Vacuuming the shop

By Bob Neidorff

Many home craftsmen get vacuums specially made for shops. These vacuums can handle large quantities of sawdust, pieces of metal, and some even handle liquid. I bought one of these vacuums and connected it permanently to the dust ports of my table saw, jointer, and a few other places in the shop. But it bothered me to have to turn on the vacuum every time that I wanted to use a power tool, so I made an automatic vacuum activation switch.

The automatic switch consists of a current-sensing transformer, a diode bridge, a solid-state relay, and a mechanical contactor. I ran a power line to each tool through the core of a transformer. This puts a small magnetic field in the transformer anytime that one of the tools is on. I connected the primary winding of the transformer to the diodes and solid-state relay, so that when there was any magnetic field in the transformer, there would be current into the solid-state relay, turning on the contactor and running the vacuum. The secondary of the transformer isn't used. I used the primary of a power transformer for this because it has more turns than the secondary, so it produced enough voltage to turn on the solid-state relay, even when running a small ¼ horsepower tool. I selected a small toroidal power transformer for this because it has a large hole in the center, so it is easy to run new wires through the transformer, but any open-frame power transformer with enough turns and a suitable hole in the core can be used.

When a motor is running with no load, motor current will be very low, so transformer output current will also be very low. This design is very sensitive, so that it will turn on even if there is very little tool current consumed. The solid-state relay requires 2mA to reliably turn on. My transformer gave 3.5mA when I ran a ¼ horsepower motor with no load, and any load increased the output current above that. You can test your own transformer with different tools by connecting a DC current meter right across the bridge rectifier output. If necessary, you can increase sensitivity by looping the power wire through the transformer a second time. The transformer output current will be related to the tool current by the ratio of turns, so doubling the turns on the primary will double the current in the secondary.

When a motor is starting or heavily loaded, motor current will be much higher than when unloaded. To prevent excessive current from damaging the solid-state relay input, an NPN transistor and resistor is used as a shunt current regulator. When the voltage drop on the resistor reaches approximately 0.6V, the transistor turns on and consumes the excess current. The solid-state relay input is rated for 50mA maximum, so the current limit is set well below that: $I_{max} = 0.6V/49.9\Omega = 12mA$. The input voltage of the solid-state relay is approximately 1.2V. The 2N3904 transistor is rated for 625mW, so this circuit can safely handle $I_{max} = 12mA + 625mW / (1.2V + 0.6V) = 360mA$. If you expect more current than that, replace the 2N3904 with a higher-power darlington transistor, such as a TIP122G, which has very high current gain and is rated for 65W. The electrolytic capacitor across the rectifier absorbs some of the inrush surge and keeps the solid-state relay on throughout the power line cycle. It also delays turn-on slightly, rejecting noise and preventing the tool and vacuum from starting at exactly the same time, reducing the power line surge.

