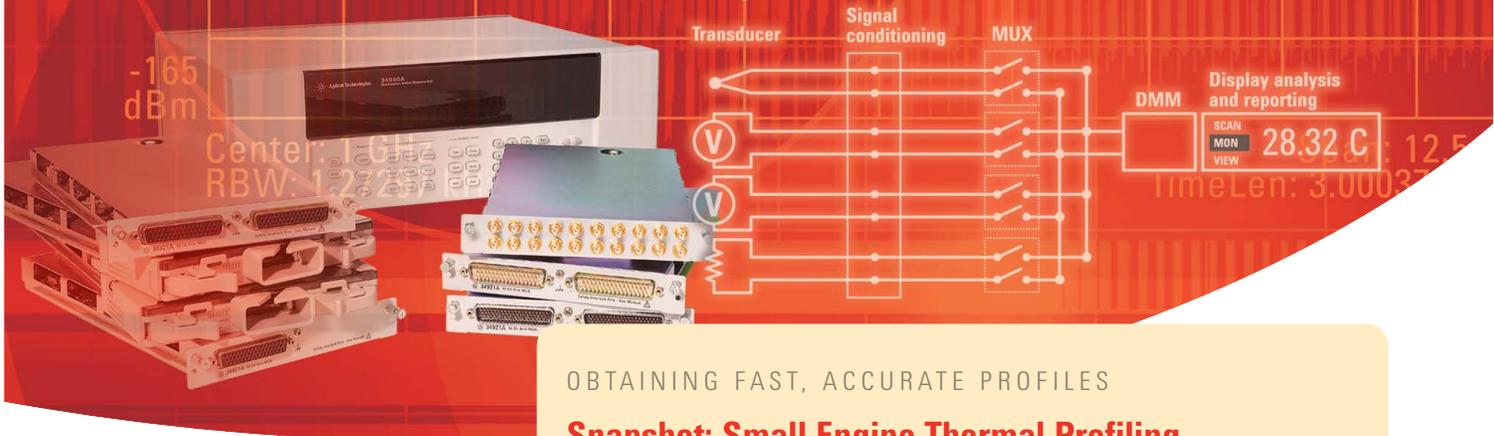


MEASUREMENT TIPS

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Practical Hints for Making Fast Scans of Multiple-Sensor Systems



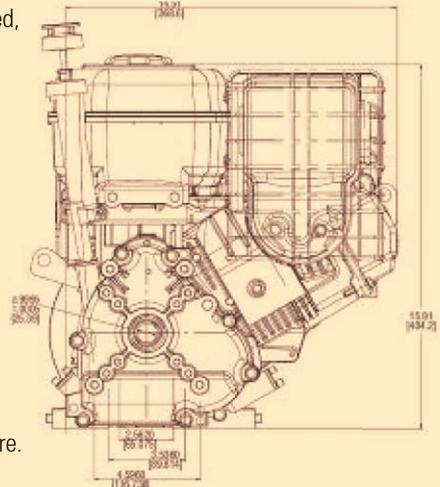
OBTAINING FAST, ACCURATE PROFILES

Snapshot: Small Engine Thermal Profiling

Often a data acquisition system is used to monitor more than one type of sensor. Different physical phenomena may need to be intermixed in the scan. For example, flow, pressure, temperature and strain may all need to be monitored at the same time. Measurement speed requirements will vary by application as well. For example, temperature change is generally a slow process, especially where a large thermal mass is involved. Measuring at rates as slow as once a second may be sufficient to capture temperature changes as they occur. However, when temperature is changing over a wide range in a short period of time, much faster scan rates are required to accurately track the change over time. Using a system such as the Agilent 34980A multifunction switch measure unit and its companion Data Logger Pro software, you can handle these higher speed requirements. However, even if you are using a different data logger, there are some things you can do to ensure scanning is as fast as possible.

