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From: Ferenc Tarnok, Engineering

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## **Position Sensors in NResearch Inc.® solenoid valves**

### **Importance of Position Sensors**

Implementation of state of the art automated laboratory research and computer or microcontroller controlled instrumentation technology has always been restricted by conventional valve technology. NResearch Inc.®, the innovator of state of the art valve design and manufacturing techniques, has successfully bridged this gap by developing a patented Position Sensor to provide independent real-time electrical verification of mechanical condition of solenoid valves. NResearch Inc.® solenoid valves equipped with a Position Sensor each contain a built-in switch in a way that the moving part of the valve incorporates one of the contacts of the switch. Accordingly, the electrical switch output continuously and precisely follows the actual mechanical state of the valve without any delay or hysteresis.

### **Wires and Connections, Modes of Operation**

Each solenoid, equipped with a position sensor comes with three wires. The two, most of the time identical color wires are to be connected to the coil (valve) power source. The applied color-coding eases the identification of the required operating voltage. Both of these wires are electrically insulated from the core and the third wire as well. The third (always green) wire is the position sensor output. The core (the larger metal part of the solenoid) is to be connected to GND (ground) through the threaded holes on it, using appropriately sized screws. A piece of wire, equipped with a ring terminal may be used. NResearch Inc.® web site offers detailed information on different screw-lengths for each valve. It's important to note that using oversized screws may prevent the valve from correct operation. The green wire will be then in a floating state while the valve is not energized, and it will become grounded as long as the valve is kept energized. The preferred mode of operation is using logic level signals (see details later).

However, if all the application requires is a simple visual confirmation of mechanical valve status change, a low-power (1 Watt) light bulb may be connected between the green wire and the positive end of the valve power source. Obviously, the light bulb needs to be rated to work at the voltage of the valve power source, i.e. 12VDC or 24VDC, etc. As the internal switch contacts have originally been designed to work in a logic level environment, they are not meant to handle high current switching. Please never use a light bulb with a power rating higher, than 2 Watts. The light bulb will accurately follow the mechanical state of the valve, it will turn on, when the valve changes state after power has been applied to it, and it will turn off whenever the valve changes state again, after power has been removed.

Alternatively, and preferably, in place of the low power light bulb, an LED in series with a current limiting resistor may be used, connected between the green wire and the positive terminal of the valve voltage supply. Connecting the LED with correct polarity is essential. (The resistor may be 2.2 kOhms for 24V, and 1 kOhms for 12V operation, 1/4W, in case of a standard LED with an approximately 2V forward voltage drop, operating at 10 mA).

To achieve standard logic level output signals, the green sensor wire is to be pulled up to +5 VDC through a 10 kOhms resistor. Note, that the GND of the 5V supply, the metal core of the valve,

and the GND of the electronics that will interpret the logic level signals, all have to be at the same potential (connected together). The signal at the green wire then becomes the raw position signal, which reads GND (LOW), when the solenoid is in its energized mechanical state and +5 VDC (HIGH), when it is not. This raw signal however can not be used in a digital environment without first considering the effects of valve response time and switch contact bounce.

### **Valve Response Time**

All solenoid valves need a certain time to change their states after the power has been changed on their inputs. This is the so-called response time. The response time ON and the response time OFF are usually but not necessarily different, and they both depend on several different factors. The most important factors are the energizing voltage for the response time ON and the method of coil transient suppression in regards to the response time OFF.

For example, in case of a standard 225 series NResearch Inc.® valve assuming normal operating conditions, the response time ON is usually less than 20 ms, while the response time OFF is around 30 ms with a simple diode-only transient suppression. Larger valves usually have longer response times, and for the entire range of NResearch Inc.® valves under normal driving conditions, the response time ON may be anywhere between 5 and 50 ms, while the response time OFF may be up to 4 times the response time ON, i.e. 200 ms.

### **Switch Contact Bounce**

Additionally, at and following the time of the mechanical position change, there is a short – usually a few ms long – switch contact bounce present, just like in any other mechanical switch.

### **Hardware Timing Requirements**

According to the above detailed behavior, in order to successfully monitor the mechanical state-change of a valve after the power on its inputs has been changed, it is advisable to include a small delay between the valve activation, and the verification of the mechanical position via electronically interpreting the logic level position signal. This delay would be the sum of the highest possible response time for the appropriate valve and up to about 50 ms to avoid the effects of contact bounce. If there is no information available on the particular valve, 250 ms should safely work with any NResearch Inc.® valves under normal circumstances. In case the time of the valve activation is unknown, a 50 ms delay after the first detected signal transition is sufficient. This way someone can easily get several hundreds of thousands, or millions of cycles out of the position sensor equipped valve, without ever missing or misinterpreting a single position change.

Connecting an oscilloscope input or other appropriate circuitry to the raw position signal output described at the end of the “Wires and Connectors, Modes of Operation” section, the valve response times (ON and OFF), as well as the effects of various valve driving conditions and transient suppression methods on the response times become easily measurable.

### **CoolDrive® Valve Driver Boards**

The use of NResearch Inc.® CoolDrive® valve driver boards in conjunction with position sensor equipped valves is not only possible but in most cases it is highly desirable, to extend valve life through cooler operation, and to significantly reduce overall power consumption.