A UNIVERSAL APPLIANCE DIRECT LOAD CONTROLLER

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INTRODUCTION

Appliances are the major elements that are connected to the electrical grid but not controlled by it. In general, the utility does not know the on/off condition of residential equipment. Because new capacity is very expensive, and because utilities are under pressure to cost-effectively meet customer needs, there is interest in utility *Direct Load Control* (DLC) of customer appliances.

The most primitive load controllers were clock timers on resistance water heaters. Modern real-time units respond to radio or line signals and typically interrupt current for 50% of the time on 7.5 or 15 minute cycles. These may have deleterious effects, from customer dissatisfaction to the installation of oversized units to defeat the goal of the controller (Kempton and McGarity, ms.). DLC is expensive. For one New Jersey utility, it is about $150 per installation. About half the cost is for licensed electricians to wire the connections between central air conditioners and DLC units.

A Universal Control Interface (UCI) would help. The UCI is an interface specification for connecting conforming devices (appliances and controllers). It describes a socket on the appliance and a mating plug for a controller. The UCI has three discrete components: A *physical layer*, for the mechanical design; a *logical layer*, for signals that cross the interface; and an *electrical layer*, specifying voltages, bit rates, or analogous parameters.

Any appliance which draws a lot of current and whose use can be interrupted is a candidate for the UCI: residential water heaters, air conditioners, furnaces, and water pumps. Appliance controllers include devices the utilities now use (radio, line signalled, etc.). In the future, Integrated Services Digital Network (ISDN) capabilities may allow control through the telephone system.

The Universal Control Interface offers benefits to all "stakeholders": utilities, appliance manufacturers, and customers. By requiring that appliances eligible for efficiency rebates be equipped with the UCI, utilities can stimulate the introduction of appliances which are controllable at lower cost: Since only low-voltage wiring is involved, homeowners or route service personnel can install the devices. Manufacturers will see new sales possibilities. Consumers can save money, or increase their control through local devices.

ON THE PROPOSED INTERFACE

The UCI plug and socket would look like (but not interchange with) a modular telephone plug. Two (24 VAC) leads would serve as external device controllers (logically in series with the appliance's thermostat or other control device). The other two leads would sense the (off/on) status of the appliance. This allows remote testing by stimulating the device controller. 24 VAC is standard for furnace and central air conditioners thermostats. Resistance hot water heaters use 220 VAC current and thermostats, but the transformers required to meet the UCI specification are inexpensive. Telephone wiring is 48 volt (dc), so 24 VAC poses minimum problems for codes or homeowner installation.

In analogy to the extended (8 wire) modular phone connection used by some telephone equipment, it would be desirable to specify an extended control interface for digital control of advanced appliances such as variable speed air conditioners. If the utility control system has "bandwidth" available, this could be easily implemented. With advanced features such as ISDN, this will give the ability to both control the device and accumulate billing information on actual usage patterns.

DISCUSSION

From the perspective of the manufacturer and his dealers, the UCI offers new markets. As a uniform interface promoted by the utilities it will stimulate broad sales. It can be sold into both the "rebate" market and the "technology" market, since third parties will undoubtedly introduce local computer controllers. The consumer gains from more efficient appliances and the opportunity to control utility costs through participation in a DLC program. The utility would offer a better appliance rebate or bounty program, tied to both the UCI and efficiency standards. The utility has several installation options: The appliance delivery service can install the utility controller, or it can be scheduled by utility service personnel. Because the UCI allows verifying control, DLC radios can be mailed for costumer installation. Utility personnel can detect fraud or failure by exercising the appliance while monitoring the meter, clamping the feed, or by equipping the DLC with a low-power transmitter that can broadcast its state.

Widespread DLC would provide a new capability for emergency response through selective short-term load shedding. DLC gives more control over more non-critical load. As such, it should be added to the utility's arsenal of response capabilities.

Because the replacement rate of appliances is much faster than the rate of new construction, the UCI program can also be a first step toward "smart homes":

Electrical safety of the UCI seems assured by using 24 VAC instead of line voltage; this even allows installation by non-licensed persons. *Operational safety* requires that the UCI introduce no new hazard. For example, shorting any pair of leads must not damage the appliance. Any allowable controller also will need to show that its failure will not damage the controlled appliance.

