TROUBLESHOOTING AND MAINTAINING ELECTRONIC KILN CONTROL SYSTEMS

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After many years of helping American Wood Dryers' customers troubleshoot dry kiln control systems, I have noticed what might be called an "instrumentation gap" in the ability to maintain and repair computer-based electronics equipment. The problem ranges from completely nonexistent electrical or electronics training to electricians who have the basic skills, but do not know how the circuits work. I believe that this is because most sawmill electrical troubleshooting involves AC power, on/off switches, relays and motors. If instrumentation equipment *does* exist, it is likely to be repaired by replacing the entire instrument, not by troubleshooting components.

The object of this paper is to provide an understanding of fundamental industrial control concepts that electricians or other *hands-on* personnel can use to approach basic dry kiln controls troubleshooting. Common control circuits will be discussed and specific examples will be related to dry kiln control systems. In addition, hand-held digital voltmeters will be explained and troubleshooting examples will be provided.

For the sake of simplicity, the discussions are restricted to digital meters (Figure 1), RTD temperature sensors, and pneumatic valve actuators.

Basics of Electricity

Basic science teaches us that the atoms that make up all materials have electrons orbiting around their center, or *nucleus.* Different elements have different numbers of electrons in various orbits around the nucleus. Metals are elements that have electrons in their outer orbits that are easily knocked out of orbit, and get pulled into the orbits of neighboring atoms. When an atom has an extra electron, it has a negative charge. If it is missing an electron from its outer orbit, it has a positive charge. When an electron gets into the outer orbit of another atom, it causes an imbalance, pushing another electron out and into another atom which displaces an electron there. This causes a chain reaction that we call *electricity.*

An electrical charge can be created by chemicals, as it is in batteries, or by moving a magnet within a winding of wire, as is done in electrical power generation. Electrical circuits can change the intensity of the charge and control how fast the electrons are pushed from atom to atom.

Voltage is the measure of electrical charge, or force, which tries to push the electrons in a metal. Voltage is expressed in volts. In electronics instrumentation, voltage may also be expressed in millivolts (mv) for thousandths of a volts, or microvolts (μv) for millionths of a volt.

Electrical **resistance** is the opposition to the flow of electrons. The arrangement of electrons in orbits around the nucleus determines how easily electrons will be given up and/or taken on. That is, how well the material will *conduct* electricity.

Resistance is measured in *ohms.* On wet lumber you may measure a resistance of 50,000 ohms (50K). Dry lumber has extremely high resistance, up to billions of ohms, and must be measured with a specially designed resistance meter.

Current is the resulting flow of electrons through a conductor. When *voltage* is pushing, depending on the amount of *resistance* present, some *current* will flow. Current flow is measured in amperes, or amps. In electronics and industrial control applications, current is usually expressed in milliamps, for thousandths of an amp.

In industrial control, these three properties of electricity are manipulated to express real-world values such as temperature, pressure, mechanical position, etc.

Voltage-Based Control Elements

Various ranges of voltage levels are used to communicate a range of numbers. For example, a device can measure a temperature for its own use, then relay the value to a chart recorder for display. In order to do this, the transmitting device and the chart recorder must agree on the voltage range to be used and the temperature range that the voltage range represents. For example, both instruments could use a 0-10 volt range to represent 0-300 degrees F. If the voltage measured is five volts (half of the output range), you would expect the indicated temperature to be 150 (half the range).

A common use of voltage control is to set the speed of a variable frequency (VF) drive. A computer can receive a VF drive speed requirement from an operator or a drying schedule and send it to the VF drive by a voltage signal. The signal could be a 0-5 volt, 1-5 volt, 0-10 volt or other voltage range to represent the desired speed.

Current-Based Control Elements

Current control is similar to voltage control, but the hardware card or module that creates the signal is slightly more complex and is usually more expensive. Current control is superior because it is less susceptible to electrical noise than voltage control. To communicate with another device, current control hardware produces a range of current flow to indicate a range of values.

The most common current control device is the *4-20 milliamp loop*. In this approach, the output hardware expresses the output value in terms of current flow instead of voltage. The output range of 0-100 percent will be communicated by a current flow of 4-20 milliamps. A very common use of this control type is in controlling the position of steam valves.

To position a steam valve, the computer's 0-100 percent output requirement is translated to a pressure range by a device called an *I-to-P converter.* This device translates an input range of 4-20 milliamps to an output range of 3-15 psi or 6-30 psi, depending on the steam valve used (Figure 2).

