Nikko's Solenoid-Control Relay Circuit

That small relay you'll find attached to many Nikko industrial starters is more than just your ordinary starter relay. Nikko calls it a solenoid-control relay. As the name implies, it controls the operation of the starter solenoid. Nikko utilizes the output from the alternator **R** terminal, in conjunction with this relay, to prevent accidental engagement of the starter once the engine is running. This document will explain how the system works and how to test the relay to ensure it is working properly.



Figure 1 – Nikko Solenoid-Control Relay
Photo courtesy Electric Motor Service (EMS)

The Nikko solenoid-control relay is used on many different applications, including Komatsu, Hitachi, John Deere, Link-Belt and other industrial equipment. In nearly all applications, it is mounted directly on the starter. If you look closely, you'll notice there's an electronic component attached to what looks like a standard 4-terminal relay. For purposes of explaining how the relay works, we'll call the electronic part the *controller* and the 4-terminal relay the *relay*. The diagram in *Figure 2* shows the relay's internal circuits.

The controller has five wires coming out of the potting compound on the underside. Two wires are soldered to connections on the relay which go to the internal relay coil. The ground wire is black, and in most cases, it's attached to the relay's bracket. Another wire, black/white on most applications, is connected to the harness leading back to the start side of the ignition switch. The fifth wire, white/green on most applications, is connected to the harness leading to the alternator's **R** terminal. This wire is used to sense when the engine is running.

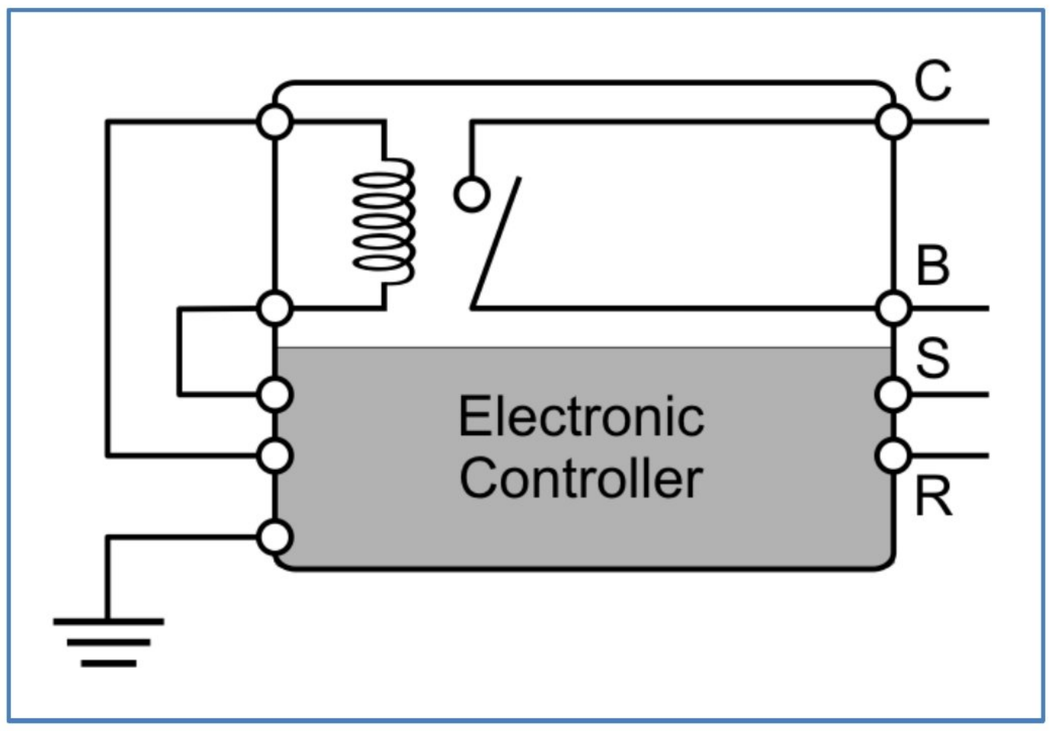


Figure 2 - Internal Parts of Control Relay

There are two things you need to know about the Nikko alternator used with the control relay. First, it is self-excited by a resistor connected internally between **B+** and the diode trio. Second, the **R** terminal is also connected to the trio. The **R** terminal serves as a secondary output to signal the controller that the alternator is running. The diagram in *Figure 3* is for the Hitachi EX200 excavator, but all equipment using a Nikko system with control relay will be similar.

The battery relay shown in *Figure 3* prevents small drains from discharging the batteries whenever the equipment sits idle for long periods of time. This is important, because the alternator's excitation resistor will present a small parasitic drain. When the switch is turned on, the battery relay closes to connect the batteries to: the starter solenoid, the alternator, the control relay and the rest of the electrical system. At this point, the **R** terminal will have no (or very low) voltage present, because the field circuit will bleed-off nearly all current coming through the alternator's internal excitation resistor.

Since the engine has not yet started, the trio cannot provide output. When the switch is turned to the

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start position, the black/white wire signals the controller to start. With no (or very low) voltage present on the white/green wire, the controller allows the current from the switch to pass through to energize the relay, which in turn activates the starter solenoid.

