible package with the latest advancements for open channel hydraulics visualization.

- Load, view, and analyze multiple data sets simultaneously.
- Collect data and disconnect/reconnect again. Easily swap between phone and laptop mid-measurement.
- Automatic profiling set-up. Start collecting data in seconds!
- View multiple data results (bottom-track, GPS-GGA, and GPS-VTG) simultaneously.
- Quality status/data, statistics, and color coded graphical display for clear feedback in the field.
- Customizable interface, graphs, and tabular data.
- Reports & MATLAB® export.

*Hydroboard design and color subject to change.
Taken to Incredible Extremes.

It’s an immense goal - to build a river discharge measurement system without the traditional limitations. It had to be small, portable and so easy to use that anyone could make a measurement. It had to be so robust that it could be used just about anywhere in the world under extreme conditions. The results had to be immediately recognizable. Conceived to advance measurement practices, the RiverSurveyor S5 and M9 systems give a whole new perspective to the notion of open channel hydraulic measurements.

It’s a SonTek exclusive - multiple acoustic frequencies fused with precise bandwidth control make for the most robust and continuous shallow-to-deep measurements ever. A deterministic microcontroller expertly apportions the proper acoustics, pulse scheme, and cell size so you can focus on the measurement - not the instrument setup. The system even has a vertical beam for precise channel definition - and it’s all designed to work intuitively.

Leading edge technologies such as Bluetooth®, spread spectrum radio, mobile phones, and RTK (Real-Time Kinematic) GPS are all incorporated to elevate performance and expand utility.

### Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple acoustic frequencies*</td>
<td>Combines the highest resolution with the greatest range of depths.</td>
</tr>
<tr>
<td>Vertical acoustic beam*</td>
<td>Superior channel definition, extends the maximum measurable discharge depth.</td>
</tr>
<tr>
<td>Automated cell size*</td>
<td>Always uses the optimal resolution for channel depth – no user input required.</td>
</tr>
<tr>
<td>Automated pulse scheme and frequency hopping*</td>
<td>Automatically adjusts the acoustic Doppler sampling (ping) scheme for channel conditions. User does not need to pre-program unit.</td>
</tr>
<tr>
<td>Microprocessor computed discharge and secure data*</td>
<td>All discharge computations are done within the S5 or M9 unit internally (not in the computer!) – No lost data from communications drop outs.</td>
</tr>
<tr>
<td>Standard 360° compass and two-axis tilt sensor</td>
<td>Compensates for vessel motion due to surface conditions.</td>
</tr>
<tr>
<td>Reverberation control with ping rates to 70Hz</td>
<td>High ping rates ensure extremely robust data collection.</td>
</tr>
<tr>
<td>Pulse-coherent processing</td>
<td>Maximizes high resolution performance in shallow water.</td>
</tr>
<tr>
<td>Bottom-tracking</td>
<td>High precision vessel tracking and depth measurement without GPS requirement.</td>
</tr>
<tr>
<td>RTK GPS (optional)</td>
<td>Ultra precise earth-referenced positioning as an alternative to bottom tracking in moving bed or other difficult situations.</td>
</tr>
</tbody>
</table>

*Patents pending
RiverSurveyor

Useful options and accessories make the RiverSurveyor a complete, turn-key solution!

Mobile Operation: RiverSurveyor runs on both PC and mobile phone platforms making system operation simple without any risk of losing data.

Power/Communications: The RiverSurveyor Power/Communications module supports both the S5 and the M9. Featuring rechargeable battery packs, it can be factory-configured with Bluetooth®, spread spectrum radio, VTG GPS, or RTK GPS.

RTK GPS: Available exclusively from SonTek, the optional RTK GPS solution is easy to use and offers an incredibly precise, fully integrated position solution that can augment or be an alternative to bottom tracking with moving bottom.

Floatable Platform: The flexible design of the S5 and M9 systems enables use either over the side of a boat, or on a small floating/tetherable platform such as the SonTek Hydroboard or the OS Trimaran.

SPECIFICATIONS

Velocity Measurement
- Profiling Range (Distance)
  - S5: 0.06m to 5m
  - M9: 0.06m to 30m
- Profiling Range (Velocity)
  - S5: +/- 20 m/s
  - M9: +/- 20 m/s
- Accuracy
  - S5: Up to +/- 0.25% of measured velocity; +/- 0.2 cm/s
  - M9: Up to +/- 0.25% of measured velocity; +/- 0.2 cm/s
- Resolution
  - S5: 0.001 m/s
  - M9: 0.001 m/s
- Number of Cells
  - S5: Up to 128
  - M9: Up to 128
- Cell Size
  - S5: 0.02m to 0.5m
  - M9: 0.02m to 4m

Transducer Configuration

Five (5) Transducers;
- 4-beam 3.0 MHz Janus at 25° Slant Angle;
- 1.0 MHz Vertical Beam

Nine (9) Transducers;
- Dual 4-Beam 3.0 MHz/1.0 MHz Janus at 25° Slant Angle;
- 0.5 MHz Vertical Beam

Depth Measurement
- Range
  - S5: 0.20m to 15m
  - M9: 0.20m to 80m
- Accuracy
  - S5: 1%
  - M9: 1%
- Resolution
  - S5: 0.001m
  - M9: 0.001m

Discharge Measurement
- Range with Bottom-Track
  - S5: 0.3m to 5m
  - M9: 0.3m to 30m
- Range with RTK GPS
  - S5: 0.3m to 15m
  - M9: 0.3m to 80m
- Computations
  - S5: Internal
  - M9: Internal

S5/M9 Additional Specifications

- Temperature Sensor
  - Resolution: ± 0.01º C
  - Accuracy: ± 0.1º C
- Compass/Tilt (Solid State Type)
  - Range: 360º
  - Heading Accuracy: ± 2º
  - Pitch/Roll: ± 1º
- Internal Recorder Size: 8GB
- Power/Communications
  - 12 - 18v DC
  - RS232 Communications
  - RS232 Serial GPS Input
  - Max Data Output Rate: 2 Hz
  - Internal Sampling Rate: Up to 70 Hz
- Physical/Environmental
  - Depth Rating: 50m
  - Operating Temperature: -5º to 45º C
  - Storage Temperature: -10º to 70º C

Power Communications Module Specifications

- Batteries
  - Type: Rechargeable
  - Capacity/duration: 8 hours of continuous operation (4 hours with RTK GPS enabled)
- Telemetry Options/Range
  - Bluetooth (Phone): 60m
  - Bluetooth (Laptop): 200m
  - Spread Spectrum Radio: 2000m
- GPS Options
  - GGA / VTG Accuracy: 1m
  - RTK Accuracy: 0.03m

Floating Platform Options

- SonTek Hydroboard
- OS Trimaran

RTK GPS: Available exclusively from SonTek, the optional RTK GPS solution is easy to use and offers an incredibly precise, fully integrated position solution that can augment or be an alternative to bottom tracking with moving bottom.