Another concern is fraud. If consumers are to be paid or have reduced rates in return for participating in DLC, it must be easy to show that the device is actually interrupting loads. Since off/on information flows across the UCI, it is feasible to design controllers that can verify installation. One approach is to use transponder controllers. When stimulated by a transponder carried by utility personnel, the controller would respond with its identification and its present state. In this way, the utility staff could turn a device off or on without entering the house. As an alternative, utilities could install controllers at the meter, with feedback via signal lamps.

Even if all of these technical issues can resolved, the UCI is not patented, so no one has a large incentive. The benefits are broadly distributed among utilities, appliance and controller manufacturers, and the public. This means that the work will have to be done by standards bodies representing all stakeholders.

If these considerations can be met, the development and use of the UCI offers the potential of greatly facilitating the introduction of effective load control and of a better generation of smarter appliances.

REFERENCE

Kempton, W., and A. E. McGarity (ms.) Variable speed air conditioner technology: New opportunities for cooperation among manufacturers, utilities, and users.

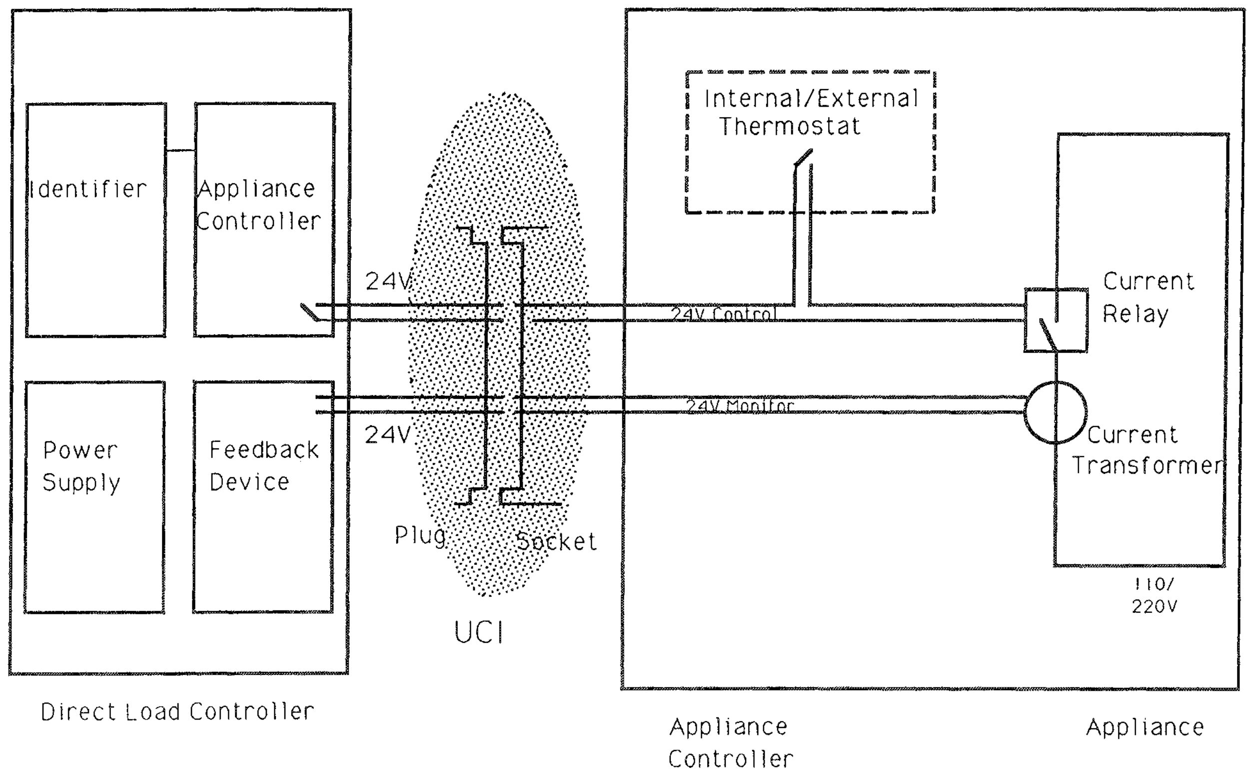

Figure 1. Schematic Design of the Universal Controller Interface. Left: Direct Load Controller (radio, line-connected, or local). Note identifier and feedback sections for appliance status. Center: The Standard Universal Interface, as a plug and socket. Right: The Controlled Appliance (e.g., air conditioner, water heater, etc.) See text for details.