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THE HALL-EFFECT ELECTRONIC COMPASS

It's easy to stay on the right course with this easy-to-assemble electromagnetic direction locator.

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Let's face it. If you do much traveling outside of your home state or even your neighborhood, for that matter, eventually you are going to get lost. Ask someone for directions, and it's "Go north about a quarter mile, then head east another half mile 'til you come to a creek"—you get the picture. Somehow, people seem to think that travelers either carry or have a built-in compass guiding them through life. Well, it *jist ain't so*! Of course, if you are in your car, provided that it is equipped with a GPS (Global Positioning System) receiver, you don't have to worry about losing your way. But for casual hiking, biking, camping, or even excursions into the next county, there is a simpler and cheaper alternative—the *Hall-Effect Electronic Compass*.

The electronic compass, described in this article uses a Hall-effect sensor that can detect the earth's magnetic field and convert that information into a directional indication. Powered from a single 9-volt battery, the compass is easy-to-build and makes a great learning project that will provide many hours of fun!

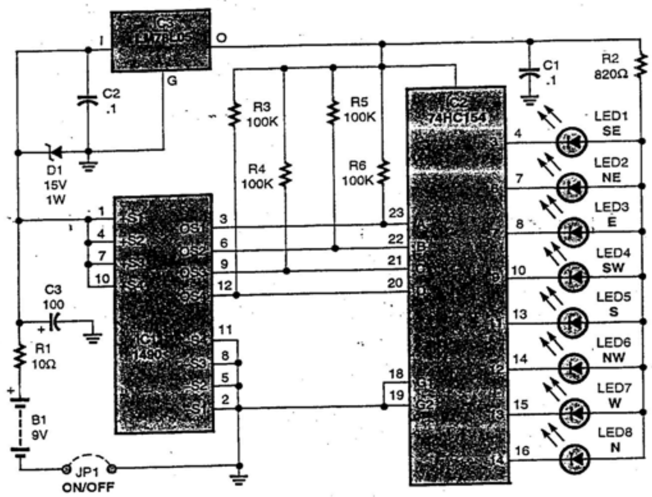

Fig. 1. At the heart of the Hall-Effect Electronic Compass is a 1490 digital compass—a unique magnetic sensor, containing a miniature rotor on jewel bearings surrounded by four solid-state, Hall-effect ICs. The sensor is supported by a 74HC154 high-speed CMOS 4-to-16 line decoder that's used to drive eight LEDs.

Circuit Description. A schematic diagram of the Hall-Effect Electronic Compass is shown in Fig. 1. At the heart of the circuit is IC1, a 1490 digital compass—a unique magnetic sensor (available from Dinsmore Instrument Co., 1814 Remell St., Flint, MI 48503) that is based on the Hall-effect. The Hall-effect, named for its discoverer (physicist Edwin Herbert Hall), is based on the principle that a voltage will develop at the edges of certain current-carrying materials when they are placed in a magnetic field.

The author's unit was simply mounted on spacers to a small section of Plexiglas. Note: When using the unit, it is important to keep the sensor horizontal.

The 1490 digital compass (IC1) contains a miniature rotor on jewel bearings surrounded by four solid-state, Hall-effect IC's. The 1490 has four outputs that correspond to each of the four main compass directions (North, South, East, and West). However, because the range of adjacent outputs overlap each other by 45 degrees, a total of eight different compass directions can be resolved with proper decoding.

The 1490 sensor is internally damped to give a smooth response to directional changes without over-swing. It has built-in hysteresis to prevent unstable output signals. The 1490 is designed to operate in a vertically-mounted position only. If held off vertical, some directional error will occur. The 1490 operates from a wide range of supply voltages, ranging from 5 to 20 volts DC. The sensor can be damaged, however, from over-voltage spikes or reverse power polarity. Its power consumption is approximately 30 milliamps (mA), and the four outputs, which are comprised of open-collector (NPN) transistors, can sink up to 25 mA each.

