Data comms and lightning protection

THE RS485 BUS

The RS485 bus is the defacto standard bus used in industry. Even the newer buses like CAN and PROFI use RS485 or similar technology and often use RS485 transceivers or similar.

RS485 is a single MASTER, multi SLAVE type bus. All communications are initiated by the master; a slave is not permitted to talk unless invited to do so by the master. In Autogrow systems the masters are (1) the PC interface for the PC bus, the weather station for the WS bus and each controller will be master for its local peripheral bus on which items such as enviro sensors, output expanders etc are slaves.

The software protocol used by Autogrow is based on the ASCII MODBUS protocol from Modicon. This is also a defacto industry standard and is familiar to most industrial technicians.

The RS485 bus is a multidrop bus. This means the data cable goes from the master and loops into each slave in turn in a “daisy chain” fashion. Star configurations or even stubs longer that say 1m are forbidden. The A and B lines of the RS485 must be from the same “twisted pair” in the cable. In situations where voltage surges from lightning or machinery may be induced into the cable it is recommended to use shielded cable with the shield connected firmly to ground at one point only – normally at the master.

At the far end of the bus a terminator must be fitted. This must match the characteristic impedance of the cable used. RS485 twisted pair cable and CAT5 have a characteristic impedance of about 100 Ohms. Note that it requires a terminator at each end but the master devices (eg the PC interface and the weather station) have terminators built in. If ever it is required that the master is positioned in the middle of a daisy chained bus then the built-in terminator must be removed by carefully cutting out the terminating resistor from the circuit board. If this is done then a terminator must be added at both ends of the bus. There must never be more than a total of two terminators on any bus. The terminators basically stop echoing of the signal back and forth which would otherwise disrupt normal data flow.

LIGHTNING PROTECTION

The frequency and severity of lightning discharges appears to be increasing world-wide. Countries that often took no precaution against lightning are now finding that they need to address this issue, at least at a basic level. Countries that have used some lightning protection in the past are now finding that they need more sophisticated and powerful methods of protection. In addition, to the installation of adequate lightning conductors which protect against direct hits, it is becoming increasingly important to protect electronic devices from indirect or secondary effects of lightning.

Secondary lightning surges enter systems by three main routes; 1) via the incoming mains supply, 2) by induction directly into data and sensor cables and 3) by hitting the ground nearby and raising the ground potential causing a ground potential gradient in the surrounding area. Any two grounding points within this area with therefore experience a brief potential difference during the lightning discharge. What all this means is that there are two main areas within a system where surge protection is needed.

Mains surge protection

Firstly, protection is needed on the incoming mains power supply – especially where this is by overhead power lines. The rule here is that the most powerful protection must be applied as close as possible to the point of entry of the power lines onto the site. This is normally at the main distribution board. Secondly, lighter power surge arrestors should be fitted on sub-distribution boards in each greenhouse. Finally all modern electronic products will have some surge protection within it. Where this is not sufficient, there are many proprietary plug-in surge arresters or even better, UPS devices, on the market.

Data cable protection

The second place where surges can enter is by induction (inductive or capacitive) into any long lengths of cable – particularly sensor cables and data cables. Any current (or lightning bolt) flowing parallel to a data cable will induce voltages into it. For example, lightning discharge between clouds often travels horizontally; this will tend to induce voltages into long cables running horizontally for example, cables running to enviro sensors positioned along the greenhouse. Lightning discharging to ground is more often vertically orientated and so it will tend to induce voltages into data cables running vertically – for example the cable running down a pole from the wind sensors.

