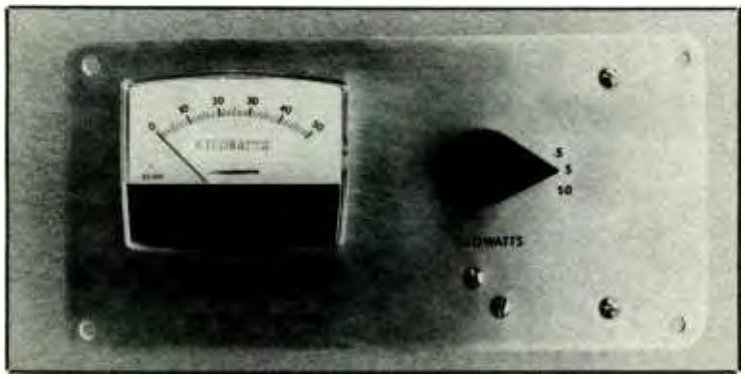
The "Watt Watcher"



Inductive-pickup meter monitors instant ac power usage so that you can more efficiently manage energy consumption

By Dennis P. Blum, CET

The kilowatt-hour meter your local utility company installed on or in your home measures electric power consumption. However, being an accumulating device, it is not overly useful for the homeowner who wants to monitor power used for conservation purposes. The "Watt Watcher" described here, on the other hand, displays actual power usage in kilowatts from moment to moment without ambiguity. Any change in load, such as a refrigerator switching on or a lamp being switched off, immediately registers on a built-in meter movement.

The metering system consists of two inductive-pickup devices you mount inside your electrical service box (no potentially hazardous connections are required) and a remote indicating panel meter and driving circuitry. The circuit is self-powered, eliminating any need for a battery or connection to the ac line.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Watt Watcher circuitry. Inductive pickup coils *L1* and *L2* are remotely located from the circuitry, in the electrical service box. They provide a voltage to transformer *T1* that is directly proportional to the amount of current flowing in each leg of the ac power line supplying your home.

Any voltage that appears at the input to *T1* from *L1* and *L2* is stepped up by transformer action and applied to the full-wave bridge rectifier circuit made up of diodes *D1* through *D4*. After rectification, the pulsating dc from the rectifier circuit is filtered to pure dc by capacitor *C1* and passed

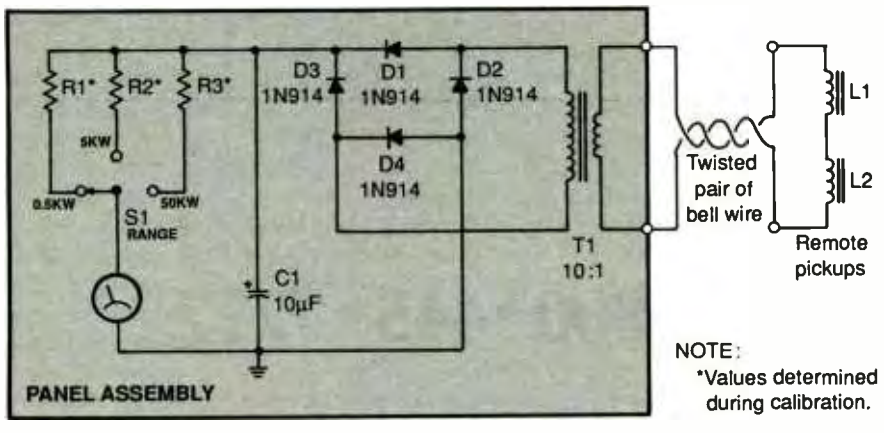


Fig. 1. Complete schematic diagram of circuitry used in the Watt Watcher.

PARTS LIST

C1—10-µF, 10-volt electrolytic capacitor
D1 thru D4—1N914 or similar diode
L1,L2—Inductive pickup coil (see text)
M1—50-µA full-scale analog panel meter movement (Radio Shack Cat. No. 270-1751 or similar)
R1,R2,R3—See text for value
S1—3-position, non-shorting rotary switch
T1—12.6-volt power transformer (Radio Shack Cat. No. 273-1365 or similar)
Misc.—Suitable enclosure; transformer for pickups (see text); two multiple-lug terminal strips; control knob for S1; twisted-pair bell wire; tape; cable ties; foam rubber; machine hardware; hookup wire; solder; etc.

