HOW TO SELECT THE IDEAL PORTABLE DAQ SYSTEM

Measure Temperature, Current/Voltage and more

Portable data acquisition systems are convenient solutions used to monitor and record temperature voltage/current and other values in industrial and laboratory applications, whether on the factory floor, in the field, or even in a vehicle. These compact devices are used in a variety of different tasks to troubleshoot problems, to collect data for quality control and process monitoring/optimization, for reliability evaluation, or for collecting experimental data. With the aid of some initial planning, prospective users can choose a flexible system with the right features to monitor multiple parameters in different tasks.

However, selecting the most appropriate DAQ system for a project requires careful consideration of a number of factors. In this latest CAS DataLoggers White Paper, we examine some of the questions to consider when deciding on a measurement system for your specific application.

Asking the Right Questions:

When selecting a portable data acquisition system for their needs, users face a bewildering choice of available manufacturers, models and specifications. Each system has its own strengths that make some units more suitable than others for certain applications. Anticipating both your current and future project's needs will save time and money on installation now, and also save on updates or new applications later.

Data acquisition system designs range from the simple to the complex, with a related variety in performance, options, and cost. Fortunately you can quickly narrow down your search by considering several important factors:

Number and Type of Inputs:

One of the first questions you should ask is how many inputs you will need and what type of signals you will measure. There are literally hundreds of data acquisition systems from dozens of manufacturers. Answering these questions will allow you to immediately narrow the scope of the search.

In general, systems match one of two broad categories:

1. Those with dedicated inputs designed to handle a specific type of input or sensor such as a thermocouple data acquisition system, and
2. Universal or mixed signal systems that can handle a variety of sensor and signal types. Universal systems are more cost-effective but limit the application of the system. The latter are more expensive but provide the flexibility to handle different types of applications, and/or can accommodate changing needs as the project evolves.

Basic System Properties:

Of course, the main function of data acquisition system is its ability to accurately collect data. This involves a tradeoff between three key parameters: the basic measurement accuracy of the instrument, the measurement resolution, and the measurement speed.

Measurement Accuracy and Resolution:

Accuracy is how close the value either measured or sourced by the device will be to the actual value. This may be specified as a value (mV, V, etc.) a percentage of reading, as a percentage of scale, as an offset, as bits, or as a combination of these which can make comparison between devices difficult.

Measurement accuracy is heavily based upon the particular sensors you plan to use.

For most sensors calibrated in a laboratory and installed in the field, accuracies in the range of 0.1 % to 1% of full scale are typical, with many other sensors having less accuracy. What sense does it make to specify and pay for a measurement system with an overall accuracy of .01% when the sensor that you are measuring has a base accuracy of .25 or .50%? As a general rule of thumb, aim for a system accuracy that is three times better than the sensor. If the base accuracy of your sensor is 1%, then a system with an accuracy of 0.1% should be more than adequate.

Resolution is the smallest change that the instrument will report and is based on the measurement hardware. While in the past, common analog to digital (A/D) converters used to digitize the signals were 12 to 16 bits, today most instruments offer at least 18 bits of resolution and 24-bit instruments are not uncommon. To put this in perspective, an instrument with a ±10 Volt input range and a 24 bit A/D will provide a theoretical resolution as small as .000001 Volts! This is theoretical because a number of factors including noise and internal filtering will limit the resolution by reducing the number of useable bits by 1 to 4.

As with accuracy, the above advice applies to resolution: for example if you have a 100 psi pressure sensor with a 0-10VDC output that has an accuracy of .25% (.25 psi or .025VDC), you don't need to choose a data acquisition system with a resolution of 1 uV when 1 mV would be perfectly adequate.

Measurement Speed:

Measurement speed, i.e. sampling rate, is available in a wide variety from as low as once per day to millions of measurements per second! Based on the application and the signal, the system must also acquire signals quickly enough to avoid missing any of the data of interest. For example, when trying to capture waveforms, the necessary measurement rate can be calculated by using Nyquist's Sampling Theorem, which states that a signal must be sampled at twice the frequency of the spectral signal components of interest in order to accurately reconstruct the waveform.

There is always a tradeoff between a system's sampling rate and the accuracy and/or resolution. Part of this tradeoff is due to the measurement hardware, part due to physics, and part due to noise. Typically, a faster sampling rate will result in either a reduced accuracy, resolution, or both.

First, there are settling issues related to measurement hardware and the RC (resistor-capacitor) time constant of the combined sensor and instrument system so that a step change in the signal at the output of the sensor will take a finite amount of time to pass through the cabling and measurement circuits and settle out. At faster sampling speeds the signal may not be completely settled at the input of A/D converter when the measurement is taken, resulting in reduced accuracy.