Floatable Platform: The flexible design of the S5 and M9 systems enables use either over the side of a boat, or on a small floating/tetherable platform such as the SonTek Hydroboard or the OS Trimaran.
SATLINK2 TRANSMITTER/LOGGER
SL2-G312
MULTI-SATELLITE CERTIFIED

10 INDEPENDENT MEASUREMENTS:
4 ANALOG INPUTS, SDI-12, TIPPING BUCKET, & MORE (page 2....)

BUILT-IN LOGGER
POCKET PC (PDA) COMMUNICATIONS

SATLINK2 - SELF-ENCLOSURE OPTION
AIRTIGHT ENCLOSURE & INTERACTIVE DISPLAY®

SATLINK2 ADVANTAGES
SatLink2's innovative design includes everything needed to collect high quality data, without costly options. Our standard unit includes a Built-in Logger, SDI-12 Interface, dedicated Tipping Bucket Input, 4 Analog Inputs, & a powerful Mathematical Equation Editor.

NEW
✓ Front Panel Programming
✓ MIN/MAX Processing
✓ Process Non-Linear Sensors - simply copy & paste a formula without any programming!
✓ SL2 DISPLAY Includes SD CARD SLOT for Log Downloads
✓ Two-Level Password Protection

TRANSMISSION FORMATS
- GOES High Data Rate 100/300/1200 bps
- GOES International
- INSAT/METSAT
- METEOSAT 2nd Gen. (MSG)
- GMS / MTSAT
- FY2C
- ARGOS/SCD

EASIEST SET-UP & OPERATION
Intuitive data view makes set up & data collection incredibly straightforward.

ACCURACY
You'll collect & transmit data more accurately and with the lowest power consumption available!

SUTRON
21300 RIDGETOP CIRCLE
STERLING, VA 20166
(703)406-2800
WWW.SUTRON.COM
SALES@SUTRON.COM

BASIC SATLINK2

BASIC SATLINK2 WITH DISPLAY® ADDED
SATLINK2 TRANSMITTER/LOGGER
SL2-G312 FEATURES

SL2 SD CARD ADVANTAGES

- Multiple choices for downloading the log from SatLink2: download all data since the last download, download the entire log, or download a range of dates.
- SL2 setup can be saved on the SD card to use to setup another SL2
  A setup can be prepared on a PC using SatLink Communicator, saved to the SD card, and uploaded to a SatLink2 from the SD card.

SATLINK2 BASIC FEATURES

- Forward & Reflected RF Power Measured.
- Scheduled & Random Reporting & Alarm Detection
- Easy integration with Existing &/or New Sensors as well as Existing &/or New Loggers
- Easy Data Merge - Logs its own measurements & receives data from other loggers, especially Sutron's 8210, 8080 Xpert, 9210 XLite, 8400 & 8200
- User programmable from ALL PCs
- Trimble GPS w/fast satellite acquisition every unit
- Gain setting options on analog inputs
- Internal flash log (downloaded @ 115200 Baud.)
- Standard RS-232 Interface to Datalogger
- Quick & easy firmware & field upgrades
- Powerful mathematical equation editor - analog data conversion with polynomial & trigonometric support port
- SDI-12 Support for VAST ARRAY OF SENSORS
- Switched +12Vdc Output
- Text Messages, Manual Data Entry
- Internal Diagnostics - transmission quality & GPS
- Reference voltage output for direct thermistor support programs.

SATLINK2 DISPLAY & SD CARD FEATURES

Front Panel Access to SatLink Allows User to
- Start/Stop SatLink
- View Current Status
- View Current Set-up
- Fully Set-up Transmissions
- Initiate Transmissions
- Fully Set-up Sensor Measurements
- Calibrate Sensors
- View Current & Previous Measurements
- Use Two Levels of Password Protection

SD Card Interface Allows User to
- Download Entire SatLink Log (or Any Part of It)
- Increase Logging Capacity & Data Redundancy (when card is left inserted, SL2 backs up Log to Card)
- Save SatLink Set-Up
- Send Saved Set-Up from Card to SatLink

SatLink2 Display
(ordered separately, attach to basic SL2)
## SATLINK2 TRANSMITTER/LOGGER
### ORDERING & ACCESSORIES

<table>
<thead>
<tr>
<th>PART #</th>
<th>SATLINK2 CONFIGURATION</th>
<th>BASIC SL2</th>
<th>XLITE</th>
<th>DISPLAY</th>
<th>ENCLOSURE</th>
<th>MODEM</th>
<th>PCMCIA OPTION</th>
<th>AMPLIFIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL2-G312-1</td>
<td>Basic SatLink2</td>
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<td>SL2-Display-1</td>
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<td>SL2-Display-2</td>
<td>Display+Internal Modem (w/SD Card Slot)</td>
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<td></td>
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<tr>
<td>SL2-ENC</td>
<td>SatLink2 w/NEMA 4 Enclosure</td>
<td>✓</td>
<td></td>
<td>✓ ✓</td>
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<td>✓</td>
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<tr>
<td>SL2-ENC-DISP-1</td>
<td>SatLink2, Display, Enclosure</td>
<td>✓</td>
<td>✓ ✓</td>
<td>✓ ✓</td>
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<td>SL2-ENC-DISP-2</td>
<td>SatLink2, Encl., Display &amp; Modem</td>
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<td>✓ ✓</td>
<td>✓ ✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9210-SL2-1A</td>
<td>Satlink2 &amp; XLite Datalogger</td>
<td>✓</td>
<td>✓ ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9210-SL2-2A</td>
<td>Satlink2, XLite, PCMCIA</td>
<td>✓</td>
<td>✓ ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9210-ENC-SL2</td>
<td>Satlink2, XLite, Enclosure</td>
<td>✓</td>
<td>✓ ✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL240W</td>
<td>Satlink2 with 40 Watts for Busy Applications</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

**NOTE:** Sutron recommends installing Satlink 2 in a NEMA 4 enclosure for any humid or hostile environment. Sutron recommends using an optional lightning protection module such as the Sutron 6461-1240 for most remote systems.

