

Environmental Data Acquisition (EDA) Applications Using SoftPLC, SDI-12 protocol, and TagWell

SDI-12 Overview

SDI-12 stands for serial data interface at 1200 baud. It is a standard communications protocol to interface controllers, computers or data loggers with micro-processor based sensors, typically designed to read environmental type measurements. The most common application is using battery powered data recorders for Environmental Data Acquisition (EDA). SDI-12 networks are especially advantageous in applications when it is necessary to acquire hydrologic data at remote sites that rely on battery or solar-power, and need to operate unattended and for long periods of time.

SDI-12 is a multi-drop interface that can communicate with up to ten sensors on a single serial network. Some sensors can take multiple measurements. For example, some water quality sensors read temperature, conductivity, dissolved oxygen, pH, turbidity, and depth.

SDI-12 Intelligent Sensors

A micro-processor in the sensor may calibrate the sensor, control sensor measurements, and convert raw sensor readings into engineering units. The micro-processor also controls the SDI-12 interface. It accepts and decodes instructions received from the data recorder, starts the measurements, controls all timing, and uses the SDI-12 protocol to communicate with the data recorder.

For example, an SDI-12 pressure sensor may take a series of pressure measurements, average them, and then output pressure in psi, inches of mercury, bars, millibars, or torrs. The sensor's micro-processor makes the computations, converts sensor readings into the appropriate units, and uses the SDI-12 protocol to transfer data to the recorder.

Advantages of SDI-12

- Unique and complex self-calibration algorithms can be done in microprocessor-based sensors.
- Sensors can be interchanged without reprogramming the data recorder with calibration or other information.
- Power is supplied to sensors through the interface.
- Hybrid circuit and surface mount technologies make it practical to include the power supply regulator, a microprocessor, and other needed circuitry in small sensor packages.
- Sensors can use low cost EEPROMs (electrically erasable programmable read only memory) for calibration coefficients and other information instead of internal trimming operations.
- The use of a standard serial interface eliminates significant complexity in the data recorders.
- Data recorders can be designed and produced independently of future sensor development.
- SDI-12 data recorders interface with a variety of sensors.
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SDI-12 Applications

SDI-12 sensors are used in water resource research and management, industry, government, and agriculture. SDI-12 sensors are available that measure the following:

- bridge scour
- conductivity
- dissolved oxygen
- distance
- groundwater level
- petroleum hydrocarbons in water
- pH
- pressure
- redox (ORP)
- tank level
- temperature
- tide and sea state
- turbidity
- water velocity
- weight of snow and ice
- and much more ...

Examples:

Water Quality/Quantity: Measurement of water quality in coastal regions and estuaries is critical in the characterization of hypoxic ‘dead zones’ as a result of nutrient loading and algal blooms in the water bodies. Sediment loading analysis through turbidity measurement is also important for coastal trend identification and modeling. Measuring groundwater salinity and conductivity can detect saltwater intrusion into freshwater coastal aquifers. Continuous monitoring of nutrient levels (eg: nitrate and phosphate) provides crucial information about daily, seasonal and event based changes in water quality conditions, and can be a strong indicator on the overall health of the water body. Monitoring the hydrological cycle is important in applications such as water-conservation, irrigation, land slide and watershed studies, erosion, and soil remediation to name a few. Monitoring can include all natural water flows as well as precipitation, storm water, groundwater, as well as the infrastructure and systems for water supply and sanitation.

Hydropower: Monitoring the impact of hydropower plant activities on water bodies can be important for regulatory compliance and modeling purposes. Instruments can measure total dissolved gas (TDG) levels around hydroelectric dams and can be used to monitor temperature and dissolved oxygen. Sensors can be used to measure water level and flow of the reservoirs feeding the hydropower plants, as well as the in-flows and out-flows from the plant and sluice monitoring.

Oil & Gas/Mining: Ensuring that pollutants from oil & gas or mining activities do not enter surrounding natural water bodies is a key issue in environmental monitoring and regulatory compliance. Sensors can measure a variety of parameters including conductivity and specific conductance, total dissolved solids, salinity, pH & Redox potential (ORP), chloride, dissolved oxygen, and turbidity. Groundwater level sensors can measure quality as well as water levels and support systems that regulate and pump water levels around mining and drilling sites. Groundwater level sensors are also involved in **remediation** monitoring.

Agriculture: Measuring soil moisture helps farmers manage their irrigation systems more efficiently. Not only are farmers able to generally use less water to grow a crop, they are able to increase yields and the quality of the crop by better management of soil moisture during critical plant growth stages. In situ soil electrical conductivity monitoring is useful as agricultural soils over time may become sodic or saline, and there are techniques that can remove the sodium to improve soil quality and increase crop production. Measuring solar radiation, temperature, humidity, etc. both within and outside plant canopies, greenhouses, controlled environment chambers, confined laboratory conditions or at remote environmental monitoring sites provides information to help optimize yield.