Secondly, it seems that there is always noise (EMI, RFI) present that requires the use of some type of filter (either hardware or software) to reduce or eliminate. Faster sampling will require a larger bandwidth in these filters, reducing their effectiveness to the point where the measurement may be dominated by noise signal.

For example, thermocouples are a very common sensor. The output of a thermocouple is a mV- level signal where an error of several uV can make a difference in degrees in the reported value. These measurements are often encountered in industrial environments where there is a great deal of electrical noise due to motors, heating elements, and other equipment. To obtain useful measurements it is essential that some sort of filtering be used to eliminate line cycle (60 Hz) noise which is directly at odds with fast sample rates. In other words, you can either go slowly, use a filter to eliminate the noise and get accurate measurements, or you can turn the filter off and go fast but with reduced accuracy because at least some of what is being measured is noise and not the signal from the sensor.

It is also important to consider the response time of the sensor. Again, taking thermocouples as an example, a standard ¼ inch thermocouple probe may have a response time measured in seconds – what good is it to sample it at 50 times per second if it takes a 100 times longer to respond?

Sensor Signal Conditioning:

Additionally, the particular system’s input types must match the sensor outputs that your project requires. In some cases, the sensors may provide high-level signals (such as a 0-10VDC output pressure transducer) which are directly compatible with the inputs to the DAQ system. In other cases it may be necessary to choose a system which features internal signal conditioning capabilities to support the sensors being used. For example strain gauges and Wheatstone bridge-based load cells require an excitation signal and an amplifier for the low- level voltage output of the gauge. Different types of signal conditioning include excitation, amplification, buffering, attenuation, and filtering. There are a number of systems available which feature universal analog inputs that can support measurement of many common types of sensors such as thermocouples, RTDs, resistance bridges, and more. In other cases it may be easier to use a simpler DAQ system and a separate signal conditioning module.

For example, one of the most common measurements is temperature. Depending on the requirements of the application, there are at least 4 common temperature sensors that could be used: thermocouples, RTD's, thermistors or solid state temperature sensors, each with its own signal conditioning requirements. Thermocouples produce a mV level output voltage which varies with the temperature in a very non-linear way. Measuring a thermocouple with a data acquisition system requires a separate cold junction temperature reference to obtain accurate results. Also, the DAQ system should incorporate built-in linearization tables or the common thermocouple types to convert the voltage to a temperature. Both RTDs and thermistors are resistive devices which require an excitation source in addition to the measurement electronics.

Signal conditioning can also be used for signal amplification to mitigate any noise distortion, and is also useful when a DAQ device is connected to other transducers such as strain gauges, accelerometers, etc.

Do You Need Standalone Operation?

Next determine if you need a standalone solution (a system operating independent of a PC) or if the device will be tethered to a PC while in operation. The operating mode will impact how the system is powered, what type of internal processing and data storage is required, and what type of local user interface will be required.

If standalone operation is required, for example in a vehicle or for remote applications in the field, access to a standard 120V AC power outlet isn't available. In these cases, power to the system can be provided either through an internal battery pack (replaceable or rechargeable) or from an external DC power supply. Additionally, in order to maximize battery life, the system may need to incorporate a sleep mode to minimize power consumption when it is not actively collecting data.

Standalone operation will also require that the device has adequate local storage for measured data to support the longest interval between data retrieval. To help determine the storage requirements, multiply the sample rate x number of channels x the longest required recording time to figure out how many samples need to be retained in local memory, and compare this with the capabilities of the system. Some systems also feature the ability to store data in a circular buffer whereby once the available memory is full the system will start overwriting the oldest data, effectively keeping a buffer on the last x minutes or days.

Another possibility is to select a system that can automatically offload data to another device. With today's wireless and cellular communications networks, more and more data acquisition devices offer the ability to "push" data to a server or the cloud on a regular or on an as-required basis.

The last factor to consider for a standalone system is any user interface requirements. This can be as simple as a power switch and LED to indicate that the system is in operation, to a simple LCD screen and several pushbuttons to view data and start/stop data recording, to a touchscreen HMI capable of displaying graphs and collecting operator input. Before selecting a system it is always beneficial to consider the typical use model to determine what level of interaction will be required when the system is in operation.

When looking at a system that will be tethered to a PC during operation, many of these questions are not as important. The system can probably run off the same power source as the PC and utilize the hard disk of the PC to store data. Any user interface requirements can be easily accommodated via the PC. However there are other issues to consider. Does the system need to incorporate its own local co-processor which manages the DAQ hardware to take the load off of the PC, or does it need to help prevent any problems arising from OS crashes in mission critical applications?