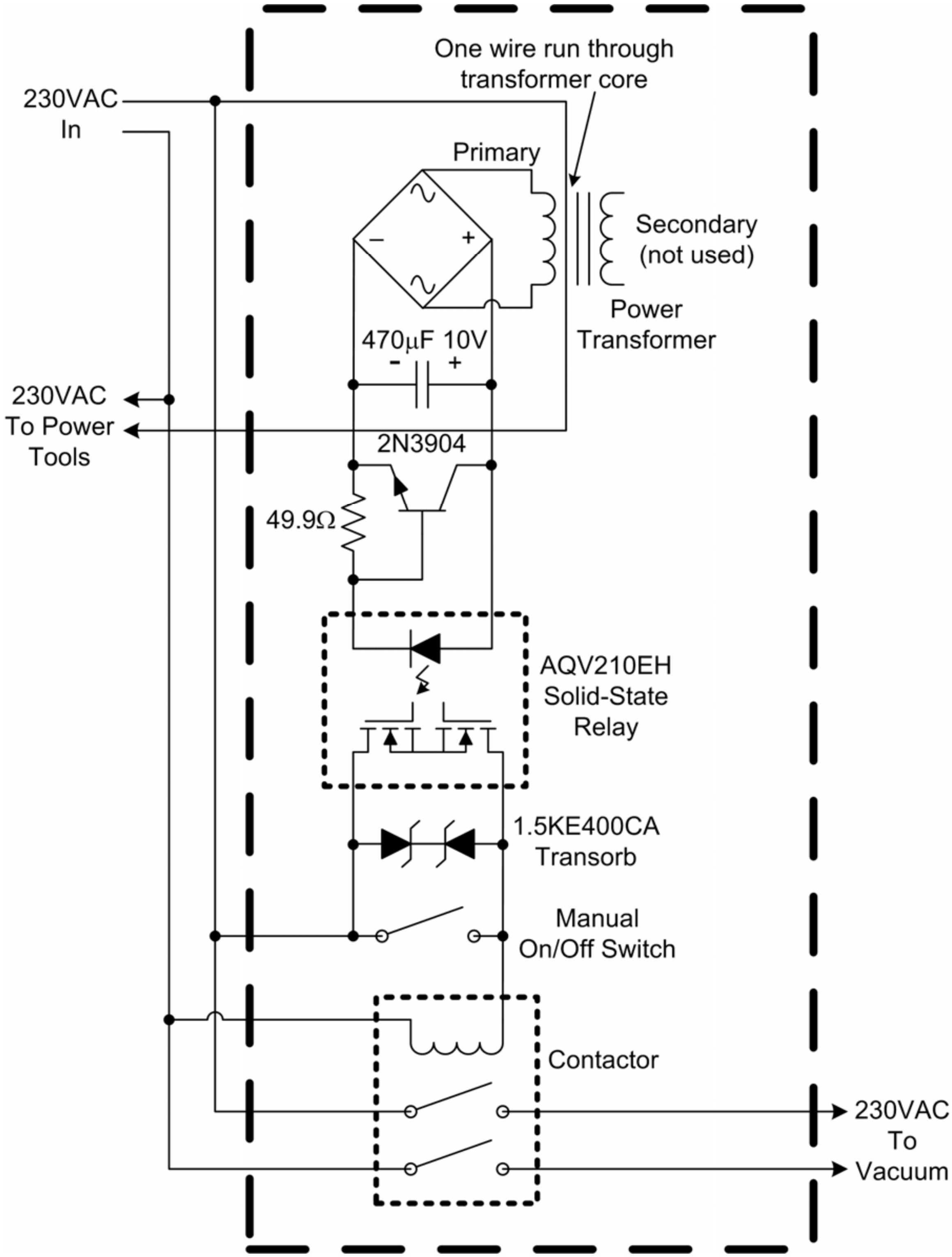
To prevent inductive spikes from damaging the solid-state relay, a bidirectional transient voltage suppressor ("transorb") is placed across the solid-state relay output. A transorb is a power zener diode engineered to withstand high-energy surges.

Be careful when bolting down a toroidal transformer. If a metal bracket or strap forms a closed-loop, it will act as a shorted turn on the transformer and prevent any output current.

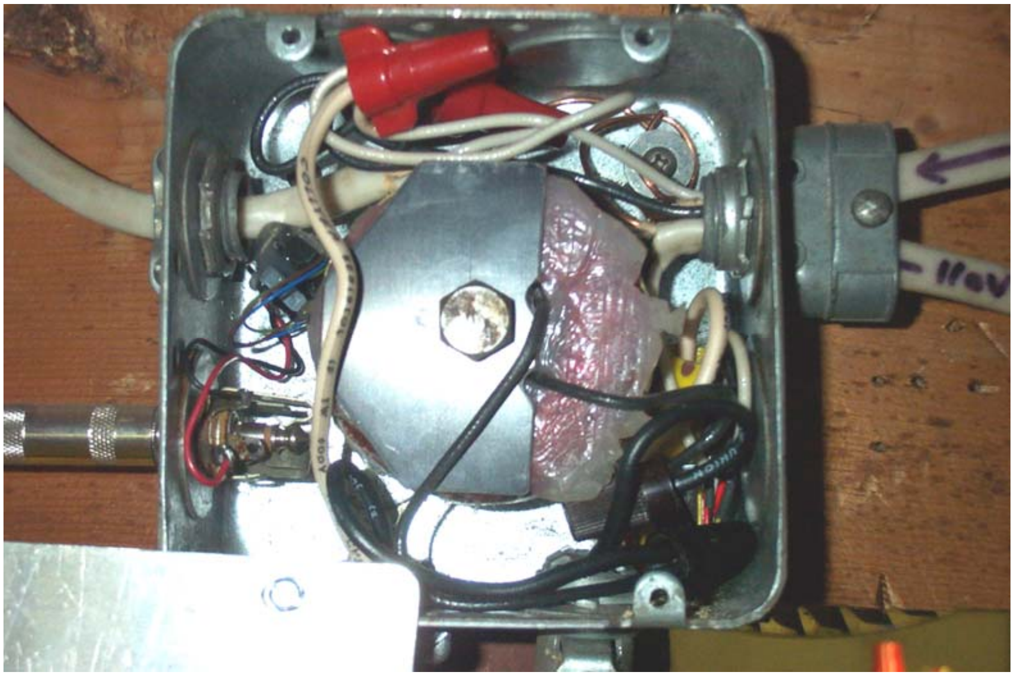
I added a manual switch across the solid-state relay, to turn on the vacuum when sweeping the floor. I put a few vacuum ports around the shop that accept normal vacuum hose. These ports and the power tools are plumbed to the vacuum manifold with 4" lightweight PVC drain pipe. An uninsulated grounded wire inside each line prevents electrostatic charge from building up in the vacuum hose.