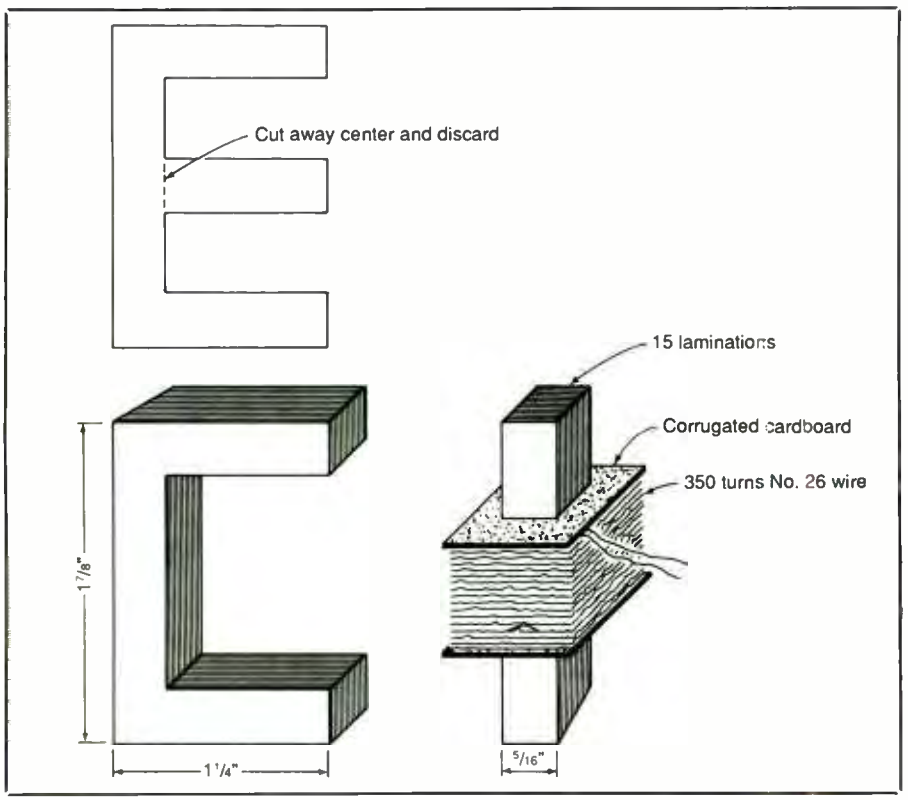


Fig. 2. Inductive pickups are built around laminations salvaged from a small power transformer.

through one of the three resistors, via switch *S1*, to meter *M1*.

Resistors *R1*, *R2* and *R3* are in the circuit to provide calibration for the meter to register accurate readings. The values of these resistors are determined during calibration of the project. Switch *S1* provides range-selection capability.

Construction

Begin construction by fabricating the two inductive pickup assemblies. For these, you need laminations salvaged from a small power transformer. A defunct small home stereo unit or other light-duty electronic device may have just what you need. Otherwise, purchase a new power transformer and use it.

The laminated core of the transformer you use must have "E" and "I" shaped laminations, as illustrated in Fig. 2. The transformer used for the prototype had laminations that measured approximately 2 inches square and contained 30 each "E" and "I" laminations, half of which were used for each pickup assembly.

As shown in Fig. 2, you must remove the center bar of each "E" lamination with sheetmetal shears or a hacksaw. If you use a hacksaw, clamp five or so laminations between two pieces of lumber and secure in a bench vise while cutting. In either case, once you have removed all center bars, make sure each lamination is as flat as possible. Then stack the now "C" laminations in two separate and equal piles and tape them together. Do the same with the "I" laminations.

Around each "I" lamination stack, wind 350 turns of No. 26 magnet wire. There is no particular need to be neat about the windings, but the neater they are, the more compact the assemblies. If you wish, you can cut pieces of corrugated cardboard and place them at opposite ends of the "I" laminations to serve as bobbin ends, as shown.

When you finish winding both coils, secure the winding in place with electrical tape. Then carefully scrape away all enamel from both ends of both coils for a distance of ½ to 1 inch and tin with solder.

Dimensions shown in Fig. 2 are for reference purposes only. Your assembly may have different dimensions, depending on the particular power transformer used. Any difference in output voltage can be compensated for during calibration by selecting appropriate values for the three resistors.

