TEACHING THE USE OF SOLID STATE CONTROLS WITH A DEMONSTRATION PANEL

By

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There are many uses for electronic controls in all kinds of control circuits involving motors, heaters or lights. The silent operation, the ability to provide variable voltage, the capacity to carry overloads when starting motors, the long life and efficient operation make solid state controls desirable for many uses. There are special operating features that all students can best learn by using a panel board. The board can also be used by the instructor for preliminary demonstrations and teaching.

In the rural electrification division of agricultural engineering we have many panel boards for teaching different phases of electricity. The following boards are used for both agricultural engineering and agricultural mechanization classes and laboratories.

1. General demonstration board
2. Motor-starter panel
3. Two station motor starter wiring panel
4. Motor control with SCR's
5. Motor control with Triac
6. Solid state motor starter
7. Electronic power supply panel
8. Overload protection
9. Variable voltage supply panel
10. Heating control panel
11. Fluorescent light display panel
12. Series parallel circuits
13. A study of Triac's and SCR's

Students like the approach of seeing these panels as a demonstration in class and then having the opportunity to use them in the laboratory. Some units are made to close like a suitcase and others are just open panels. A panel is developed when there is a need. Some of the panels, such as the motor-starter panel, were developed by students as a project for the Little International Agricultural Engineering Show.

To illustrate, the following is the exercise developed for the panel used to explain the operation of Triac's and SCR's. The exercise that follows is exactly as presented to students.

A STUDY OF TRIAC'S AND SCR'S

Exercise No. 27

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Apparatus:

1. SCR - Triac board
2. Jumper leads
3. Oscilloscope
4. Resistance decade box
5. Instruction sheet and references

Part I. How a SCR is used for switching.

A. Connect oscilloscope to load-have instructor help if needed.

B. Connect up leads 1, 2, and 3 as shown in diagram 1. Turn on power source for D.C. and then A.C. and note that lights do not light up on either source of power. This indicates that the SCR does not permit current to flow in either direction.

C. Connect up leads 4,5,6, and 7. Turn on D.C. power source. Then turn on switch for control circuit. Note the shape of the D.C. current on the oscilloscope. Now turn off the switch in the control circuit and note that the SCR remains on. This is typical of a SCR and one limitation. Now turn off the main switch and then turn it on again and note that the SCR remains off. This means that when using a SCR some other means must be provided for turning the circuit off.

D. Turn power source to A.C., then turn the control circuit on and now note that as you turn the control switch on and off the SCR also turns on and off. This is due to the fact that the A.C. current reduces to zero each half cycle which turns the SCR off. You may also note that you are only getting a half wave on the oscilloscope which means that by using an additional SCR connected into the circuit backwards, full power could be obtained.

E. Questions:
   1. Name some uses of the SCR.
   2. Draw a circuit using two SCR's to control an A.C. circuit.

Part II. How triacs are used for switching?

A. Connect up leads 1, 2, and 3 as shown in diagram 2. Turn on the power source to both A.C. and D.C. and note the triac does not allow current to flow in either direction. Now connect up leads 4,5, 6 and 7. Note that by turning the control switch on and off you are turning the load on and off and are getting a full wave on the oscilloscope. Now connect up lead 8 which permits only D.C. power to the gate of the triac and note that by switching the control switch up and down you get full wave or half wave which actually gives you two levels of power as indicated by the lights.

B. Remove lead 8 and install the resistance decade box in series in the control circuit as shown on diagram 3. Starting with the decade box on zero, gradually increase the resistance on up to the point where the triac turns off. Leads 4 and 5 may need to be reversed at power supply.

1. At what resistance does the triac turn off?

2. For what purpose can you use this arrangement?

C. Disconnect all of the leads on the panel except for the main leads 1, 2, and 3. Now connect up leads 4, 5, and 6 as on diagram 4. Now turn circuit on and off using the control switch. This method of switching avoids the use of a low voltage power supply, and by adding a variable resistor is the common circuit that is used in a dimming switch. You will note, however, that the leads are all potentially hot leads and if the switches were to be remotely located that the use of well insulated wires and switches would be necessary.

D. Now disconnect all of the control leads and make your connections as shown on diagram 5. Note that on the control circuit the final wires to the switch are isolated and of extremely low voltage and could be installed using ordinary doorbell wire and low voltage switches.