### INSTALLATION KITS, MOUNTING KITS, CABLES, CONNECTORS

<table>
<thead>
<tr>
<th>PART #</th>
<th>PERIPHERALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>6661-1248-1</td>
<td>SDI-1 2 Analog Plus Module</td>
</tr>
<tr>
<td>6661-1258-2</td>
<td>Bluetooth CSA, Standard</td>
</tr>
<tr>
<td>6661-1280</td>
<td>128M SD Card (SL2 Display includes slot)</td>
</tr>
<tr>
<td>6461-1247-1</td>
<td>Tipping Bucket Rain Gauge Adapter for SL2 Logger</td>
</tr>
</tbody>
</table>

### LIGHTNING PROTECTION

<table>
<thead>
<tr>
<th>PART #</th>
<th>CONFIGURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>8111-1113-1</td>
<td>RF COAX Cable Lightning Protection Kit, Bulkhead mount, 36&quot; RG-59 N to N cable (for mounting in NEMA enclosure)</td>
</tr>
<tr>
<td>8111-1099-1</td>
<td>Protector, Coax Kit with Cable (wall/panel mount)</td>
</tr>
<tr>
<td>3121-1543</td>
<td>Connector, Heliox, 7/8&quot; to N-Mate 50</td>
</tr>
<tr>
<td>6461-1240</td>
<td>Lightning Protection Module</td>
</tr>
</tbody>
</table>

### POWER SUPPLY

<table>
<thead>
<tr>
<th>PART #</th>
<th>POWER OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5100-0010, 5100-0030, 5100-0040</td>
<td>Battery, 12VDC: 7 AH, 24 AH, 105 AH</td>
</tr>
<tr>
<td>5100-0020-3</td>
<td>Battery Charger, Float</td>
</tr>
<tr>
<td>5100-0046</td>
<td>Solar Panel, 53 Watts (Mount 2271-1049 &amp; Cable 6411-1017-3 ordered separately)</td>
</tr>
<tr>
<td>5100-0410-1</td>
<td>Solar Panel, 20 Watts unregulated, Includes Mount (Cable 6411-1017-3 ordered separately)</td>
</tr>
<tr>
<td>5100-0401-1</td>
<td>Solar Panel, 10 Watts unregulated including 10 ft. Cable &amp; Mount</td>
</tr>
<tr>
<td>5100-0407</td>
<td>Solar Panel Charger Control, 4 amp</td>
</tr>
<tr>
<td>5100-0408</td>
<td>Solar Panel Charger Control, 8 amp</td>
</tr>
<tr>
<td>5100-0411</td>
<td>Solar Regulator, 3 amp</td>
</tr>
</tbody>
</table>

### ANTENNAS

<table>
<thead>
<tr>
<th>PART #</th>
<th>ANTENNA OPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5000-0020-1</td>
<td>OMNI-Directional Satellite Antenna, Half-Wave</td>
</tr>
<tr>
<td>5000-0021-1</td>
<td>OMNI Satellite Antenna, Full-Wave</td>
</tr>
<tr>
<td>5000-0080</td>
<td>YAGI Antenna, Crossed, 401.8 MHz, 11d8 gain, 2&quot; pipe mount, Type N Connector</td>
</tr>
<tr>
<td>5000-0081</td>
<td>YAGI Antenna, Stainless Steel Elements, Crossed, 401.8 MHz, 11d8 gain, 2&quot; pipe mount, Type N Connector</td>
</tr>
<tr>
<td>5000-0100</td>
<td>GPS Antenna, SMA with 1.5 ft. cable</td>
</tr>
<tr>
<td>5000-0151-1</td>
<td>YAGI Antenna, 402 MHz (formerly #5000-0010-1)</td>
</tr>
<tr>
<td>5000-0151-2</td>
<td>YAGI Antenna, Stainless Steel, 402 MHz (formerly #5000-0010-2)</td>
</tr>
<tr>
<td>5000-0155-1</td>
<td>YAGI GOES Satellite Antenna</td>
</tr>
<tr>
<td>5000-0156-1</td>
<td>YAGI GOES Satellite Antenna, Stainless Steel Mast &amp; Elements</td>
</tr>
<tr>
<td>5000-0170</td>
<td>GPS Antenna, Bullet (High Gain)</td>
</tr>
</tbody>
</table>
# SATLINK2 TRANSMITTER/LOGGER

## LOGGER SPECIFICATIONS

Applies to all SatLink2 versions unless otherwise noted.

### MEASUREMENTS

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANALOG INPUTS</strong></td>
<td>4 single ended (0-5V, differential ratiometric selectable)</td>
</tr>
<tr>
<td><strong>A/D RESOLUTION</strong></td>
<td>24 bit A/D converter</td>
</tr>
<tr>
<td><strong>A/D ACCURACY</strong></td>
<td>+/- 0.02% FS @25C</td>
</tr>
<tr>
<td></td>
<td>+/- 0.03% FS @ 25 during TX</td>
</tr>
<tr>
<td><strong>TEMPERATURE COEFF</strong></td>
<td>+/- 5 ppm/C typ.</td>
</tr>
<tr>
<td></td>
<td>+/- 10 ppm/C max</td>
</tr>
<tr>
<td><strong>LINEARITY</strong></td>
<td>+/- 0.005% FS</td>
</tr>
<tr>
<td><strong>REFERENCE OUTPUT</strong></td>
<td>2.5 Volt, 10 ma. max (for temp. sensors)</td>
</tr>
<tr>
<td><strong>SWITCHED +12V OUT</strong></td>
<td>500 ma. Nom</td>
</tr>
<tr>
<td><strong>TIPPING BUCKET / PULSE COUNTER</strong></td>
<td>Dedicated switch closure counter input, 16 bit resolution</td>
</tr>
<tr>
<td><strong>INTERNAL MEASUREMENTS</strong></td>
<td>Battery Voltage &amp; Temperature</td>
</tr>
<tr>
<td><strong>SOLAR PANEL CHARGING STATUS</strong></td>
<td>Optional</td>
</tr>
<tr>
<td><strong>ENCLOSURE HUMIDITY MEASUREMENT</strong></td>
<td>Optional</td>
</tr>
<tr>
<td><strong>SDI-12:</strong></td>
<td>V1.0, V1.1, V1.2, V1.3 sensors</td>
</tr>
<tr>
<td><strong>SENSOR SUPPORT</strong></td>
<td>Supports 10 sensors or measurements</td>
</tr>
<tr>
<td><strong>SCHEDULES</strong></td>
<td>Independent for each sensor</td>
</tr>
<tr>
<td><strong>SENSOR LABELS</strong></td>
<td>User enterable</td>
</tr>
<tr>
<td><strong>MATHEMATICAL EQUATION EDITOR</strong></td>
<td>For analog sensor data conversion allows user entry of virtually any equation</td>
</tr>
<tr>
<td><strong>READINGS</strong></td>
<td>Manually Entered</td>
</tr>
</tbody>
</table>