Temporarily set aside the pickup-coil assemblies and proceed to building the main circuit. This circuit is quite simple in terms of number of components. You can assemble it using point-to-point wiring and two multiple-lug terminal strips, as illustrated in Fig. 3.

Machine the meter panel as needed. Drill mounting holes for the transformer, switch and terminal strips. Then cut an appropriate-size hole in which to mount the meter movement. When you are finished machining the panel, deburr all holes to remove sharp edges. Then mount the transformer, switch, meter movement and terminal strips in their respective locations.

Plan your component connections to the lugs of the terminal strip carefully. Trim leads to length and crimp them to the appropriate lugs of the terminal strips. Make sure when you are done that the diodes and capacitor are properly polarized. Defer installation of the resistors until after calibration.

Referring back to Fig. 1, interconnect the components with hookup wire. If you are using stranded hookup wire, strip ¼ inch of insulation

from both ends, twist together the exposed fine wires and sparingly tin with solder. Then crimp and solder the ends of the wires to the various locations in the circuit.

Determine where you will locate the Watt Watcher in your home and mount its enclosure where it will be in easy view. Then determine how you will route the bell wires that will connect the main circuit to the remote inductive pickups. The simplest and most direct route is to drop straight down through a hole drilled through the floor and then to take the most direct route to the location in your basement (or elsewhere) where your main fuse box is located.

Having selected the wiring route to take, determine how long must be the bell wires. Add 6 feet to the measured length and cut the wires to the length needed. Run the wires along the route, using thumbtacks to secure them into place wherever possible.

At the remote end, temporarily connect the wires to the leads of the inductive pickup assemblies, wiring the latter in series with each other, by twisting together the wires. Do *not* solder any connections.

Installation of the pickups is simply a matter of placing the two sections of each assembly around the high-side conductors in your electrical service fuse box, as illustrated in Fig. 4. Do *not* use the ground wire when doing this.

Before you proceed with this portion of installation, keep firmly in mind that any work done inside the fuse box can be potentially lethal, even though you will be making no direct electrical connections to the ac line. Work carefully and touch only the insulated mains conductors.

When installing the pickups, strive for a zero gap in the magnetic circuits, or as near to it as you can get. This will assure maximum sensitivity. Use a cable tie at both ends of the assembly to secure it in place and foam rubber between the assemblies and conductor to assure a tight fit.

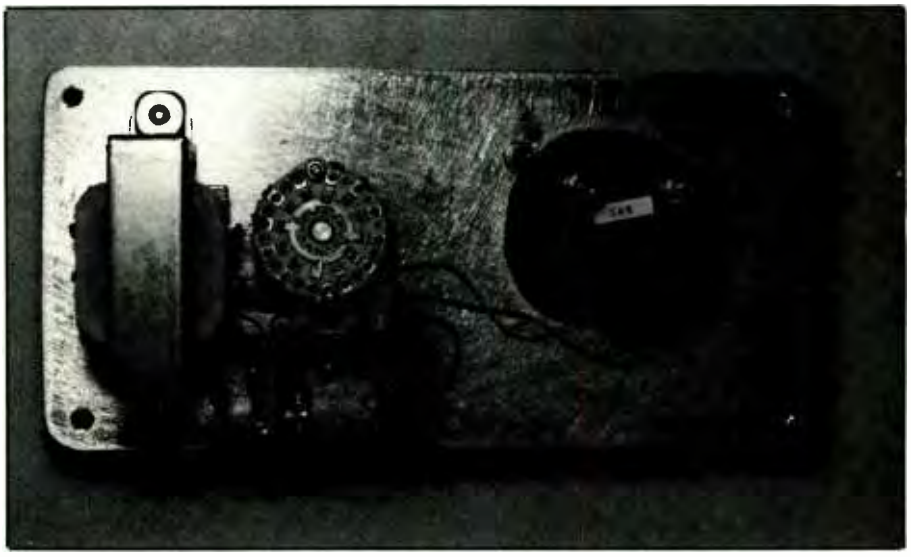


Fig. 3. All components, except pickups, mount directly on panel of project's enclosure, smaller ones with aid of two terminal strips.

At the other end of the bell wire, temporarily connect the two conductors to the unused leads of the transformer.

Calibration & Use

Before you can calibrate the circuit, you must check the phasing of the pickup coils to make sure that their effects are additive. Connect a resistance substitution box or 50,000-ohm potentiometer across the connection points for *R1* in the main circuit and set *S1* to the 0.5 KW position. Turn on a number of loads in your home, including at least one 220-volt appliance to assure that both high sides of the ac line are carrying current. Adjust the resistance box or potentiometer for a mid-scale reading on the meter.