Resistance-Based Control Elements

In this paper we are discussing how changing resistance is used to indicate a value, so we are talking about types of *variable resistances*. The most common variable resistor is a potentiometer (pot) which is used to control the volume on a radio. When we turn the knob, we change the resistance, which changes a voltage which controls the volume.

Resistance also varies with temperature and various metals have individual responses to temperature changes. Platinum wire, for example, increases its resistance in a very precise and predictable manner when heated.

Platinum RTD temperature sensors (Resistance Temperature Detectors) use a winding of thin platinum wire which reads 100 ohms at 32 degrees F. As the temperature increases, the resistance increases. This type of measurement, although very accurate, is prone to errors due to the added resistance of connecting wires. This can be considerable, since the connecting wires can easily be over a hundred feet in a dry kiln control system. This would result in tens of degrees of error in readings if corrections were not made. Three-wire RTDs provide for cancellation of the lead resistance.

Special electronics circuits are designed to read the RTD temperature sensors (see Figure 3). The path through one of the common leads, back through the ***R Lead***, measures the sensor, plus the resistance of two leads. A second path goes through the two common leads, and back into an input that ***subtracts*** from the ***R*** input. This results in the measurement of the resistance value ***minus*** two lead lengths of connecting wire.

Digital Voltmeters

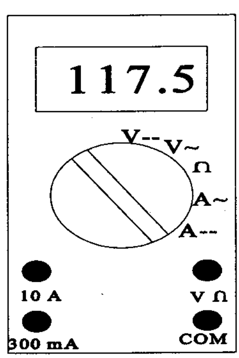

FIGURE 1: Typical Digital Voltmeter

We can easily troubleshoot the basic circuits used in the control systems with a hand held digital multimeter. A digital meter is preferred because it has several advantages over analog (needle type) meters. A digital meter has a number display to read the value measured, where an analog meter requires you to pick a reading based on what scale the meter is on. Digital meters (good ones) have auto-ranging to automatically select the proper voltage range, whereas analog meters will slam the needle violently if the range is set too low. Digital meters do not care if the polarity (red or black lead placement) is incorrect, it they merely show a "minus" sign when the leads are reversed.

A suitable light duty digital meter can be purchased for as low as $40 US, and rugged, good quality meters should start at about $150.

Making Measurements

To measure voltage, first determine if it is AC or DC. To measure **AC volts**, make sure the black lead is plugged into the "COM" or "COMMON" plug and the red lead is plugged into the plug marked "V" and "Ω" for Volts and Ohms. Move the selector knob to the AC Volts setting. This position may be marked by a wavy line (~) representing AC. If your meter does not follow this example, you must consult the meter manual or get help before making any readings.

When measuring **DC volts**, the probes are also plugged into the "COM" and "V Ω" position. The selector is placed at the Volts DC position which may be noted by a straight line(--), indicating DC voltage. The red lead is placed on the positive signal and the black lead is placed on the DC common position. You will normally be using a drawing, which will show the positive voltage with a plus sign (+) and the negative or ground signal with a minus sign (-).

To measure **resistance**, the probes will be plugged in the same as for voltage, but the selector knob will be placed at the "Ω" position, for ohms. Always make sure the device you are measuring is not powered on, since the meter may be damaged from existing voltage on the device. Also, any attached circuitry will provide additional paths for the measurement signal and will lower the resistance reading.

When **current** is measured, the meter is connected into the circuit and current actually runs through the meter (see Figure 2). If the circuit is <u>not</u> a current loop, for example a 4-20 milliamp loop, the meter will be damaged. Configure the meter by selecting DC Amps--indicated by an A and a straight line. Plug the red test lead into the *milliamp* input (eg 300 ma). Place the meter into the circuit as shown in Figure 2.

Troubleshooting RTD Temperature Inputs

Common problems with RTDs are broken wires in cables, poor screw terminal connections, bad solder joints or bad sensor elements. The digital meter will help to find any of these problems. When a bad reading occurs, you do not know if it is the RTD or the input device. You should move another *known good* input to the same position to see if the problem persists. If so, you must troubleshoot the input device, not the RTD. Most likely the input device is a module that can be swapped