### LOG

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>READINGS</strong></td>
<td>120,000</td>
</tr>
<tr>
<td><strong>TIME STAMP</strong></td>
<td>Individually w/1 sec. resolution</td>
</tr>
<tr>
<td><strong>NUMBER RANGE</strong></td>
<td>Can log numbers as small as 1E-38 or as large as 3E+38</td>
</tr>
<tr>
<td><strong>QUALITY FLAG</strong></td>
<td>One for Each Data Sample</td>
</tr>
<tr>
<td><strong>MEMORY LOG</strong></td>
<td>Non-volatile Flash</td>
</tr>
<tr>
<td><strong>DATA MERGE MODE</strong></td>
<td>Supports merging of SL2 Logger data with data from external logger</td>
</tr>
<tr>
<td><strong>CIRCULAR BUFFER MODE</strong></td>
<td>Enhanced transmission data mgt. Excess data is stored &amp; sent on subsequent transmissions.</td>
</tr>
</tbody>
</table>

### ALARMS

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPES</strong></td>
<td>High, Low &amp; Rate of Change Alarms</td>
</tr>
</tbody>
</table>

### SENSOR DIFFERENTIATION

User configurable for each sensor

### SATELLITE SUPPORT

<table>
<thead>
<tr>
<th>Satellite Name</th>
<th>Coverage Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOES 100, 200, 1200</td>
<td>METEOSAT 2nd Gen (MSG)</td>
</tr>
<tr>
<td>INSAT</td>
<td>ARGOS/SCD FY2</td>
</tr>
</tbody>
</table>

### TRANSMISSION SUPPORT

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RANDOM REPORTING</strong></td>
<td>Self-Timed</td>
</tr>
<tr>
<td><strong>SHEF SHEFFIX</strong></td>
<td>Pseudo Binary</td>
</tr>
</tbody>
</table>

### MISCELLANEOUS

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONFIGURATION STORAGE</strong></td>
<td>Non-Volatile</td>
</tr>
<tr>
<td><strong>DATA COLLECTION</strong></td>
<td>Visual Indication</td>
</tr>
<tr>
<td><strong>SET-UP UTILITY</strong></td>
<td>Window-Based</td>
</tr>
<tr>
<td><strong>TIME</strong></td>
<td>GPS Support for Accurate Time</td>
</tr>
<tr>
<td><strong>CLOCK ACCURACY</strong></td>
<td>Max +/- 0.1 seconds with GPS (4 seconds/month without GPS)</td>
</tr>
</tbody>
</table>

Specifications Subject to Change without Notice
## SATLINK2 TRANSMITTER/LOGGER
### TRANSMITTER SPECIFICATIONS

<table>
<thead>
<tr>
<th>Optional Internal Mode (with display only)</th>
<th>Transmission Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max Data Rate</strong> 33.6 kbps</td>
<td>100 BPS GOES random and self-timed</td>
</tr>
<tr>
<td><strong>Power Off</strong> Special power saver circuitry to power off while inactive</td>
<td>300 BPS GOES random and self-timed</td>
</tr>
<tr>
<td><strong>Auto Power</strong> Auto power on ring</td>
<td>1200 BPS GOES random and self-timed</td>
</tr>
<tr>
<td><strong>Error Correction</strong> v.42, MNP2-4 &amp; 10-EC</td>
<td>4800 BPS INSAT selectable 10 min. window (3 randomized repeat sequence)</td>
</tr>
<tr>
<td><strong>Data Compression</strong> V.42 bis &amp; MNP-5 data compression</td>
<td>METEOSAT Alert &amp; Self Timed</td>
</tr>
<tr>
<td><strong>Weight</strong> 2.2 lbs.</td>
<td>ARGOS/SCD Format</td>
</tr>
<tr>
<td><strong>Size</strong> 5.55 in. x 7.70 in. x 1.75 in. (not including mounting ears)</td>
<td><strong>SL2 Transmitter Output Power</strong></td>
</tr>
<tr>
<td><strong>Environmental</strong> -40°C to +65°C</td>
<td>Software selectable power levels</td>
</tr>
<tr>
<td><strong>Operating Voltage</strong> 10.4 to 15 VDC, reverse voltage protected</td>
<td>7.0 Watt nominal, 100/300 BPS</td>
</tr>
<tr>
<td><strong>LED Indicators</strong> Status, Fault &amp; Transmit</td>
<td>14.0 Watt nominal 1200 BPS</td>
</tr>
<tr>
<td><strong>Connections</strong></td>
<td>3.5 Watt (adjustable to 18 watt) INSAT</td>
</tr>
<tr>
<td><strong>Power</strong> Built-in cable</td>
<td>2 Watt output for ARGOS, SCD</td>
</tr>
<tr>
<td><strong>GPS</strong> SMA (Bulkhead Mounted)</td>
<td><strong>Protection Against Open or Short Circuit Loads on Transmitter Output</strong></td>
</tr>
<tr>
<td><strong>RS232</strong> DB9</td>
<td>Specifications Subject to Change without Notice</td>
</tr>
<tr>
<td><strong>SDI-12</strong> 5 position removable terminal strip</td>
<td></td>
</tr>
<tr>
<td><strong>Tipping Bucket</strong> 5 position removable terminal strip</td>
<td></td>
</tr>
<tr>
<td><strong>Analog Input</strong> 7 position removable terminal strip</td>
<td></td>
</tr>
<tr>
<td><strong>Timekeeping</strong> Accurate within 10 ms.</td>
<td></td>
</tr>
<tr>
<td>**Frequency discipline to within 10 Hz typ</td>
<td></td>
</tr>
<tr>
<td><strong>Power Requirements (@ 12.5 VDC)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Quiescent</strong> 6 mA (typ)</td>
<td></td>
</tr>
<tr>
<td><strong>Transmitting 100/300 BPS</strong> 3.2 Amps (typ)</td>
<td></td>
</tr>
<tr>
<td><strong>Transmitting 1200 BPS</strong> 4.2 Amps (typ)</td>
<td></td>
</tr>
<tr>
<td><strong>Recommended Antenna</strong></td>
<td></td>
</tr>
<tr>
<td>5000-0080 or 0081 Sutron Yagi, 10.5 dB gain (-0081 ss)</td>
<td></td>
</tr>
<tr>
<td>5000-0010-1 INSAT Yagi</td>
<td></td>
</tr>
<tr>
<td>50000-0010-2 INSAT Yagi, stainless steel</td>
<td></td>
</tr>
<tr>
<td><strong>Transmission Format</strong></td>
<td></td>
</tr>
<tr>
<td>SHEF &amp; Pseudo Binary formats</td>
<td></td>
</tr>
<tr>
<td>INSAT 422 bit format</td>
<td></td>
</tr>
<tr>
<td>Meteosat</td>
<td></td>
</tr>
<tr>
<td>CE approved</td>
<td></td>
</tr>
</tbody>
</table>

![Stand-Alone Rainfall Station](image-url)
XLITE 9210 DATALOGGER
9210-0000

SUTRON’S MOST POWERFUL DATALOGGER ENGINEERED FOR MAXIMUM VALUE! HIGHLY MODULAR WITH REMOVABLE MEDIA SUPPORT:

- SD CARDS
- MMC CARDS
- USB THUMB DRIVES

DESCRIPTION

The XLite 9210 Datalogger, a high performance data recorder & communications device for UNATTENDED, REMOTE DATA ACQUISITION, CONTROL & COMMUNICATIONS, is a multi-tasking logger capable of making measurements & communicating SIMULTANEOUSLY.