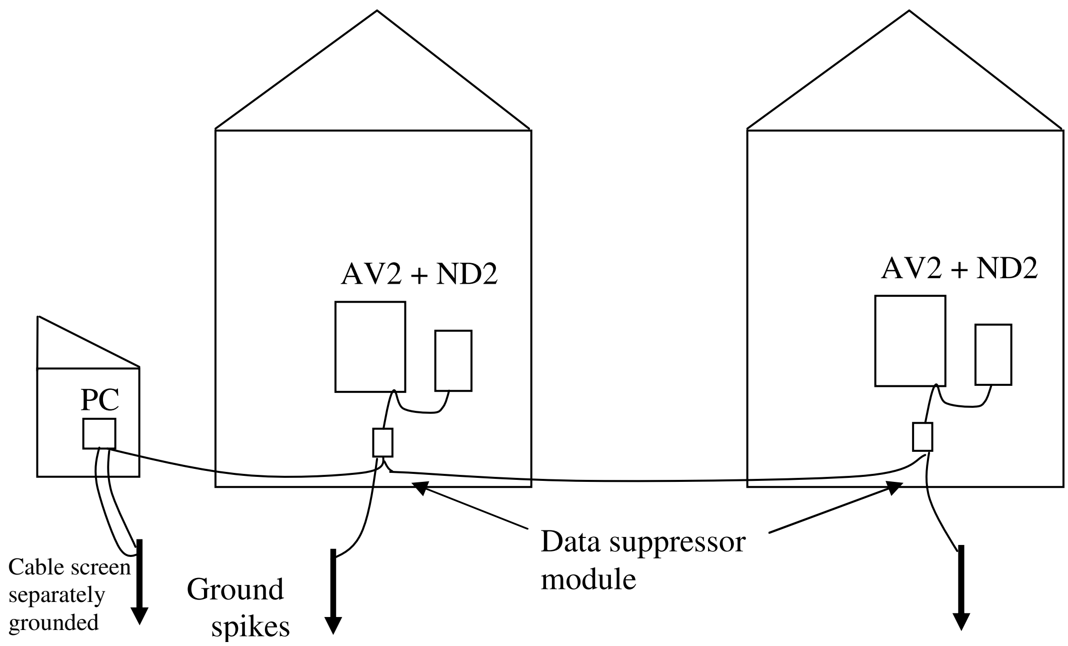
Not only does the lightning induce voltages directly into these cables but it also raises the ground potential where it strikes the ground. The ground potential at one greenhouse can thus be raised many hundreds or even thousands of volts relative to the ground potential at the next greenhouse. A cable running between greenhouses may therefore have a large voltage difference at its two ends. Potentially we might have 100s of volts or more applied to the terminal of the RS485 transceivers. Bang!

What we do to mitigate this risk is use optical isolation so the two transceivers can float at a voltage above ground. This also largely solves the problem of induced voltage but only if the voltage induced in both the A and B cables is EXACTLY the same. That is why we use TWISTED PAIR wires to try to expose each wire to exactly the same induction forces. However, when 100s or 1000s of volts are induced, there is bound to be relatively small differences in voltages between the two wires eg a 1000 volts on one and 1010 on the other. If this difference exceeds more than about 10V then again, BANG!

Using screened cable will further help but this is still not the complete answer and some voltages will still be induced during violent lightning events. To try to clamp these smaller voltages down we use suppression diodes (transorbs). When small surges are received these should clamp the voltage to say 6 volts but if a large hit comes in they may fail – normally as a short circuit (ie fail safe). However, although they fail in a way

which will protect the bus they also prevent the bus from operating. For this reason they are normally made removable but this in itself makes them less effective (through the resistance and inductance of the plug) and frequently the transceiver is damaged before, or at the same time, that the diodes fail. For future designs, we will include small suppressors on an easily replaced comms module which will also include the transceiver chip together with more robust suppression diodes.
For lightning prone areas, we also have available a data cable surge suppressor module that should be installed outside the equipment it is protecting – ideally 1m away. These have some fairly heavy duty gas discharge suppressors as well as smaller high speed Transorbs. Unfortunately, these heavy duty suppressors will degrade the signal quality to some extent and so their use should be limited to only particularly vulnerable positions – eg at the entry point of a cable into a greenhouse or at a piece of equipment that is frequently affected by lightning.

The following diagram shows a possible method of fitting these suppressors.



Note that the stub of cable connecting between the suppressor module and the local controller(s) should not exceed 1m to 2m at the most. Also note that the cable screen is grounded separately at a single point in the system, normally at the master device.

DELAYED LIGHTNING DAMAGE

Unfortunately, even after applying all of these safeguards, damage from lightning is still possible and even worse, this damage is not always immediately apparent. Sometimes it makes pin-prick holes through the semiconductor material inside the chips which then gradually degrades and may fail anytime in the following 9 months. In high security situations any equipment that is even slightly damaged by lightning should be completely replaced.