Basic Troubleshooting for Experimental Equipment

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by

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1. Foreword

The aim of this lecture note is to provide some basic knowledge and guidelines to troubleshoot typical problems occurring in experimental facilities and laboratories of Aalborg University, Department of the Built Environment [1], concerning only experimental equipment and instruments that perform measurements. This troubleshooting guidelines focus on the measurement capabilities of such equipment. Many of those common problems are due to a lack of caution when setting equipment up. It is thus believed that following the simple advice, guidelines and good practices of this document will probably solve 99% of all problems encountered by the operators.

2. Simple Tests

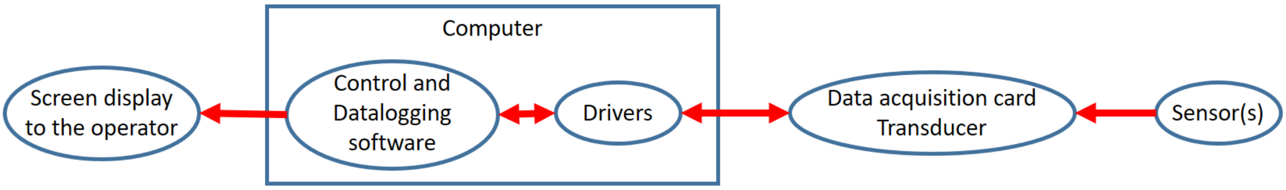
Always perform simple tests to verify that the sensor/instrument is reacting, that is reacting in the right direction (increase or decrease of the measured signal), that the reaction is not delayed, and that it measures what is expected for a known simple case. For example, a temperature sensor in a room should react quickly (with regards to its time constant), should not have large electric noise, should increase the measured temperature when pressing warm fingers on it, and should record room temperature if left in a room.

3. General Approach to Troubleshooting Experimental Equipment

As mentioned before, this document focuses on the measurement capabilities of experimental equipment and instruments. Experimental setups for measurements are usually composed of the following main elements:

- Sensors: transforming the measurand into a signal (usually electrical signal).
- Transducer/data acquisition card: acquiring (measuring), processing and transforming the sensors' signals into digital information. This digital information can be treated to generate valuable measurement information.
- Datalogger: usually software that records the digital information into a file in the memory of a computer.
- User interface: displays the measurement results onto a display for the experimental operator.

These different elements are linked together into a chain-of-information by connections: electrical wires, electrical cables, instrument drivers, software, screen, etc. If the operation of the instrument cannot proceed correctly or if there is no proper measurement recorded by the device and displayed to the operator, the most probable reason for the malfunction is that one of those connections is broken, inadequate or not configured properly. Consequently, systematically checking those elements will lead to rapid identification of the problem in most cases.

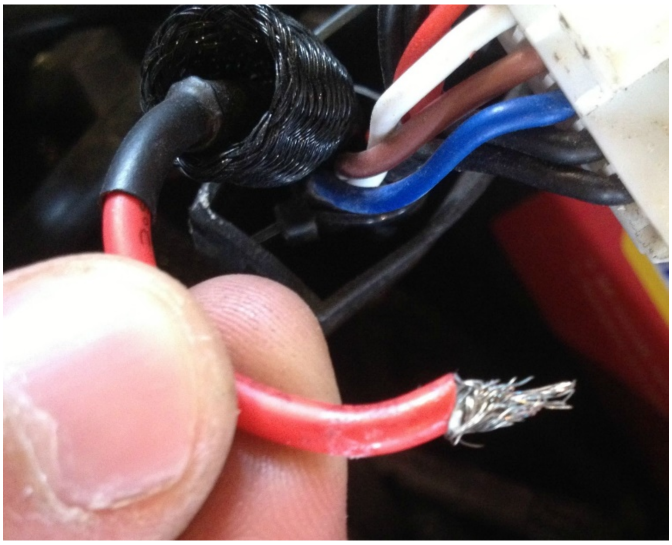


The chain-of-information

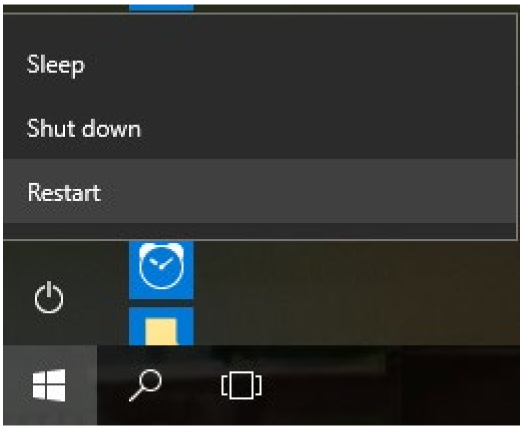
To optimize the chances of fixing rapidly the issue, it is recommended to follow a systematic problem location method: starting by checking what is the closest to the eyes of the operator and going down the chain-of-information until reaching the sensors. Some of the pieces of advice presented hereafter might seem obvious, common sense, or useless. However, one should not underestimate the probability of them solving most of the problems because many of those problems are due to simple (stupid) mistakes that all experimental operators make (even the ones with years of experience).