- CONNECT A WIDE VARIETY OF SENSORS to the system using built-in high-precision analog & digital interfaces as well as via RS232, RS485, & SDI-12.
- EXPAND SENSOR CAPACITY via I/O modules plugged into the the XLite’s I²C port.
- With 32 MB OF FLASH DISK for data storage, the 9210 also has 4 COMMUNICATIONS SERIAL PORTS for SATELLITE TRANSMITTERS, MODEMS, RADIOS & OTHER SERIAL COMMUNICATION DEVICES.
- Retrieve data using any communication interface, USB or SD MEMORY CARDS.
- VIEW DATA, CALIBRATE & ADJUST the XLite using its built-in LCD and buttons. Locally or remotely, ALL 9210 FUNCTIONALITY IS ACCESSSED THROUGH COMMUNICATIONS PORTS using easy to-understand set-up, data display & system maintenance GUIs.
- EASILY CUSTOMIZE the 9210 with BASIC or C++ routines to become the core of virtually any hydrological, meteorological &/or control application including

Automatic Weather Synoptic Weather
Climatic Weather Airport Weather
Agricultural/AgMet Oceanic, Tidal & Coastal
Rainfall Stations Water Distribution
Flood Warning Irrigation/Gate Control
Stream Gaging Flow Monitoring

MORE FEATURES

- Built-in I/O!
  - 8 digital I/Os & 10 Analog inputs
  - Expandable I/O capacity using modules
- BROAD SENSOR SUPPORT:
  - Analog & Digital Sensors (expandable w/add-on modules)
  - SDI-12 Sensors
  - Serial Sensors (RS-232 and RS-485)
- 32 MB EXPANDABLE FLASH MEMORY Standard for Log & Config Files
- Built-in ETHERNET
- Multiple Telemetry - 4 SIMULTANEOUSLY!
  - GOES, INMARSAT, METEOSAT, INSAT, more!
  - VOICE/DATA MODEM
  - LOS RADIO
  - MODBUS
  - IRIIDIUM
- Wide Operating Temperature (-40 to +60°C)
- Remote Access & Control (XTerm Software)
- Flexible Scheduling
- Custom Programming (BASIC, C++)
- Battery Operated, Low Power (<2.5mA quiescent)
- Secure Access (user names & passwords)
X-LITE 9210 DATALOGGER
9210-0000

FEATURES DETAIL

■ **UNPARALLELLED SENSOR SUPPORT**
The X-Lite provides unparalleled sensor support through its expansive I/O capabilities & built-in program libraries. The X-Lite SUPPORTS A WIDE VARIETY OF MEASUREMENT TYPES: single voltage, differential voltage, resistance, 4-20mA, frequency, counter, binary, binary alarm, gray-code binary, smart serial (RS-232 and RS-485), SDI-12, etc.

Most Sensors are SUPPORTED SPECIFICALLY BY NAME using an X-Lite Sensor “Block” from the extensive built-in library. Support for new sensors not already in the Sensor Library can be easily added by writing a simple program in Xpert Basic. More complex custom processing tasks also can be added by writing a program in C++ (required development tools are available for free from Microsoft).

■ **ROBUST LOGGING**
X-Lite boasts 32 MB built-in memory expandable via removable media. Logged data is compressed and not affected by changes to the Setup. System events are logged independently of measurement data.

■ **FLEXIBLE SCHEDULING**
EACH MEASUREMENT CAN BE INDEPENDENTLY SCHEDULED. Sample intervals can be set from 1 sec. to 24 hr., in 1-second increments. Built-in functions to support min, max, average, and accumulation calculations are provided.

■ **EVENT DRIVEN PROCESSING**
Digital inputs can be configured to trigger measurement processing, including logging and telemetry transactions.

■ **EASY TO USE DISPLAY**
The X-Lite provides a 2-line LCD character display with 3 front panel control buttons, making it very simple to view data and make minor Setup changes in the field.

■ **INTUITIVE SETUP**
System Setup and configuration are performed using the XTerm program, providing the same intuitive graphical user interface (GUI) as Sutron’s mighty Xpert (both based on the familiar Microsoft Windows CE, intuitive and easy to use).

ORDERING

| 9210-0000-2B | X-Lite, basic |
| 9210-SL2-2B | X-Lite with SatLink |
| 9210-ENC-B | X-Lite within rugged enclosure |
| 9210-SL2-ENC-B | X-Lite w/SatLink within enclosure |

EXPANSION ACCESSORIES

- 8080-0002-1 Xpert Digital I/O Module
- 8080-0003-1 Xpert Analog I/O Module
- 8080-0005-1 Voice Modem Module
- 6661-1275-1 Enclosure for X-Lite (empty)
- 6661-1276-1 Enclosure for X-Lite w/SL2 (empty)

SATLINK2 & X-LITE: OPTIONS

X-Lite can be ordered with or without an enclosure and packaged with or without SatLink2 GOES Transmitter/Logger.

<table>
<thead>
<tr>
<th>ENCLOSURE FEATURE</th>
<th>9210-ENC-B</th>
<th>9210-SL2-ENC-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosure for 9210 only (6661-1275-1)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Enclosure for 9210 &amp; SatLink2 (6661-1276-1)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Size: 14.13” x 12/26” x 6.13”</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>3 DIN rails to mount optional equipment inside (ie, I/O modules, modems, etc.)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Protection Board Mounting Holes</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>3 digital, 4 analog, VREF, SW’D 12, 4 SDI-12, Input Power &amp; a phone line (RJ to Terminal block) supplied</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>3 PG-9 and 2 PG-11 plugs</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Cable strain relief fittings for additional wires</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Single point grounding connector</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>GPS and RF-out connections</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>RF-out configured for panel-mounted Polyphase Lightning Protection (in RF-out &amp; ground connections)</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
# XLITE 9210 DATALOGGER