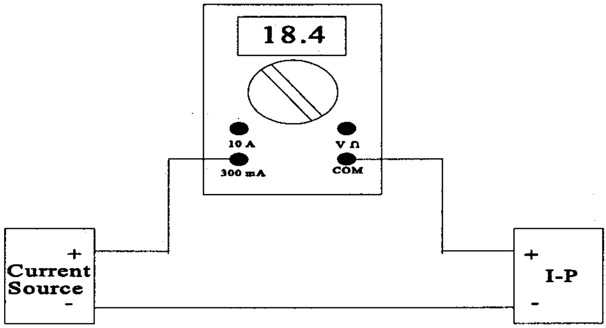

FIGURE 2: Measuring 4-20 Milliamp I-to-P Converter Signal

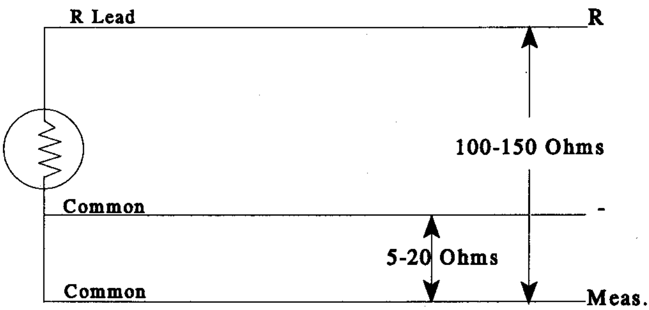

FIGURE 3: RTD Sensor Diagram

out with another of the same type, or perhaps a spare device is available. To troubleshoot the bad RTD input, set the meter up for resistance measurements. Measure the two common leads and note the resistance. It is usually 5-20 ohms, depending on the cable length. If it is shorted (near zero ohms), the cable is defective near the end you are holding. If it reads high resistance or "open", you should look for bad connections or a broken cable. It is possible that the break is within the RTD assembly itself. If the two common leads are ok, measure between one of the common leads and the resistor lead. This value is the lead length plus the resistance element of the sensor. The resistance should read 110 to 150 ohms, depending on the temperature and the type of RTD. You can get the exact resistance for the current temperature if you have the conversion tables for the RTD you are using. Subtract the resistance of the two common leads from the resistance of the reading through the sensor. This is the sensor resistance only, since the resistance of two lead lengths is subtracted. Go to the resistance table and find the temperature value that corresponds to the resistance reading.

If you cannot find any problems in the cable, you can find the RTD, remove the insulation from the solder joints and measure at the RTD. If you replace the RTD, remember that the leads **MUST BE SOLDERED** and wrapped with tape that will seal out moisture and withstand kiln temperatures. Normal electricians tape does not hold.

Troubleshooting the I-to-P Converter Current Loop

When a proportional controller positions a pneumatic steam valve it calculates an output, 0-100 percent, which is the desired valve opening. The valve operates by a range of pressure, usually 3-15 psi or 6-30 psi, corresponding to 0-100 percent open. To produce the air pressure signal to work the valve, an I-to-P converter is commonly used. "I-to-P" stands for "Current to Pressure" (*I* is the symbol for current). The kiln controller varies the current flow in a loop of wire between 4 milliamps and 20 milliamps to represent zero to 100 percent output. The current loop runs through the I-to-P converter (Figure 2), which translates its input range of 4 to 20 milliamps to its output range of 3-15 psi, or 6-30 psi, depending on the diaphragm valve.

You should be able to manually control your output value for the valve opening over the range of zero to one hundred percent. Also, you should be able to place the output at a fixed value, for example 70 percent, and have the valve stay at this position. With the valve open, check for leaks in the air lines, around the I-to-P converter, and the valve diaphragm itself.

The position of the valve is usually indicated by an air gauge, which will indicate the position of the valve if no significant leaks are present. If your I-to-P converter uses solenoids to inject air into the lines to add pressure, then you want to listen for a constant clicking sound which will indicate that the I-to-P is trying to make up for leaking air (the needle on the air gauge may show this by jumping constantly).

If you cannot open the valve completely at one hundred percent output, and no leaks are present, then you want to see if the I-to-P, the current source, or the cable is bad. If you can put a meter into the circuit as shown in Figure 2, you can isolate the problem. Set up the meter for milliamps measurement, break the circuit path and insert the meter as shown. If you can vary the current reading between 4 and 20 milliamps, without the I-to-P responding, then the I-to-P is bad. If the current indicates but does not change, then it is the current source. If there is no current reading, then it is the cable or the current source. In the latter case, eliminate the cable by connecting the meter directly to the current source.

Conclusion

There are as many approaches to controlling kiln temperature as there are kiln controls manufacturers. However, only a few basic electronic circuit types are used. A reliable digital voltmeter and some basic instrumentation concepts can help to troubleshoot most hardware problems that can occur. It is my hope that this quick overview of electronic control concepts will add some understanding and perhaps hasten the troubleshooting and repair of some dry kiln control systems in the future.