<u>Basic troubleshooting workflow (from the most common to the least common problems):</u>

1. **Check loose cables** and loose plugs for the computer display, the computer and the equipment connected to the computer. Also check proper connections of the sensors: some sensors might be mounted with loose screws or unsoldered wires. The connection plug of the sensor might be broken or unsoldered. There might be some short circuit due to wires without protective plastic sheath that are in direct contact. If in doubt of the integrity of the connections plugs inside a sensor or a device, contact the person in charge of the laboratory. Once permission has been granted from the latter, switch the device off, disconnect it from the power plug, and carefully dismount the casing to inspect the integrity of the wiring and soldering inside and that no loose wires create a short circuit.

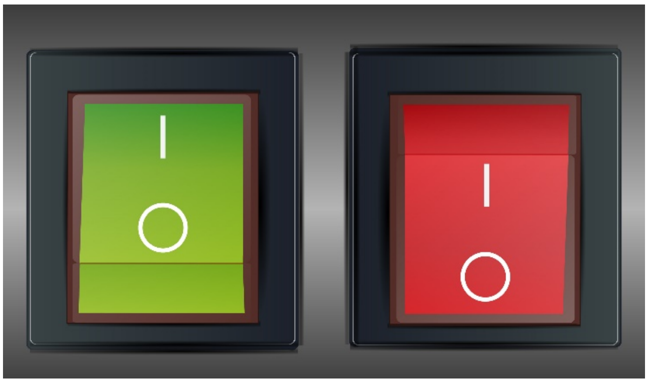


2. **Restart** the computer (switch off and on again), restart the equipment (switch off and on again), restart the software. This is usually perceived as a running joke, but it actually solves most of the problems in the daily tasks of an engineer.



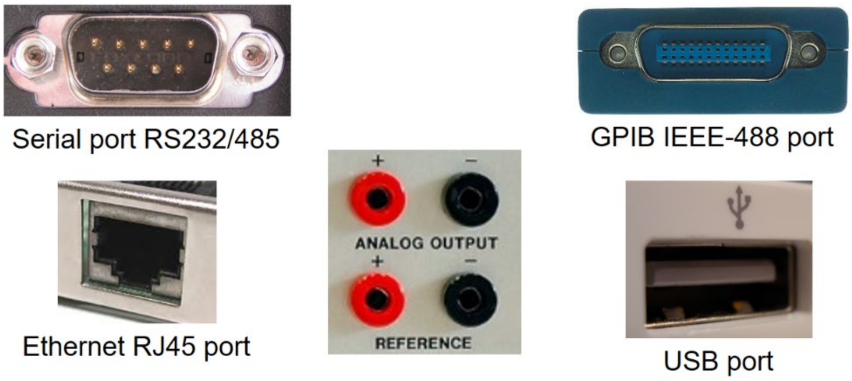
3. Check that all elements and **equipment are actually powered up** (power cable connected to a power socket that has power) and switched on. Switched off and on and make sure that something has changed in the equipment. Most devices do not have the same state when switched on or off: they make some

noise (ventilation fans), they have some LED switching on when powered up. Look for LED and verify in documentation if they should light up when the equipment is powered up. If the LED that is supposed to be on is not, or if ventilation fans are not running, then it probably means that the equipment is not powered up. Several possibilities: no electricity in the electrical socket (verify electrical socket of the electrical network with another device such as a desktop lamp); the power cable is broken (test another power cable); the fuse of the equipment is broken; the equipment is damaged.

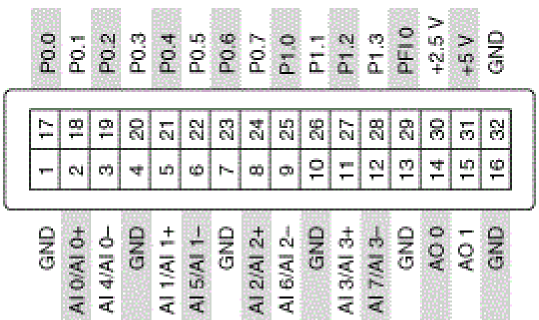


4. **Verify and change fuses**: Most experimental devices have one or several fuses to protect its power supply. Check that the fuses are not jumped off or burnt. You can usually access equipment's fuse by dismounting a small hatch next to the power supply block where the power cable is plugged in. Test the fuse with a multimeter (check for current continuity) if a visual inspection is not conclusive. If the fuse is broken, make sure to replace it with a new fuse that has the appropriate rated current (maximum current above which the fuse interrupts the circuit).