Advantages of triacs and SCR's.

1. Switching without contacts-no burning or arcing.
2. No noise due to vibrating coil.
3. Long life.
4. Variable voltage obtainable without heat loss.

Disadvantages of triacs and SCR's

1. Radio noise and interference.

E. Questions:

1. From a catalog or handbook determine the current through the gate. What size wire would you use on a remote switch located 100 feet from the triac as shown in diagram #5. Limit the voltage drop to 2%.

2. Using the circuit shown in diagram #4, determine the amperes in the control circuit by using a VOM across the 100 ohm resistor. Also determine the voltage across the gate with the VOM.

3. Using an electronics catalog or handbook find the SCR's and Triac's used in the panel. How would you identify a switching device?

DIAGRAM #1

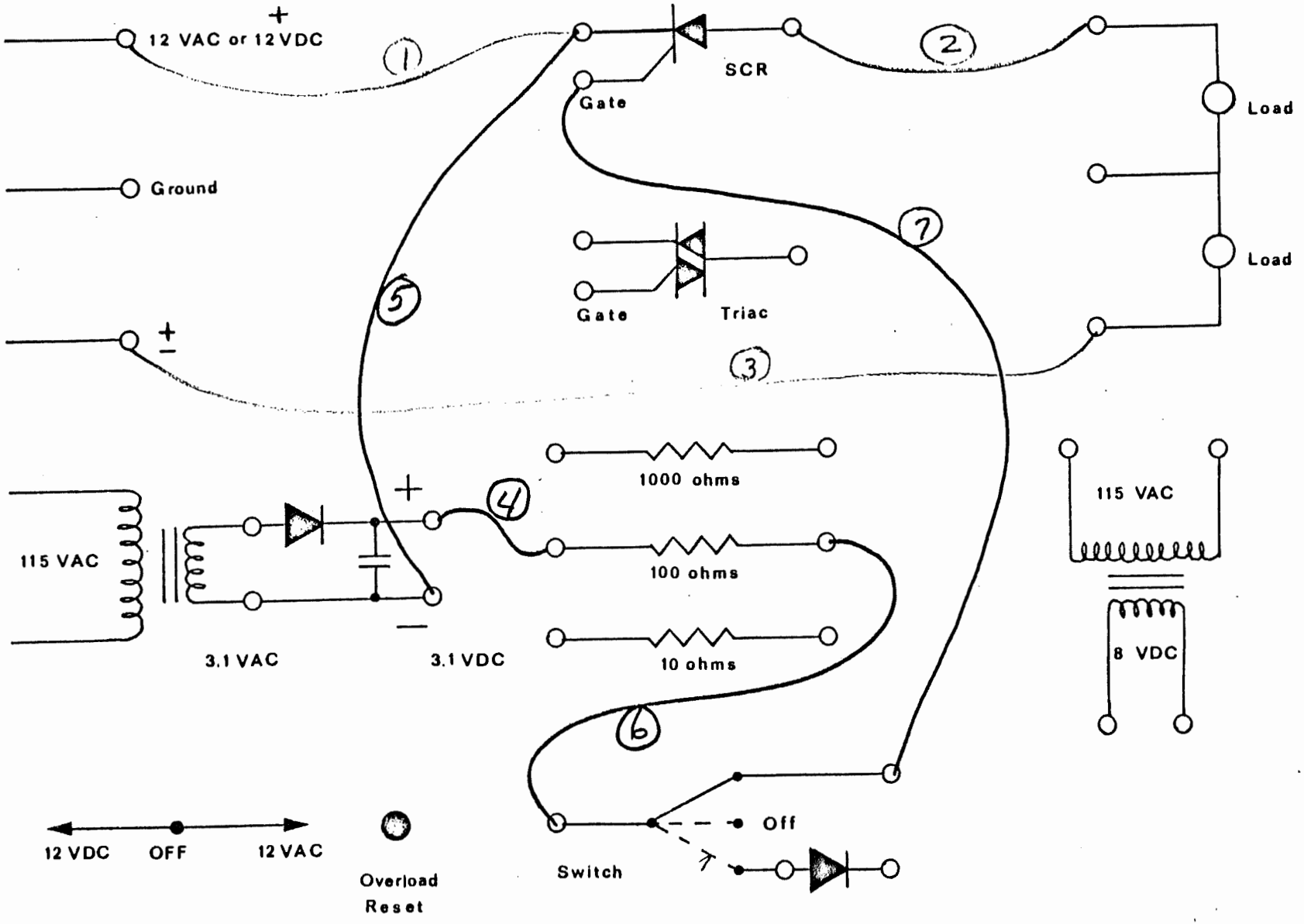
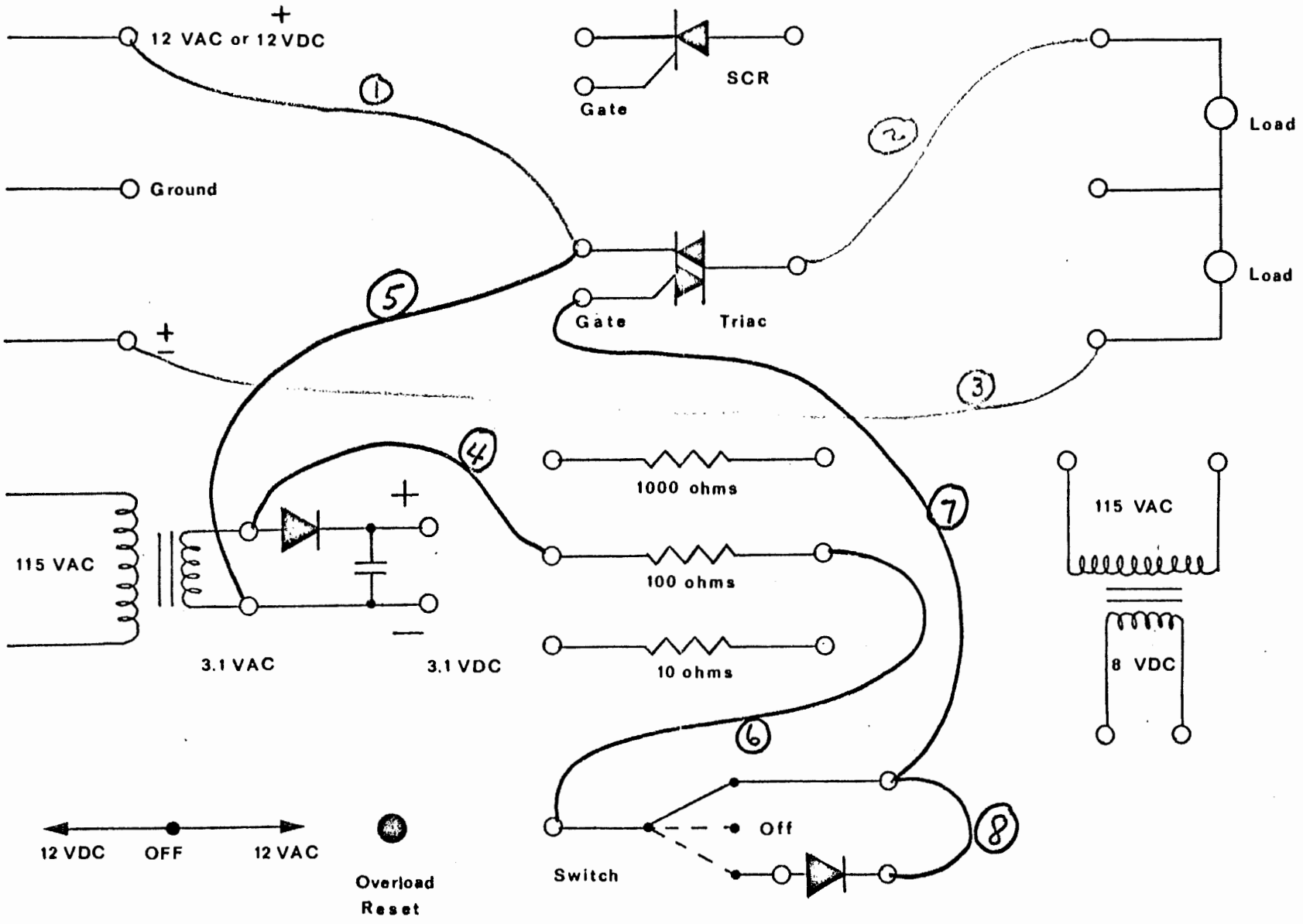