Parts:

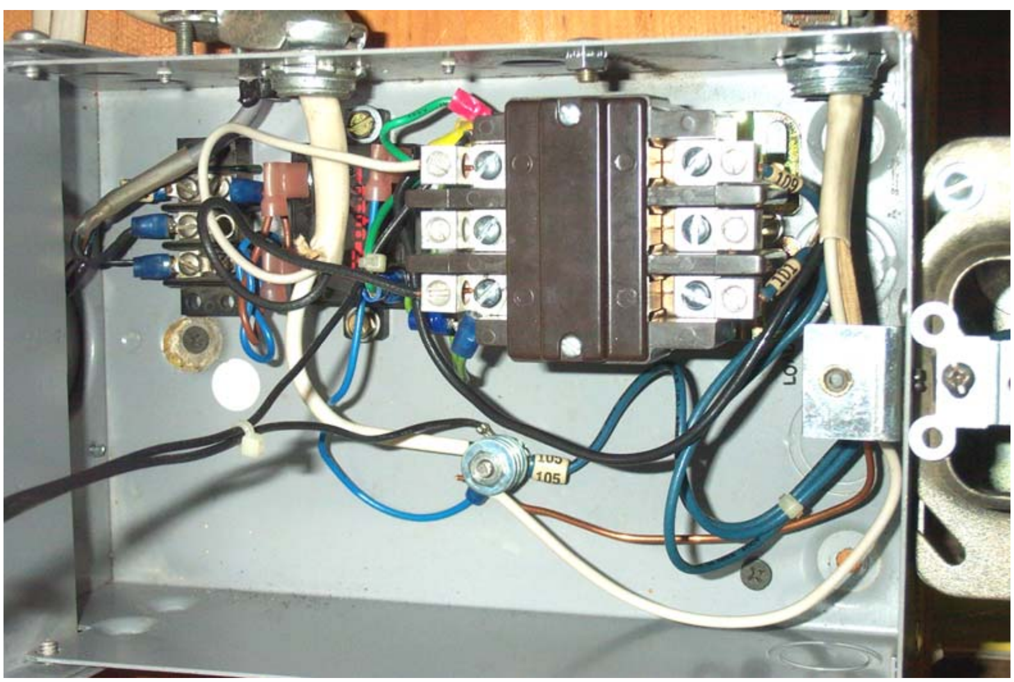
Description	**Allied Part #**
Toroidal power transformer, 117V to 12VCT (Hammond 182L6)	836-0814
Bridge rectifier, ≥500mA, ≥25V (Semikron S380)	550-6006
Capacitor, 470uF, ≥10V (Illinois Capacitor 477CKS010M)	613-0089
Resistor, 49.9Ω, ≥1/8 watt (Dale RN55D49R9F)	895-0962
NPN Transistor, 2N3904 (TO-92) or NPN Darlington, TIP122G (see text)	568-0292 568-0402
Solid-state Relay, 400V, 120mA (Panasonic AQV214EH)	788-1253
Transorb, 400V (Littlefuse 1.5KE400CA)	846-0729
Contactor, 30amp, 2 pole (Stancor 122-903)	576-3006
Toggle switch, Single Pole, 5A, 250V, Carling DA100-PB-B or use common light switch	683-0085
Metal box for everything above, 10"x5"x3" (Bud AC-404)	736-0004
Miscellaneous:	
4" PVC drain pipe and fittings, from a local lumberyard or hardware store	



Schematic Diagram of Automatic Vacuum Switch



I mounted the power transformer in a 4x4 electrical box and wired the transformer primary to the solid-state relay with a low-voltage cable. Here's a photo of my toroidal transformer, cushioned with silicone RTV, held in place by a bolt through the center. The ¼" phone plug on the left side goes to the box holding the relays.



I put the contactor, solid-state relay, and other electronic components in another box, near the vacuum.

To make a vacuum hose port, start with a PVC pipe cap. Glue a ¼” thick disk of PVC sheet inside the cap to make it thicker if necessary. Bore a hole in the cap to friction-fit the vacuum hose. Then fashion a sheet-metal swinging door and loosely screw it to the cap. I tapped the PVC 8-32 and used an 8-32 screw as the pivot. I also made a small handle for the door from a knurled nut and a flat-head screw.

When the port is not in use, the door hangs down, covering the port. Suction pulls the door tightly against the PVC cap, sealing it in place.