## 9210-0000

<table>
<thead>
<tr>
<th><strong>DIMENSIONS</strong></th>
<th>11”x6”x3”: Aluminum, IP52 drip resistant when installed vertically. Suitable for gauge house, shelter, NEMA enclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WEIGHT</strong></td>
<td>3.6 lbs.</td>
</tr>
<tr>
<td><strong>TEMPERATURES</strong></td>
<td>Operating: -40°C to +60° (-60°C to +60°C optional)</td>
</tr>
<tr>
<td><strong>DISPLAY (VIEWING) TEMP.</strong></td>
<td>-25 ≤ T ≤ +60 °C</td>
</tr>
<tr>
<td><strong>SUPPLY VOLTAGE</strong></td>
<td>8-16 VDC recommended, 20 V max</td>
</tr>
<tr>
<td><strong>VOLTAGE MEASUREMENT</strong></td>
<td>5 V single ended ± 2.5 V differential</td>
</tr>
<tr>
<td><strong>REFERENCE VOLTAGE</strong></td>
<td>2.5 Volts</td>
</tr>
<tr>
<td><strong>POWER CONSUMPTION</strong></td>
<td>Quiescent: &lt;2.5 mA</td>
</tr>
<tr>
<td><strong>TYPICAL AVERAGE</strong></td>
<td>3 mA @ 15 min sample intervals of shaft encoder</td>
</tr>
<tr>
<td><strong>BATTERY BACKUP</strong></td>
<td>Internal lithium backup battery (for clock, not required for logged data) 2 years min</td>
</tr>
<tr>
<td><strong>TCXO REAL-TIME CLOCK</strong></td>
<td>Real-time clock accuracy better than 10 seconds per month (-40°C to +60°)</td>
</tr>
<tr>
<td><strong>WATCHDOG TIMER</strong></td>
<td>System resets upon microprocessor failure</td>
</tr>
<tr>
<td><strong>AMBIENT RH</strong></td>
<td>0 to 95%</td>
</tr>
<tr>
<td><strong>MEMORY</strong></td>
<td>32 MB Flash Memory for log &amp; configuration files. Expandable! 16MB Flash Operating System 32 MB RAM</td>
</tr>
<tr>
<td><strong>SAMPLE INTERVALS</strong></td>
<td>Multiple Sample Intervals set from 1 sec. to 24 hr. in 1-second increments</td>
</tr>
<tr>
<td><strong>DATA RETRIEVAL</strong></td>
<td>RS-232 Ports, Memory Cards</td>
</tr>
<tr>
<td><strong>ETHERNET</strong></td>
<td>802.3 10BaseT</td>
</tr>
<tr>
<td><strong>REMOVABLE MEDIA</strong></td>
<td>SD Cards, MMC Cards, USB Thumbdrives</td>
</tr>
<tr>
<td><strong>DISPLAY</strong></td>
<td>2 line by 20 character alphanumeric LCD</td>
</tr>
<tr>
<td><strong>EXTERNAL DISPLAY</strong></td>
<td>Full feature Windows display</td>
</tr>
<tr>
<td><strong>SERIAL PORTS</strong></td>
<td>4 RS-232 ports, 1 RS-485 port</td>
</tr>
<tr>
<td><strong>SDI-12</strong></td>
<td>Dedicated SDI-12 V1.3</td>
</tr>
<tr>
<td><strong>COMMUNICATIONS</strong></td>
<td>4 RS-232 ports Up to 4 of the following types: SIMULTANEOUSLY: Satellite Radio, LOS Radio, Data &amp; Voice Modem, Direct Connect MODBUS</td>
</tr>
<tr>
<td><strong>DIGITAL INPUTS &amp; OUTPUTS</strong></td>
<td>8 digital I/O lines</td>
</tr>
<tr>
<td></td>
<td>2 input only</td>
</tr>
<tr>
<td></td>
<td>6 bi-directional</td>
</tr>
<tr>
<td></td>
<td>1 high frequency 8kHz</td>
</tr>
<tr>
<td><strong>ANALOG INPUTS</strong></td>
<td>10 Inputs single ended, or up to 5 differential, expandable using external I/C modules</td>
</tr>
<tr>
<td><strong>OUTPUT</strong></td>
<td>+12VDC SW power available</td>
</tr>
<tr>
<td><strong>DC EXCITATION OUTPUT</strong></td>
<td>+2.5, +12V Expandable using external I/C modules</td>
</tr>
<tr>
<td><strong>I/O INTERNAL PROTECTION</strong></td>
<td>Outputs internally protected against short circuits.</td>
</tr>
<tr>
<td><strong>OPERATION MODE</strong></td>
<td>Operation mode is software selectable w/ frequency, analog &amp; counter inputs.</td>
</tr>
<tr>
<td><strong>SHAFT ENCODERS</strong></td>
<td>Quadrature output encoder (3 max.) uses 2 digital inputs each.</td>
</tr>
<tr>
<td></td>
<td>7 bit gray code encoder (1 max) uses 7 digital inputs</td>
</tr>
<tr>
<td></td>
<td>Expandable using external I/C modules</td>
</tr>
<tr>
<td><strong>TIPPING BUCKET</strong></td>
<td>Input: 100 Kohm pullup for switch closure software debounced uses 1 digital input each</td>
</tr>
<tr>
<td><strong>COUNTER INPUTS</strong></td>
<td>Input Frequency: 1 channel @ 8kHz max., 7 channels @ 1 kHz max.</td>
</tr>
<tr>
<td><strong>COUNTER ACCURACY</strong></td>
<td>± 0.1% with 32 bit resolution. Expandable by external I/C modules</td>
</tr>
<tr>
<td><strong>ACCURACY RATIO METRIC</strong></td>
<td>± 0.01% of full scale</td>
</tr>
<tr>
<td><strong>ABSOLUTE ACCURACY</strong></td>
<td>0.1% -40 to +60°C</td>
</tr>
<tr>
<td><strong>INPUT RANGE</strong></td>
<td>0-5 V full scale</td>
</tr>
<tr>
<td><strong>PRESSURE TRANSFER</strong></td>
<td>Bridge sensors require 2 channels</td>
</tr>
<tr>
<td></td>
<td>Voltage output sensors require 1 channel.</td>
</tr>
<tr>
<td></td>
<td>Current output sensors require external bridge completion resistor 1 channel.</td>
</tr>
<tr>
<td><strong>DATA RESOLUTION</strong></td>
<td>32 bit resolution displaying up to 6 decimal places, user selectable</td>
</tr>
<tr>
<td><strong>A/D RESOLUTION</strong></td>
<td>16 bits</td>
</tr>
</tbody>
</table>
Sutron's XTerm communications program allows any PC to remotely setup and operate an Xpert or XLite - without using a front panel.

**FEATURES**

- Remote operation of Xpert or XLite
- Automatically displays the graphic display of the Xpert or XLite
- Sends mouse clicks to the Xpert or XLite as if you were pressing the touch screen
- Easy file transfer to allow uploading and downloading of setups, programs, and data files
- Set the clock of the Xpert or XLite with a single button
- Export the log to your PC
- Communicate to an Xpert or XLite via RS232 com ports 1-9 at up to 115200 baud.