Weather/Fire/Flooding: Sensors can measure wind speed and direction, precipitation, temperature, humidity, solar radiation, and more for any application where weather prediction is important. Sensors can also be used to indicate the moisture content of naturally occurring fuels in the vicinity of the weather station, which can help predict the likelihood of wildfires or when conditions are optimal for controlled burns. Flood warning systems built into hydrological stations are used to notify local emergency authorities in the case of a flood event.

SoftPLC Overview

SoftPLC is a PAC (*Programmable Automation Controller*) that provides I/O control, data logging, communications, and more. To facilitate a robust, low-cost interface from SoftPLC to SDI-12, a comprehensive combination hardware/software solution is available:

- A hardware interface for SoftPLC that provides communication and power to an SDI-12 bus
- A driver that includes a simple set of instructions to communicate to SDI-12 sensors
- A configuration/diagnostic program that enables simple sensor setup and manual testing
- A diagnostic/simulation program that enables testing without the need for sensors and that can be used as a network-wide listening tool

SoftPLC is a powerful, flexible data logger for an SDI-12 sensor network. Data can be stored in multiple formats, to a variety of media without limits to file size. Logging can be based on time interval, data values/conditions, or other criteria.

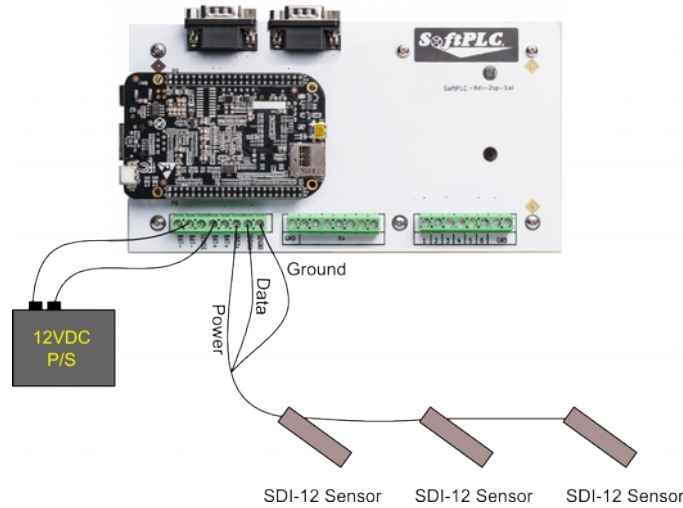
Unlike single-purpose data recorders, SoftPLC can also simultaneously provide the following additional functions:

- Control of additional I/O devices, such as to make changes in the monitored environment. For example, controlling equipment to raise/lower a level or turn on/off irrigation systems, to process liquids to eliminate pollutants in a remediation system, etc.
- Alarm notification by email, text message or to a SCADA system.
- Remote access to current values and/or data logs by email, web page, or SCADA systems.
- Remote data logging, such as logging directly from multiple sites to a database.

SoftPLC can be installed in even the harshest environments. Solar or battery powered installations are supported for remote systems. Adding a modem to the system easily provides remote access, whether it be a land-line, cellular, satellite or other type connection. Activating a TagWell connection makes it easy to securely and remotely access a SoftPLC through the internet cloud, for both reading and writing data.

Building an EDA system using SoftPLC

The SoftPLC SDI-12 driver makes it easy to communicate to any SDI-12 sensor. The driver includes some ladder logic instructions that, when triggered, initiate communications to any one of 10 SDI-12 sensors on the network. Once the data is received, a LOG DATA ladder instruction can be used to record the values to a log file. Additionally, the data can be used as conditions for other functions, such as triggering an alarm message if a value is out of acceptable range.



The above diagram shows a Micro SoftPLC (Model SPBB-x) with the SDI-12 interface (Cat No SPBB-6DI2SP1AI). The interface board provides redundant 12VDC inputs complete with an analog battery health monitoring circuit, an SDI-12 serial interface, six 5/12V digital inputs, and 2 additional RS-232 ports. The Micro SoftPLC provides a 10/100 Ethernet port, a USB host port, supports up to 8GB flash for removable, local data log files, and 512MB RAM memory for user applications.

A modem can be connected via any of the communication ports for remote connectivity for email/text functions or to safely connect to the internet via TagWell for web-based monitoring and access.



For more information:

SoftPLC SDI-12 Driver User's Guide

<http://softplc.com/usermanuals/sdi12>

Application Example - Automated Agriculture Irrigation System

Reducing water usage and increasing crop yields, as well as potentially reducing labor costs, can be achieved with a system similar to the one pictured below. The SDI-12 sensors, combined with a rain gauge and temperature/humidity sensor, provide input to the SoftPLC which can then determine by a pre-programmed algorithm when supplemental watering is required, and then automatically control the run time of any number of irrigation pumps. With powerful and unlimited logic capabilities, the SoftPLC can optimize the pump schedules for environmental conditions, the period in the growing cycle, availability / cost of water, etc. The system could also add fertilizers or insecticides to the irrigation water.

With the cellular modem connection, a web connection can provide notification of events, sensor readings, alarms, and also manual control of the pumps.