5. **Check communication cables**: the communication between an instrument and a computer is insured by a specific communication protocol that requires a specific type of cable. Make sure that the cable in use is of the right kind (check the documentation of the device). Communication cables can have the same socket (it is possible to connect them to the computer and the device) but not be of the same kind. For example, serial cable RS 232 or RJ45 cables can be a straight-through serial cable (same pinout on both sockets), or a null modem serial cable (frequently called a crossover cable) with the “transmit” and “receive” pins being flipped in between one socket and the other. Verify that the cable is working properly by testing it on another device or setup that is working properly and that is using the same type of cable.



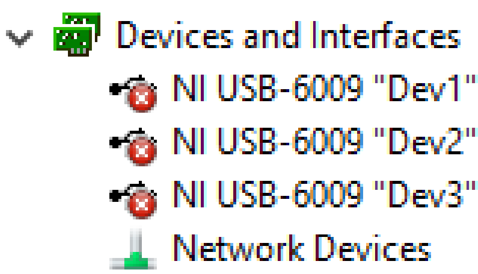
6. **Check sensor’s wiring and pinout**: verify that the sensor’s wires are connected to the device in a proper way with regards to the device documentation and measurement mode. Indeed, instruments can enable different modes of measurement that require a specific sensor’s wiring. For example, thermistors (Pt 100) can be connected to an instrument with 3 possible (but distinct) configurations: 2-wire, 3-wire and 4-wire connection. The analog voltage signal of a sensor can be measured by a data acquisition board in different ways: differential input, referenced single-ended, non-referenced single-ended. Inversion of positive and negative wires is also a very common mistake. This will typically result in sensors have “inversed” behaviour: their signal is decreasing while it should increase, and vice versa. A rule of thumb: positive wires are usually designated as “signal”, “phase”, “+”, and have a “warm” colour such as red or brown; negative wires are usually designated as “com”, “neutral”, “-“, “ground”, “grnd”, and have a “cold” colour such as blue or black.



7. **Check measurement's parameters**: check that the measurement settings of the instrument are adequate for the measurement signal that is acquired: measurement mode, measurement channel, measurement range, filter, sampling/integration time, etc.

8. **Check Adapters**: Some connections from device to computers require adapters such as USB-serial adapter, GPIB-USB adapter, or 5-pin serial to 12-pin serial adapter. These adapters contain electronic chips that can be damaged, leading to information loss or total loss of communication. Similarly to communication cables, verify that the adapter is working properly by testing it on another device or setup that is working properly and that is using the same type of adapter.

9. **Verify the communication protocol parameters**: communication via serial, GPIB or USB cables (and many others) use communication protocols that require some specific communication parameters: COM port number, address number, baud rate, handshake control, stop bit, etc. Make sure that the software communicating with the device is using the right communication protocol parameters. Read the device's documentation to find this information. For serial, GPIB and Modbus communication protocol (among others), it is possible to download free software to test direct communication and manual basic commands: auto-detect, identification, polling. You can also verify with the computer device manager that it detects the connection of a device or adapter: detection of USB or serial device. For National Instruments hardware, use the dedicated management software NI-MAX. For Ethernet device with an IP, you can "ping" it directly with the cmd window of the computer. It should be noted that the automatic IP address allocation mode can prevent communication with the connected device. It is thus recommended to manually set the IP address to a fixed IP address that is not used by any other device in the local network.



10. **Check drivers**: make sure that the adequate software drivers have been installed for the different hardware elements of your setup, including adapters such as Serial-USB or GPIB-USB adapters, or data acquisition cards. If in doubt, uninstall and reinstall the drivers, and check for the recent update of the drivers.

11. **Check sensor's response manually**: for sensors having an electric signal as an output signal, disconnect the sensor from the device and connect it directly to an oscilloscope or an electric signal acquisition board. Remember to power the sensor up adequately if the sensor is an active sensor (in opposition to passive sensors that do not require external power source). Measure the electric response of the sensor while varying the measurand and verify that the sensor's output signal is correct. It is thus possible to detect the potential malfunctions of the sensor itself: no signal, out-of-range signal, electric noise, inverted output signal, etc.

References

[1] Aalborg University, Department of the Built Environment, Aalborg, Denmark. https://www.en.build.aau.dk/

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