As shown in Fig. 1, the four outputs of IC1 are fed to the BCD inputs of IC2, a 74HC154 high-speed CMOS 4-to-16 line decoder that's used to decode the output of the sensor. The four pull-up resistors (R3-R6) are needed, since the sensor has open-collector outputs. The 74HC154 can directly drive the LEDs, as long as the current is no more than 6 mA. Resistor R2, an 820-ohm unit, is used to limit current to the LEDs.

The author's circuit is powered from a single 9-volt transistor radio

PARTS LIST FOR THE HALL-EFFECT ELECTRONIC COMPASS

SEMICONDUCTORS

U1—1490 digital compass, integrated circuit (see text)
U2—74HC154 CMOS, 4-to-16-line decoder, integrated circuit
U3—78L05 5-volt, 100-mA, voltage regulator, integrated circuit
D1—15-volt Zener diode
LED1–LED8—Light-emitting diode

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—10-ohm
R2—820-ohm
R3–R6—100,000-ohm

CAPACITORS

C1, C2—0.1-µF, 50-WVDC, monolithic
C3—100-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor radio battery connector
JP1—2-pin jumper post and shorting block
Printed-circuit materials, battery connector, 28-pin IC socket, insulated hook-up wire, hardware, solder, etc.

Note: The following items are available from: LNS Technologies, 20993 Foothill Blvd., Suite 307R, Hayward, CA 94541-1511, Tel: 800-886-7150; a complete kit of parts for the Electronic Compass including etched and drilled printed-circuit board, 1490 sensor, battery holder, ICs, and all other components listed above for $32.00; the 1490 digital compass sensor (IC1) for $15.00; the PC board only for $10.00. Please add $5.00 shipping/handling for all orders. California residents add local sales tax. MC/VISA orders accepted. No C.O.D.s.

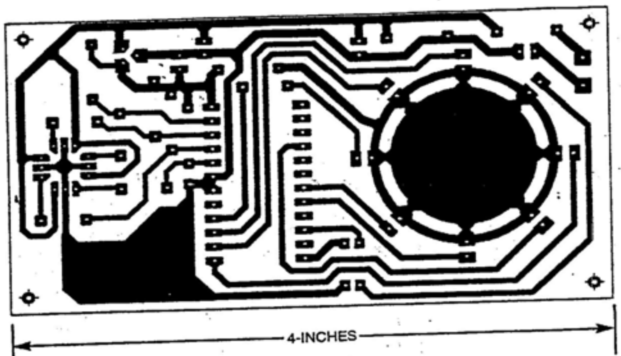

Fig. 2. The Hall-Effect Electronic Compass was built on a small printed-circuit board, measuring 4 by 2-1/8 inches. A full-sized template of that printed circuit pattern is shown here for those who don't mind etching their own board. For those who'd prefer not to fabricate their own board, a pre-etched and drilled board can be purchased from the supplier given in the Parts List.

battery, but, if you prefer, the unit can also be powered from the 12-volt supply of your car or boat. Components R1, C3, and Zener diode D1 provide voltage spike protection. Integrated circuit IC3, a 78L05 5-volt, 100-mA voltage regulator, is used to regulate the 9-volt output of the battery to 5-volts for IC2. Since the circuit draws over 30 mA of current, JP1 is used to switch the battery source on and off, otherwise battery power will be lost. Of course, JP1 can be replaced by a switch if desired.

Assembly Instructions. The Hall-Effect Electronic Compass was built on a small printed-circuit board, measuring 4 by 2-1/8 inches. A full-sized template of that printed circuit pattern is shown in Fig. 2. The pattern can be lifted from the page and used to etch your own board. If, on the other hand, you'd prefer not to fabricate your own board, a pre-etched and drilled board can be purchased from the supplier given in the Parts List.