Note the reading obtained. Then test the phasing of the pickups by reversing the leads of only one of the pickups. This may be easier to do if you have a helper to tell you what happens at the meter panel as you reverse connections. Connect the pickups for highest meter reading. Solder the connections and insulate them with either small-diameter heat-shrinkable tubing or electrical tape.

Now use a number of loads whose power consumption is known (such as lamps with a certain wattage rating

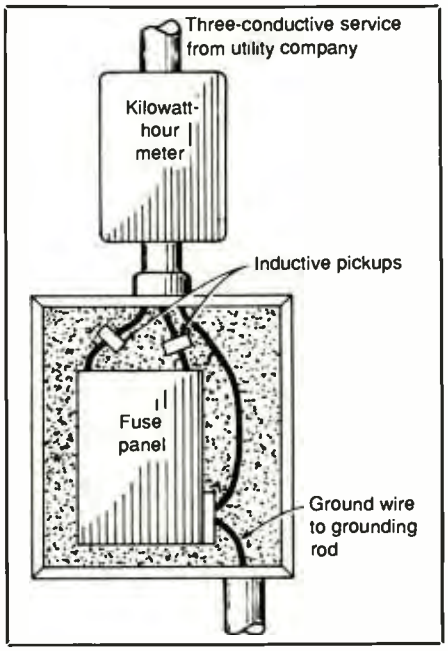


Fig. 4. Pickups must be positioned on insulated wires coming from utility company kilowatt-hour meter, before fuse panel.

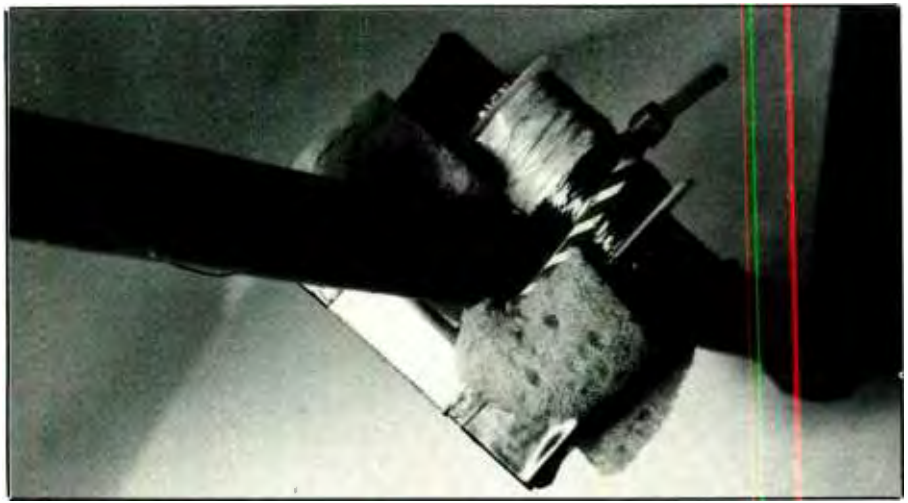


Fig. 5. Secure pickup assemblies to ac-line conductors with cable ties. Use pieces of foam rubber to assure a friction fit.

or an appliance that has a panel on it with the power consumption listed) to calibrate the meter. For the 0.5 KW range, a few table lamps or overhead lights will suffice to develop a 250-watt load for a center-of scale reading on the meter.

With the loads turned on, adjust the resistance substitution box or potentiometer for a reading equal to the load. Note on a piece of paper the value of resistance needed for *R1* to obtain this meter deflection.

Similarly establish loads for 2.5 and 25 kilowatts (you probably will not need the latter unless you have really heavy-duty appliances) to obtain the resistance values needed for *R2* and *R3*, respectively. If you use a potentiometer instead of a resistance box for these two ranges, make it a 1-megohm unit. Once you know the values of resistance needed in all three cases, you can install the nearest 1- or 5-percent tolerance standard values to them. The tighter the tolerance, the more accurate the readings.

Once installation is done, you should educate all the members of your household on electric usage and its cost. At 10 cents per kilowatt hour, for example, the center points of the three ranges represent a per-hour cost of 2.5 cents, 25 cents and $2.50. ME