+
12 VAC or 12 VDC
1
SCR
2
Gate
Load
Ground
7
Load
5
Gate
Triac
+
-
3
115 VAC
+
4
1000 ohms
115 VAC
100 ohms
3.1 VAC
3.1 VDC
-
10 ohms
8 VDC
6
Off
12 VDC
OFF
12 VAC
Overload
Reset
Switch

DIAGRAM #2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Ground
+
−
SCR
Gate
Load
Load
Gate
Triac
115 VAC
3.1 VAC
3.1 VDC
1000 ohms
100 ohms
10 ohms
115 VAC
8 VDC
12 VDC
OFF
12 VAC
Overload
Reset
Switch
Off
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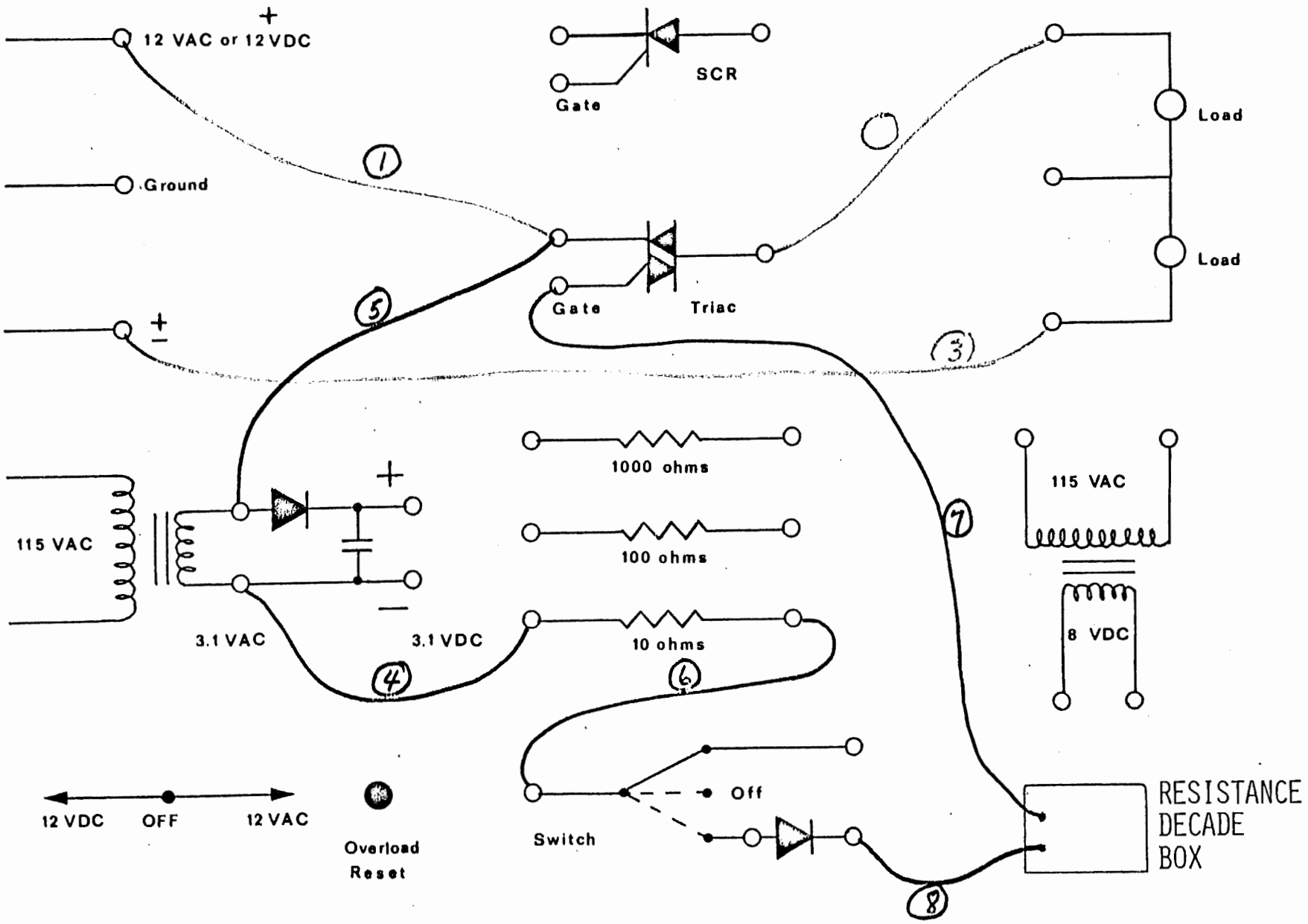
DIAGRAM #3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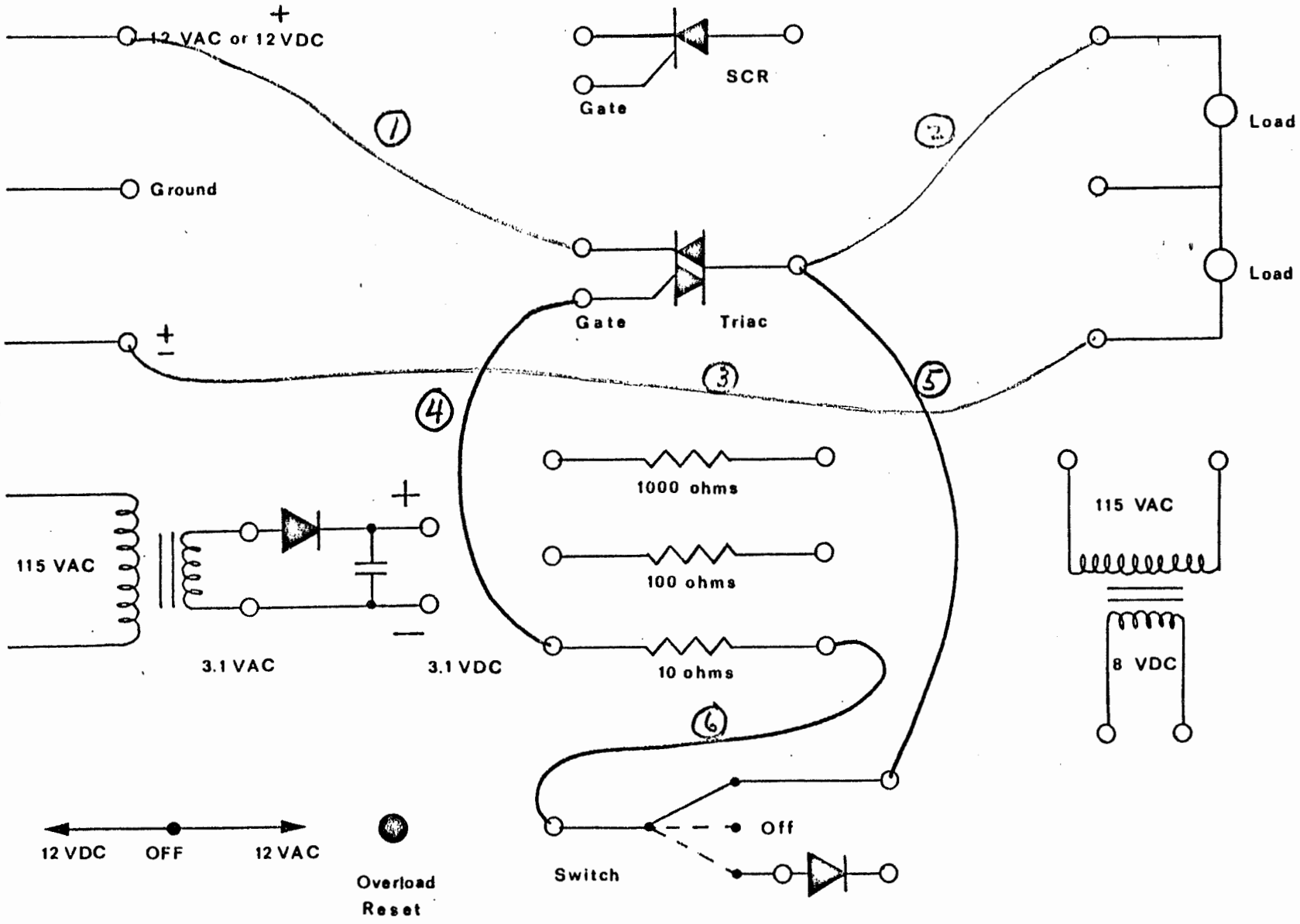
115 VAC
3.1 VAC
3.1 VDC
+
—
1000 ohms
100 ohms
10 ohms
115 VAC
8 VDC
12 VDC
OFF
12 VAC
Overload
Reset
Switch
Off
RESISTANCE
DECADE
BOX