Once you obtain all of the components shown in the Parts List, assemble the circuit using the parts-placement diagram shown in Fig. 3. Note that the printed-circuit board contains seven short jumper wires. Install them first using bits of solid insulated or bare bus wire. After that, install the Zener diode, while paying close attention to its proper orientation. Next move on to the resistors and ceramic capacitors, followed by the electrolytic unit. Be sure to observe proper polarities when installing the electrolytic capacitor. Install the voltage regulator (IC3), again observing the proper polarity. It may be necessary to bend the leads of IC3 to fit the printed-circuit board. With that done, install a 24-pin IC socket in the board position reserved for IC2.

Before continuing, clean the foil side of the PC board with alcohol or flux remover. Then install a 9-volt battery connector where indicated. Be sure to attach the connector to the board, with the polarity shown. Install the 74HC154 CMOS 4- to 16-line decoder (IC2). Since both IC1 and IC2 are CMOS devices, they can be easily damaged by static discharge. Take proper anti-static precautions when handling those chips. Refer again to Fig. 3 before installing IC2 to make sure of the proper orientation of pin 1, then press the IC firmly into the 24-pin socket, making sure that it is properly seated.

Install the 1490 sensor (IC1). It may be necessary to bend the leads of the Hall-effect compass slightly so that they fit into the holes on the PC board. Note: There is no absolute orientation of U1. It may be installed in any one of four rotated positions and will still work properly. Fig. 4 shows the label (approximately 1 inch in diameter) that was placed on the author's unit to show the direction indicated by the lit LED, along with a table showing the direction corresponding to each of the eight LEDs. You can photocopy that pattern and scale it to fit your unit, or you can devise a design of your own. If you choose, you can even omit it all together.

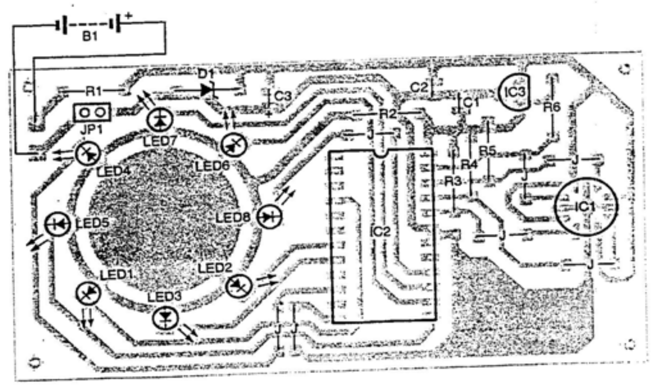

Fig. 3. Once you've obtained all the components needed for the project, assemble the circuit, guided by this parts-placement diagram. Be sure that IC2, IC3, the Zener diode, the LEDs and other polarized parts—including the battery connector—are properly oriented or polarized.

Operation. Before applying power, verify that the power-source input

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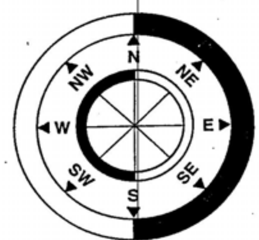
polarity is correct; reverse polarity will do serious damage to IC1. Once you check the polarity, attach a 9-volt battery to the battery connector and switch on the power. One of the eight LEDs should come on, indicating the compass heading. Remember that the compass must be held or mounted horizontal to the earth's surface for the correct compass readings.



LED1	SE
LED2	NE
LED3	E
LED4	SW
LED5	S
LED6	NW
LED7	W
LED8	N

Fig. 4. A paper label (approximately 1 inch in diameter) was placed on the author's Hall-Effect Electronic Compass to show the direction indicated by the lit LED. That label, which is shown heres-lightly enlarged, can be photocopied and scaled to fit your unit. Alternatively , you can devise a design of your own, or you can even omit it all together. The accompanying table shows the direction corresponding to each of the eight LEDs.

Like any magnetic compass, this one is affected by nearby external magnetic fields, which can present a problem when you are trying to use it inside of a car or boat. It will be necessary to experiment to find the best operating location in such cases.

Since the outputs of that circuit are digital, the compass could also be easily interfaced to mobile robots. It would be valuable, in that case, to have an absolute directional reference when the robots negotiate a room or even a rat-maze course. ■