- Supports direct connect modems, and keyed half duplex radio systems
- Communicate to an Xpert or XLite via a TCP/IP network.
- Communicate over the internet by using XTerm as a proxy
- Automatically prompts for login account and password when needed.
- Display system information regarding running processes, threads, and memory usage
- Also available for Windows Mobile & pocket PC PDAs

**APPLICATIONS**

- Automatic Weather Station
- Agricultural/AgMet Station
- Synoptic Weather Stations
- AWOS Stations
- Tidal Stations
- Hydromet Stations
- Fire Weather Station
- Water Level Station
- Water Level/Rainfall Station
- Gate Control Station
- Water Distribution Control Station
- Stream Gauging
- Irrigation Control Station
- Your Application!

**XTERM SCREEN**

No special installation is needed for XTerm. Simply copy it to any folder on your PC. When you run XTerm, you will see this screen:

Use the controls on the screen to select the com port, baud rate, type of hardware (direct, modem, radio, TCP/IP) and related values. Then select OK and Xterm will begin operation with the type of communications you have selected.
RADAR LEVEL RECORDER
NON-CONTACT LOGGING SENSOR

DESCRIPTION

A PRECISION water level measuring instrument using radar pulses to measure levels without direct contact with water, the RLR can be located on a bridge, pier or any structure over the water’s surface.

Unlike Radar Level Sensors, Sutron’s RADAR LEVEL RECORDER IS A LOGGING SENSOR - RECORDING DATA AT USER-SELECTED INTERVALS. Its 6-button, 2-line LCD front panel allows easy access to set-up, data and adjustments. Laptop, desktop, and pocket PCs can retrieve data downloads via an RLR command line.

SPECIAL FEATURES

- Special pulse-echo technique that provides 0.001 FT RESOLUTION & 0.01 FT ACCURACY
- NOT AFFECTED BY AIR TEMPERATURE & HUMIDITY, common problems with other ultrasonic-type sensors
- BUILT-IN DISPLAY for viewing data during installation
- >300,000 readings DATA RECORDING MEMORY
- SDI-12 & RS232 interfaces
- Powerful data processing modes including DQAP & moving average
- Diagnostic features include recording of signal strength and standard deviation.
- Integrated antenna or install antenna separately
- Operates as a stand-alone station or with other DCP
- Connects to a SatLink2 Transmitter/Logger for SATELLITE COMMUNICATIONS or a CELL MODEM

ORDERING

RLR-0001-1 Basic Radar Level Recorder including Integrated Antenna (w/10 ft SDI cable)
DO NOT INSTALL the RLR-0001-1 OUTDOORS UNLESS IT IS INSIDE AN OUTDOOR ENCLOSURE #6661-1265-2.

6661-1265-2 Optional Outdoor NEMA-4 Enclosure for RLR-0001-1. Order separately.

RLR-0002-1 Basic RLR in NEMA-4 fiberglass enclosure 6”x6”x4” Includes RLR-ANT-1 antenna that can be installed separately. Antenna has 1/2-14 NPT for PG or conduit fitting with 5/8” mounting bolt & swivel/leveling bracket.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RADAR TYPE</strong></td>
<td>6.2 GHz pulse echo</td>
</tr>
<tr>
<td><strong>BEAMWIDTH</strong></td>
<td>32° HPBW</td>
</tr>
<tr>
<td><strong>RANGE</strong></td>
<td>60 feet (18.3 meters)</td>
</tr>
<tr>
<td><strong>ACCURACY</strong></td>
<td>0.01 ft (3mm) up to 20 ft; 0.05% above 20 ft</td>
</tr>
<tr>
<td><strong>RESOLUTION</strong></td>
<td>0.601 ft</td>
</tr>
<tr>
<td><strong>CLOCK</strong></td>
<td>Internal real-time clock w/battery backup (coin cell - 5+ year life) ±2 minutes a month (0 to +50°C)</td>
</tr>
<tr>
<td><strong>LOG INTERVALS</strong></td>
<td>User selectable</td>
</tr>
<tr>
<td><strong>SAMPLING RATE</strong></td>
<td>10 Hz</td>
</tr>
<tr>
<td><strong>AVG. INTERVALS</strong></td>
<td>User selectable</td>
</tr>
<tr>
<td><strong>LOG CAPACITY</strong></td>
<td>&gt;300,000 Readings Flash Memory for Data &amp; Events (see Features)</td>
</tr>
<tr>
<td><strong>OPERATOR INTERFACE</strong></td>
<td>1. 6-button front panel w/2-line display &amp; status lights. 2. SDI-12 3. Command line via RS-232</td>
</tr>
<tr>
<td><strong>DATA DOWNLOADS</strong></td>
<td>Laptop, desktop, pocket PC via command line</td>
</tr>
<tr>
<td><strong>PASSWORD</strong></td>
<td>Required password option for setup changes &amp; stage adjustments</td>
</tr>
<tr>
<td><strong>SETUP DATA</strong></td>
<td>Setup stored in non-volatile flash memory</td>
</tr>
<tr>
<td><strong>STATUS LIGHTS</strong></td>
<td>Two on front panel – provide “heartbeat” and run/error status</td>
</tr>
<tr>
<td><strong>ENCLOSURE</strong></td>
<td>NEMA rated enclosure – resists dripping water and spray</td>
</tr>
<tr>
<td><strong>TEMPERATURE</strong></td>
<td>-40 to +60 °C (LCD operates -10° C)</td>
</tr>
<tr>
<td><strong>DATA CONNECTION</strong></td>
<td>RS 232 DB9 (female) for direct connection to PC/PDA/cell modem Provides +5V on pin 9 w/capacity of 71 mA to power external devices, ie, BlueTooth, etc.</td>
</tr>
<tr>
<td><strong>POWER CONSUMPTION</strong></td>
<td>&lt;0.25 mA @ 12 VDC standby</td>
</tr>
</tbody>
</table>
DESCRIPTION
INW’s patented PS98i submersible pressure transmitter represents the latest in state-of-the-art level measurement technology. Building on years of successful experience, this industry standard two-wire, 4-20 mA device offers improved noise immunity, thermal performance and transient protection. In addition to reverse polarity protection, under-current and over-current limitation is featured on the transmitter channel. The updated cable harness design reduces the probability of leakage and protects the cable jacket from damage by providing double-sealing; 316 stainless steel, Viton® and Teflon® construction increases corrosion resistance. The transmitter’s standard end cone is a 1/4” NPT inlet which allows for increased application use, easy hookup and field calibration. The modular-designed PS98i may be easily factory serviced and repaired.

OPERATION
The PS98i pressure transmitter is powered by a datalogger or control system. The internal electronic circuit controls the amount of current flowing through the loop based on the signal from the internal pressure sensor. An above-surface probe will draw 4 mA and once submerged, the current flow increases linearly with pressure (or depth). At full-scale pressure (depth), the transmitter will draw 20 mA. A data acquisition/or control system then measures this current and computes the pressure or level.