Once the engine starts and the alternator *excites*, the **R** terminal becomes a secondary output terminal. The controller immediately senses that the alternator is charging, and it cuts the activation current to the relay. As long as the engine is running and system voltage is present at the **R** terminal, the control relay cannot be activated to re-engage the starter.

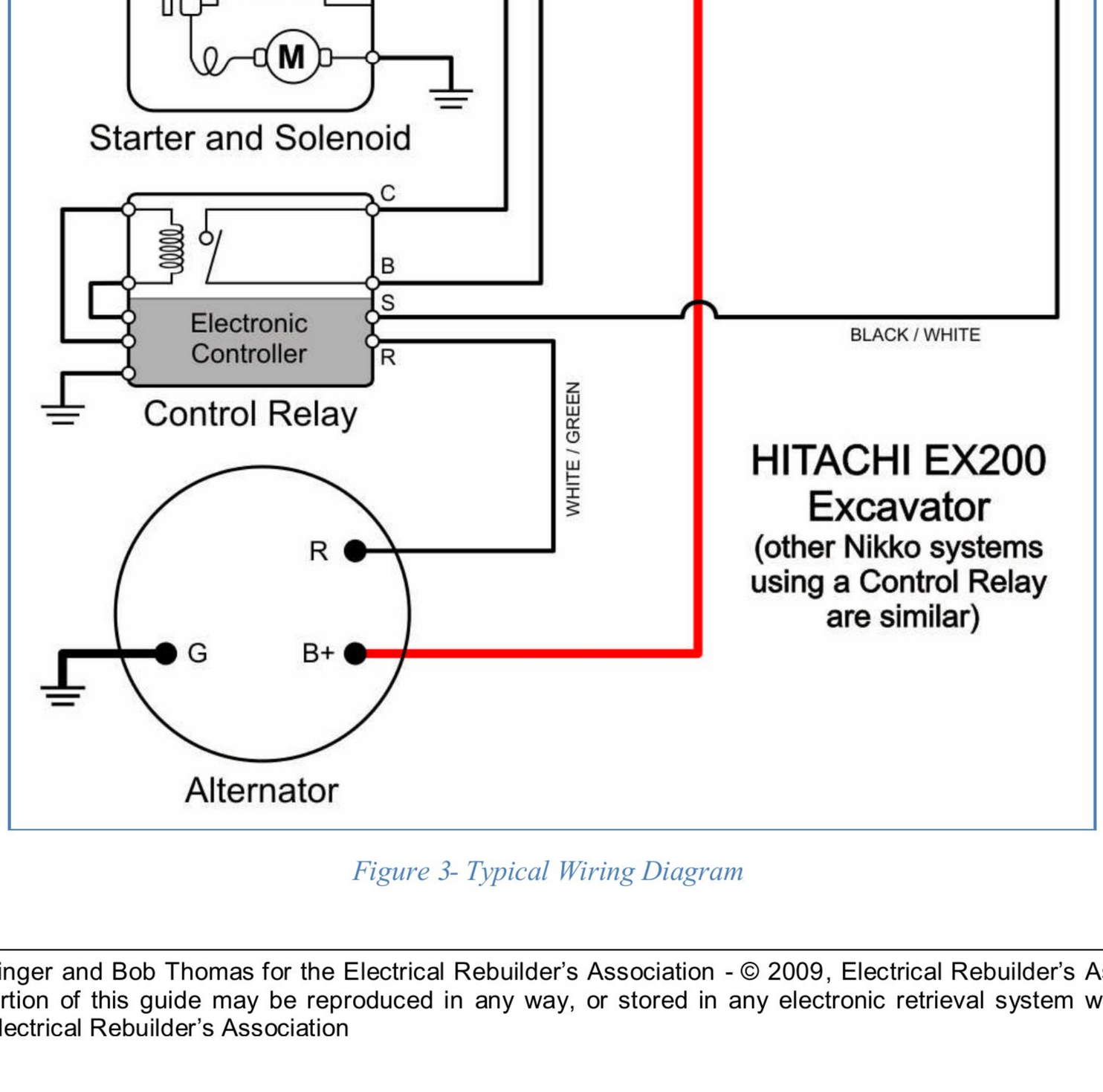


Figure 3- Typical Wiring Diagram

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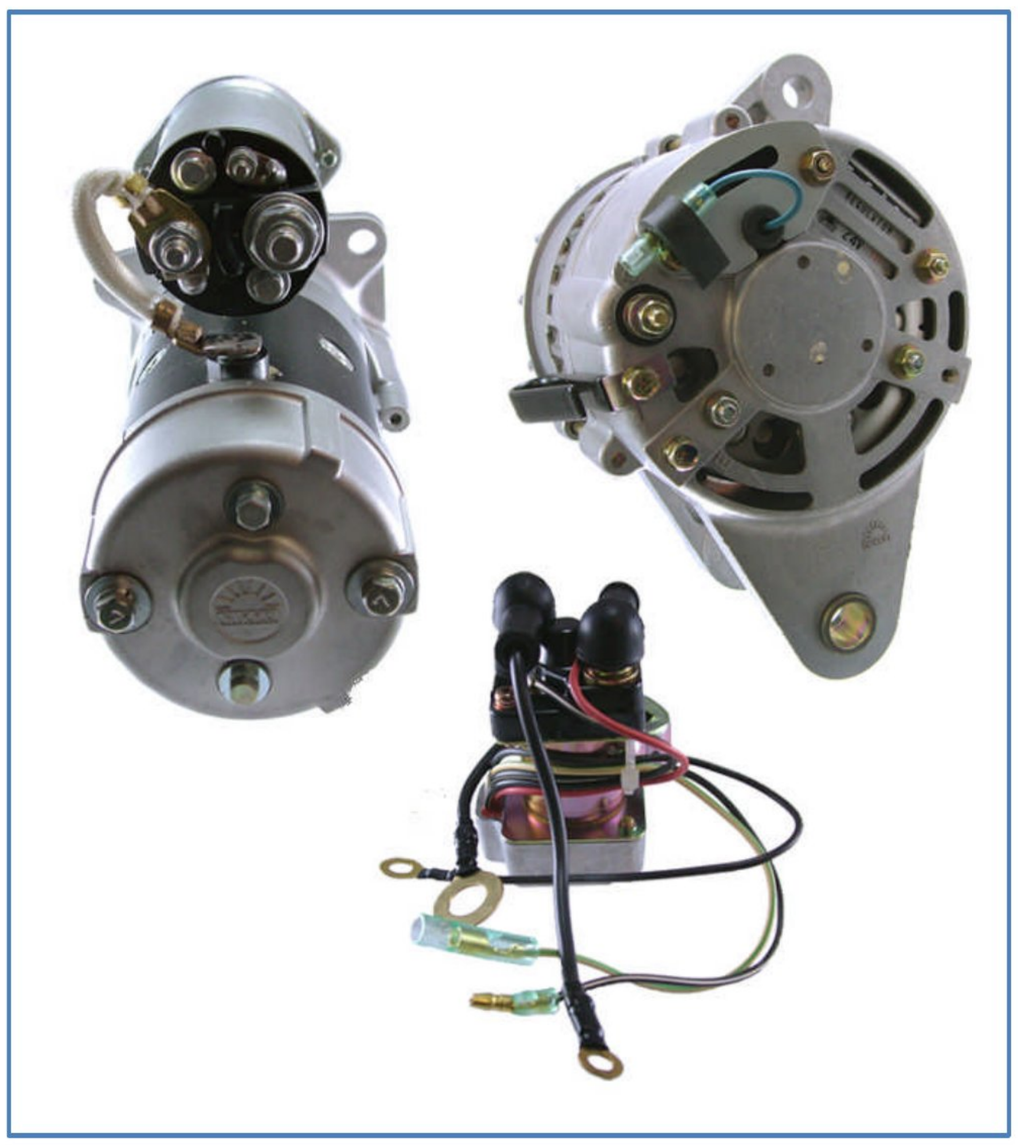


Figure 4 - Photos of a Nikko starter, alternator and relay. Photo courtesy Electric Motor Service (EMS)

Testing the system for no-crank

1. With the ignition switch in the start position, verify that there is battery voltage on the black/white wire.
2. Verify that there is no voltage on the white/green wire.
3. Verify that there is battery voltage to the control relay.
4. Verify that the control relay has a good ground.

If all of the above are present, the relay should work - if it is good.

NOTE: If a positive diode in the Nikko alternator becomes electrically shorted, it will allow battery voltage to leak back through the trio to the **R** terminal and fool the controller into thinking the engine is already running. This will create a no-crank condition. Additionally, if the field circuit in the alternator is open because of an open rotor, faulty regulator or worn out brushes, the current flowing through the excitation resistor will carry sufficient voltage to prevent cranking. You can temporarily remove the white/green wire from the alternator to determine if the alternator is causing the no-crank condition.

Bench-Testing the Controller

You can easily test the controller on your bench to verify that it is working properly. Just be careful when hooking up the wires, because most control relays taken off equipment will have been heavily painted. Be sure to get a good connection.

1. Ground the black wire coming out of the controller. It usually has a ring terminal on it.
2. Apply **12-volts** to the **white/green** wire, which usually goes to a two-pin harness-connector. Sometimes you'll find this wire has been cut during removal of the starter.
3. Apply **24-volts** to the **black/white** wire, which goes into the same two-pin harness-connector, if it has not been cut (this is assuming that the controller being tested is for a 24-volt system). The relay should not operate.
4. Remove power from both wires, and try applying power to the black/white wire again. If the relay clicks, the controller is working properly.

There is a reason for testing with 12 volts on the white/green wire as opposed to using 24 volts. Some applications may use the **R** terminal for other devices in addition to the control relay. The controller is designed to permit activation with low voltage present, but the threshold voltage for the controller was higher than 8 volts and lower than 12 volts on all relays we tested.

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