Surviving in the Field:

DAQ systems represent a considerable investment of time and cost, so their protection should be paramount. Do you need a highly durable, ruggedized system? This depends on how often you plan on transporting the device and what environment the system will be used in. The ideal portable measurement system for most users is a lightweight, compact unit for easy installation rugged case or within an industrial enclosure.

Do you plan to use your system in a wet or dirty environment such as a food processing area or steel mill? If so, carefully consider any potentially damaging extremes including high temperature/humidity, shock and vibration. For example if liquids/dust are a concern, you should consider systems with a high IP (Ingress Protection) rating and/or use a suitable enclosure. If the system will be used on a drilling rig or in a refinery, it may need to meet Class 1 Div 1 or Div 2 requirements for hazardous location. This could require an explosion-proof enclosure and special electrical safety barriers for the signals.

Portable data acquisition units may also need to be able to survive in high shock and vibration environments such as the trunk of a car or onboard an airplane, including the occasional accident such as someone dropping it. A few minutes spent thinking about the worst-case operating environment ahead of time can help avoid problems in the future. Will the system be used in an area where lightning strikes are possible? Specifying suitable surge protection up front can save a lot of headaches. There is not much that can be done to repair a data logger that gets hit by lightning!

Choose How You Communicate:

How and where the system will be used can determine what method is best for communicating to configure the system and retrieve data. For many users, Ethernet or USB are easy options for retrieving data, but if your system needs to take measurements in remote locations, it may need to use something different. In the distant past (the 1980s), landline modems using an RS-232 serial interface were often used to communicate with remote data acquisition systems. While these systems may still be viable, they do not support the bandwidth to transfer any significant volume of data in a reasonable amount of time. In most cases these have been replaced by cellular modems. Today’s 3G and 4G modems can stream live data and allow for FTP transfer of MB-size data files.

Many data acquisition systems also support wireless communications via WiFi or Bluetooth, making it very easy to offload data for live viewing or for analysis. The main limitation of these methods is the limited communication range. Falling in between

WiFi/Bluetooth and cellular modems are a variety of proprietary wireless systems. These systems typically operate at either 900 MHz or 2.5 GHz and provide a secure point-to-point link with a range that can be up to 20 miles or more. They're ideal for applications such as streaming data from a vehicle on a test track or from a remote pump lift station to a central control center.

Finally, some systems incorporate removable media such as an SD card, USB memory stick, Flash Card or removable hard drive. While, strictly speaking, not a communications method, these facilitate easy transfer of data and configuration when conventional communications are not practical.

Software:

Most system come with their own software for configuration and data retrieval. Some include the software bundled in with the price of the hardware, while others require this software to be purchased separately. When evaluating vendors, be sure to ask about any associated software costs and any applicable licensing fees. This same advice goes for a system featuring cloud data storage, which may require a subscription or monthly fees.

It's also essential to evaluate the software to make sure it meets the needs of your application. Or, you may be required to use a corporate-wide "standard" software package such as DASYlab. Does the vendor support integration with these programs? If the standard software does not meet your needs, you may have to consider a custom-designed program. In this case, you will need to ask the vendor if they can provide the appropriate interface libraries to support standard software development tools such as LabView, Microsoft VisualStudio, Java, etc.

Even if the software supplied with the system provides the necessary capabilities to set-up the instrument, if it does not provide the analysis tools you need, will it allow exporting recorded data in other formats for analysis using other programs? It seems that virtually all vendors now support export in .CSV format to allow the data to be imported into tools such as Microsoft Excel. It could be worth a demo to see how user-friendly it is. This often depends on the graphical interface style, menu navigation, and help tips. Beyond simple ASCII data export, some applications require more sophisticated data transfer such automatic storage to a SQL data base or OPC connectivity. Try to understand what will be required on the back end to manage and analyze the data that will be collected and make sure that whatever platform you choose will be capable of meeting these needs.

Miscellaneous Requirements:

Some industries will impose additional criteria that the system must meet. One that often comes up is CFR21 Part 11 compliance when systems are being used in health care and life science applications. Are there any special requirements of the application that need to be covered?

Calibration is another issue that should be considered. Does your application require any type of accredited calibration? NIST traceable? A2LA accredited? ISO 17025? How often should the calibration be performed? Does the manufacturer have any recommendations on calibration interval? Can the calibration be done by a 3rd-party lab or is the manufacturer the only source?

Summary:

Taking into account these important factors when choosing the right portable DAQ device is certainly an involved process, but one made much easier by keeping the needs of your present and future applications foremost in mind. With this initial consideration done, you'll be in a strong position to search for the right system to match your needs.

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