APPLICATIONS
Due to its rugged construction and proven reliability, the PS98i is used successfully to monitor groundwater, well, tank and tidal levels, as well as for pump testing and flow monitoring.

FEATURES
- Industry standard, two-wire, 4-20mA configuration
- Small diameter
- Improved noise immunity
- End cone option
- 316 stainless steel, Viton® and Teflon® construction
- Polyethylene, polyurethane and FEP Teflon® cable options
- Enhanced transient protection
HOW TO ORDER

- Choose the transmitter with the required pressure range.
- Determine cable type and specify length.
- Contact INW for a full list of accessories.

### MECHANICAL

**TRANSMITTER**

- **Body Material**: 316 stainless steel
- **Wire Seal Materials**: Viton® and Teflon®
- **Desiccant**: High- and standard-capacity packs available
- **Terminating Connector**: Available
- **Weight**: .75 lbs.

**CABLE**

- **OD**: 0.28” maximum
- **Break Strength**: 138 lbs.
- **Maximum Length**: 2000 feet
- **Weight**: 4 lbs. per 100 feet

### ELECTRICAL

**Pressure**

- **Transmitter Voltage**: 9-24 VDC 100 ms warmup
- **Static Accuracy**
  - (B.F.S.L. 25° C)*: ±0.25% FSO (maximum)
  - (B.F.S.L. 25° C)*: ±0.1% FSO (typical)
  - ±0.1% available on request.
- **Thermal Error**
  - (0-50° C, reference 25° C): ±2.0% FSO (maximum)
  - ±0.8% FSO (typical)
- **Maximum**
- **Zero Offset at 25° C**
- **Sensitivity Accuracy**
  - ±0.25% FSO (maximum)
  - ±0.125% FSO (typical)
- **Over Range**: 2x (except 300 PSIA)
- **Protection**
- **Compensated Temperature Range**: 0 - 50° C
- **Operating Temperature Range**: -5° C to 70° C

### PS98i SUBMERSIBLE PRESSURE TRANSMITTER RANGES

<table>
<thead>
<tr>
<th>Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C344</td>
<td>1 PSIG</td>
</tr>
<tr>
<td>3C345</td>
<td>2.5 PSIG</td>
</tr>
<tr>
<td>3C260</td>
<td>5 PSIG</td>
</tr>
<tr>
<td>3C261</td>
<td>15 PSIG</td>
</tr>
<tr>
<td>3C262</td>
<td>30 PSIG</td>
</tr>
<tr>
<td>3C263</td>
<td>30 PSIA</td>
</tr>
<tr>
<td>3C264</td>
<td>50 PSIG</td>
</tr>
<tr>
<td>3C265</td>
<td>50 PSIA</td>
</tr>
<tr>
<td>3C266</td>
<td>100 PSIG</td>
</tr>
<tr>
<td>3C267</td>
<td>100 PSIA</td>
</tr>
<tr>
<td>3C268</td>
<td>300 PSIA</td>
</tr>
<tr>
<td>3C269</td>
<td>300 PSIA</td>
</tr>
</tbody>
</table>

### PS98i CABLE OPTIONS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6E540</td>
<td>Vented PU INW Cable</td>
</tr>
<tr>
<td>6E543</td>
<td>Vented FEP INW Cable</td>
</tr>
<tr>
<td>6E542</td>
<td>Vented HDPE INW Cable</td>
</tr>
</tbody>
</table>

### PS98i MISCELLANEOUS OPTIONS

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6E405</td>
<td>End Cone (replaces ¼” FNPT adapter)</td>
</tr>
</tbody>
</table>

Information in this document is subject to change without notice.
ACCUBAR® CONSTANT FLOW (CF) BUBBLE GAUGE/RECORDER

AN ALL-IN-ONE, PRECISION DEVICE FOR MEASURING WATER LEVELS

DESCRIPTION

The Accubar® Constant Flow (CF) Bubble Gauge is a self-contained, precision device for measuring water levels. The gauge features a front panel, simplified setup, RS232 & SDI-12 ports, data communication & maintenance. The gauge also has a built-in datalogger for stand-alone operation or backup recording of data.

The CONSTANT FLOW BUBBLER consists of a pump, tank, manifold, control board, display/keypad & enclosure for the purpose of measuring water levels using long-established bubble gauge principles, all packaged within a single, NEMA-4 enclosure.

SPECIFICATIONS

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

ELECTRICAL

Power Required B-16VDC
Interface SDI-12 V1.3, RS232
Quiescent Current <1 mA
Average Current <100 mW for 3 sec. measurement every 15 min.
Pressure Range 0-25 psi
Accuracy 0-25 ft. 0.02% FSO
Resolution 0.0001 psi
Purge Pressure >/>= 50 psi max.
Bubble Rate User Settable
Compressor Type Piston

MECHANICAL

Enclosure NEMA-4 fiberglass
Dimensions 12 in. x 15 in. x 7.5 in.
Connections 8 position terminal block
Pressure Outlet 3/8 in. O.D. tubing

ENVIRONMENTAL

Temperature -40°C to +60°C
Humidity 0-95% non-condensing

KEY FEATURES

- Self-contained system needing only external power & outlet tubing
- Extended-life desiccant (up to 1 year)
- Adjustable bubble rate
- Configurable averaging
- User-variable auto purge
- Flexible auto blockage detection
- Modifiable auto measurement & logging
- Built-in FLASH LOG for over 300,000 readings*
- Stand-alone operation with other loggers/communication devices
- Precision Accubar® Pressure Sensor!
- Front panel setup & maintenance.
- SDI-12/RS232 interfaces compatible with loggers, cell modems, SatLink2 Transmitter/Logger
- Swing-out front panel for easy maintenance.
- Auto-zero function
- Easier re-calibration
- 3 Levels of filtration
- User-forced purge option
- SD Card slot!

ORDERING

56-0133-25-1 Accubar® Constant Flow Bubble Gauge 25 psi range

ACCESSORIES

2911-1183 Tubing, Orifice Line Black Polyurethane up to 2000 feet (609.6 meters)
2911-1279-1 Replacement Desiccant, full canister
Hoskin Scientific Limited has been supplying testing and monitoring instruments since 1946. Although our range is broad, we focus on three major markets including:

Geotechnical & Materials Testing  
Environmental Monitoring  
Test & Measurement Instrumentation

Hoskin Scientific operates out of three offices within Canada:

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Fax (604) 872-0281  
email salesv@Hoskin.ca

4210 Morris Drive,  
Burlington, ON L7L 5L6  
Phone (905) 333-5510  
Fax (905) 333-4976  
email salesb@Hoskin.ca

300 Rue Stinson,  
Montreal, PQ H4N 2E7  
Phone (514) 735-5267  
Fax (514) 735-3454  
email salesm@Hoskin.ca