For a small gas-powered engine going from a cold start to full operating temperature, the temperature can change by many hundreds of degrees in the matter of a few seconds. To get an accurate profile, the Environmental Protection Agency (EPA) is considering mandating that temperature measurements be made every 100-200 milliseconds when you are qualifying an engine for emissions approval. Given that as many as 40-50 sensors may be involved, scanning speeds of 500 channels per second or greater will be required.

By selecting the correct type of multiplex switches, grouping like signals together, minimizing range and function changes in the measuring A-to-D system, and doing any data conversions post-acquisition rather than in the data acquisition system, you can meet these EPA requirements with room to spare.



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Streamlining input signals

Multiple sensor types

When you are measuring multiple sensor types, it is always a good practice to group similar sensors together. The reason for this is two-fold. First, separating low-level signals, such as those produced by thermocouples, from other signals will minimize interference and interaction. Secondly, it is important to keep in mind that changing ranges in the measuring DMM is a slow process, taking 10s of milliseconds. If the DMM has to constantly change ranges, the scan will take considerably longer. The same is true if the DMM has to change functions from DC volts to resistance, for example. Ideally, all inputs would be of the same type and the same range, (for example, DC volts, 10-volt range) but this is not practical, as it may require attenuating some inputs while amplifying others. The next best solution is to organize the inputs by measurement type and output range.

From this:		To this:	
Function	Range	Function	Range
DCV	10 V	DCV	10 V
ACV	10 V	DCV	10 V
DC V	10 V	DCV	10 V
Thermocouple	100 mV	DCV	10 V
DCV	10 V	Thermocouple	100 mV
ACV	100 mV	Thermocouple	100 mV
Thermocouple	100 mV	ACV	100 mV
Resistance	10 K	ACV	10 V
DCV	10 V	Resistance	10 K

Table 1: To speed scanning, organize inputs by measurement type and output range.

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- Group all similar measurements together. Put all thermocouple measurements in adjacent channels, then DCV inputs together, then all ACV inputs together, etc. This will minimize time-consuming function changes.
- If possible, match input levels so that time-consuming range changes are minimized. This may require attenuating some channels, or even amplifying a few inputs.
- To eliminate range and function changes completely, convert all inputs so that they all are a single type, like DC volts, and can be read on the same range, such as the 10-volt range.
- Terminate all 4-20 mA loops in 250 ohms, converting current into voltage.

Choosing multiplexers

Multiplexers consist of multiple switches combined such that any one channel is connected to a common output at any given time. Scan speed is affected by the type of switches used in the multiplexer. Electro-mechanical relays are rugged and can handle relatively large voltages and currents, but as the chart shows, they are slow. Reed relays are faster, and are often used in data acquisition scanners. However, to achieve highest switching speeds, it is necessary to use FET switches. FETs however cannot handle large voltages and exhibit a relatively high "on" resistance. Due to the high input impedance of the DMM, the on-resistance of the FETs is rarely a problem.

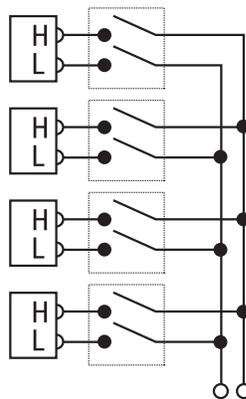


Figure 1: 2-wire, 4:1 MUX

Relay type	Voltage/ current	Offset/ on resistance	Speed	Life
Armature	300 V 1 A	3 μ V 1 Ω	60 ch/s	10 M
Reed	300 V 50 mA	6 μ V 1 Ω	500 ch/s	10 M
FET	16 V 1 mA	25 μ V 1 k Ω	100k ch/s	Infinite
Solid state	300 V 1 A	3 μ V 3 Ω	200 ch/s	Infinite

Table 2: Switch characteristics

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- Select the correct type of multiplexer depending on your speed requirements. Reed relays are faster than armature relays, and FET switches are faster still.
- Avoid crossing banks of multiplexers if possible, as this requires additional switching time.
- Minimize the effects of capacitive loading, which slows measurement speed and requires longer settling times.