DIAGRAM #4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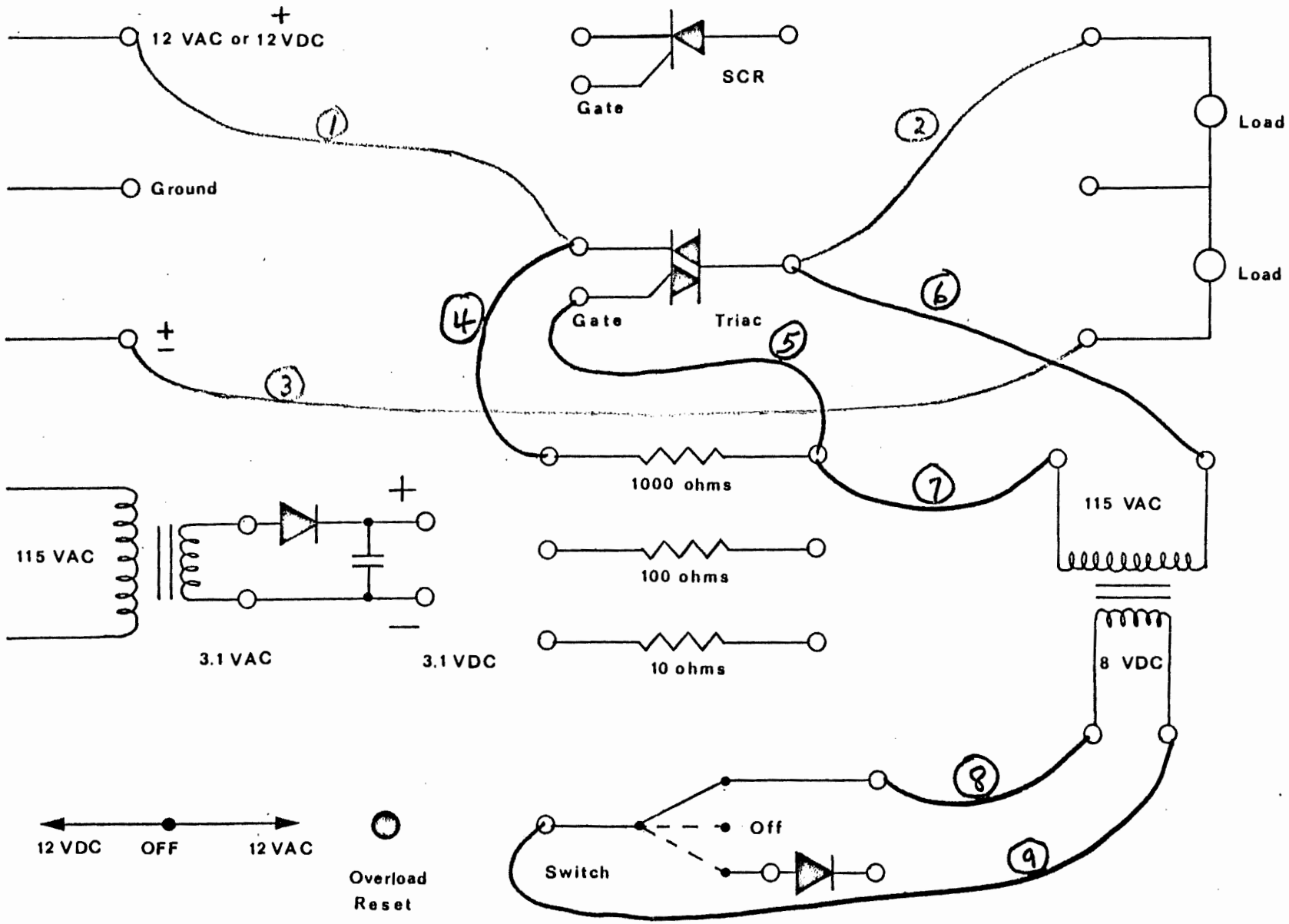
3.1 VDC
115 VAC
8 VDC
12 VDC
OFF
12 VAC
Overload
Reset
Switch
Off

DIAGRAM #5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