Optimizing integrating DMM measurements

Most data loggers, such as the Agilent 34970A data acquisition unit and the Agilent 34980A multifunction switch measure unit, use highly accurate integrating A/D voltmeters for measuring the various inputs routed to it via the multiplexer. There is a speed/accuracy trade-off with an integrating DMM. If you do not need a full 6½ digits of resolution, you can select shorter integration times, although noise rejection may suffer as a result. Most integrating A/Ds also have an auto-zero function that measures an internal short between each measurement to compensate for offset drift in the A/D. However, this also doubles the measurement time. The data acquisition system also spends time parsing commands, controlling auto-ranging, updating the display, measuring thermocouple reference junctions and converting thermocouple voltage readings into temperature. All these activities take time. By carefully considering each of these functions and eliminating those that won't affect required system accuracy, you can improve measurement time considerably.

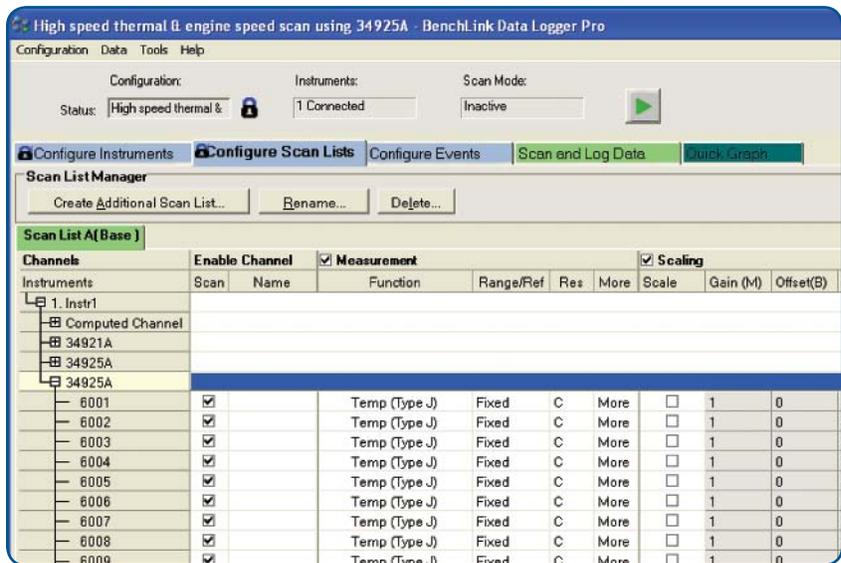


Figure 2: Configuring a high-speed scan using Agilent 34832A BenchLink Data Logger Pro software

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- If the environment around your data logger is relatively stable, turn auto-zero off.
- Program the DMM range directly rather than leaving the DMM in autorange mode.
- Set the correct integration time. Integrating over at least one power line cycle (PLC) will reduce the effect of power-line related noise, but limits the measurement speed to 50 or 60 readings per second.
- Turn off the front panel display and keyboard.
- Use constant current sources to measure resistance, which gives you a voltage measurement.
- Measure thermocouple reference junctions less frequently.
- Convert thermocouple voltage measurements to temperature in your computer rather than in the data acquisition system itself.

Summary

Most data acquisition applications involve using more than one sensor type. This mixing of sensor types can result in slower than necessary scan speeds if attention is not paid to some basic precautions and recommendations. We have discussed ways to streamline your input signals, choose the best multiplexer type for your application and methods to optimize your DMM measurements. By incorporating any or all of these recommendations, you can maximize your scanning speed for multiple-sensor systems.



*Learn more about the Agilent 34970A (TOP LEFT)
data acquisition/switch unit at
www.agilent.com/find/34970A*

*Learn more about the Agilent 34980A multifunction
switch measure unit (LOWER RIGHT) at
www.agilent.com/find/34980A*

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