Title
Final Report on Internet Addressable Light Switch

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HPCBS

High Performance Commercial Building Systems

Final Report on Internet Addressable Light Switch

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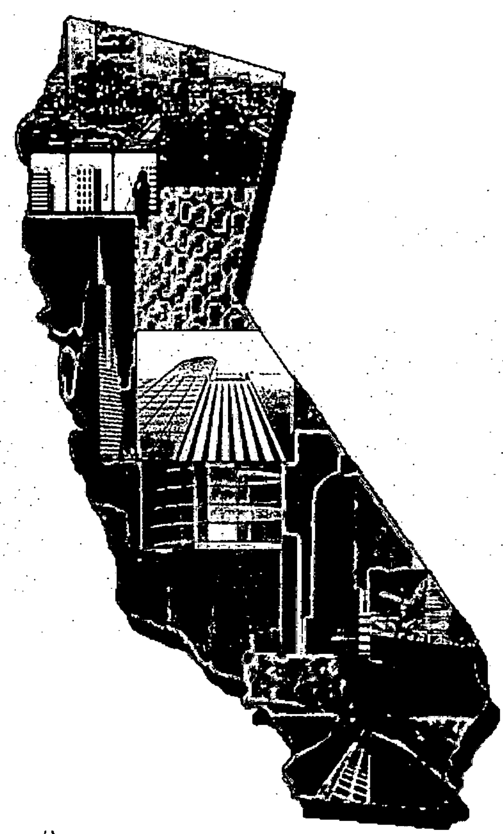
Peter Pettler
Vistron LLC

August 27, 2001



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California Energy Commission

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Final Report on Internet Addressable Light Switch

Element 3—Lighting, Envelopes, and Daylighting

Task 2.1.2—Title 24 Wall Switch, Draft Final Report

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Final Report on Internet Addressable Light Switch

Element 3—Lighting, Envelopes, and Daylighting

Task 2.1.2—Title 24 Wall Switch, Draft Final Report

Francis Rubinstein* and Peter Pettler**

Executive Summary

This report describes the work performed to develop and test a new switching system and communications network that is useful for economically switching lighting circuits in existing commercial buildings. The first section of the report provides the general background of the IBECS (Integrated Building Environmental Communications System) research and development work as well as the context for the development of the new switching system. The research and development effort that went into producing the first proof-of-concept (the IBECS Addressable Power Switch or APS) and the physical prototype of that concept is detailed in the second section. In the third section of the report, we detail the refined Powerline Carrier Based IBECS Title 24 Wall Switch system that evolved from the APS prototype. The refined system provided a path for installing IBECS switching technology in existing buildings that may not be already wired for light level switching control. The final section of the report describes the performance of the IBECS Title 24 Switch system as applied to a small demonstration in two offices at LBNL's Building 90. We learned that the new Powerline Carrier control systems (A-10 technology) that have evolved from the early X-10 systems have solved most of the noise problems that dogged the successful application of X-10 technologies in commercial buildings. We found that the new A-10 powerline carrier control technology can be reliable and effective for switching lighting circuits even in electrically noisy office environments like LBNL. Thus we successfully completed the task objectives by designing, building and demonstrating a new switching system that can provide multiple levels of light which can be triggered either from specially designed wall switches or from a digital communications network. By applying commercially available powerline carrier based technologies that communicate over the in-place lighting wiring system, this type of control can be economically installed even in existing buildings that were not wired for dual-level lighting. Final Report on Internet Addressable Light Switch

Introduction

This report describes the work performed to develop and test a new switching system that is useful for economically switching lighting circuits in existing commercial buildings. The first portion of the report provides the general background of the IBECS research and development work as well as the context for the development of the new switching system. The research and development effort that went into producing the first proof-of-concept (the IBECS Addressable Power Switch or APS) and the physical prototype of that concept is detailed in the second section. In the third section of the report, we detail the refined IBECS Title 24 Wall Switch system that evolved from the APS prototype described in Section 2. The fourth section describes the performance of the IBECS Title 24 Switch system as applied to a small demonstration in two offices at LBNL's Building 90. The appendix of the report provides the technical specifications for the key electronic components used in the Title 24 Switch.

Background

Lighting controls companies have developed controls products that can be specified as systems to achieve simple lighting control functions in buildings. Research conducted by LBNL in the late-1990s

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demonstrated that components from different manufacturers could be specified, assembled as systems and installed in buildings to achieve simple lighting control functions and obtain significant energy savings. However, poor hardware and software functionality as well as failure to involve the occupants in the commissioning process resulted in low occupant acceptance of more advanced lighting control strategies such as daylighting.

To address the above market shortcomings, the overall technical goal of the Lighting/Daylighting and Envelope Element (Element 3) of the HPCB Program is to develop an integrated building equipment communications (IBECS) network that will allow appropriate automation of lighting and envelope systems to increase energy efficiency, improve building performance, and enhance occupant experience in the space. This network will provide a low-cost means for occupants to control local lighting and window systems, thereby improving occupant comfort, satisfaction and performance. A related goal of this program element is to improve existing lighting control components and accelerate development of new daylighting technologies that will allow daylighting to be more extensively applied to a larger proportion of building floor space.

The objective of this project is to design, build, and test the IBECS interface and networking system between controllable lighting devices that will enable local and system-wide energy-efficient operations of various lighting systems and components. Additional work includes developing working prototypes of advanced multi-functional sensors and power-metering devices.

Development of Title 24 Switch Proof-of-Concept

The thrust of the first year's work on the High Performance Commercial Buildings Program with respect to IBECS Project was the design, development and testing of an advanced light switch that would provide the user with additional lighting control capabilities while providing the building operator with a means to reduce lighting loads throughout a complex from a central location. The objective of this task is to design and fabricate an IBECS-ready wall switch. This switch would fit in a standard wall box, provide bi-level switch control (be compliant with California's Revised Title 24 requirements) and would be controllable (addressable) via IBECS (Integrated Building Environmental Communications System).

Initially, the general specifications for the switch proof-of-concept were as follows (more detailed technical specifications follow). In the refined switch discussed in Section 3, we developed additional specifications that would improve the usability of the switch in retrofit applications.

Initial Switch Specifications:

1. Switch must be a direct replacement for an existing wall switch.
2. Switch must be capable of switching at least two lighting switch circuits in order that the occupant be able to obtain more than just one level of light.
3. Switch must be capable of being switched remotely over a digital network (IBECS)

We completed the initial proof-of-concept for the IBECS-ready wall switch in February 2001 ahead of schedule. The proof-of-concept was in the form of circuit diagrams (**Figures 2 and 3**) specifying exactly what electronic components were necessary to achieve the switch functionality as indicated by the above specifications. In addition, Pete Pettler, our main subcontractor on this task, constructed a physical prototype of the IBECS addressable power switch (**Figure 1**) embodying the proof-of-concept circuit.

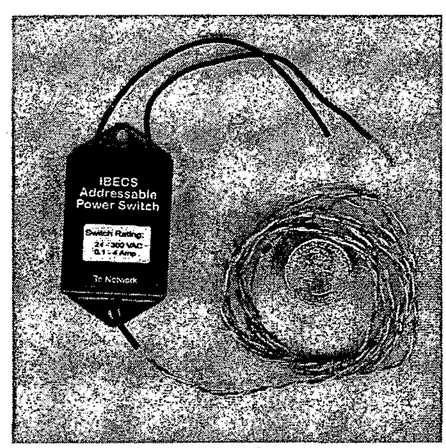


Figure 1. First prototype of the Title 24 wall switch built according to original specifications.

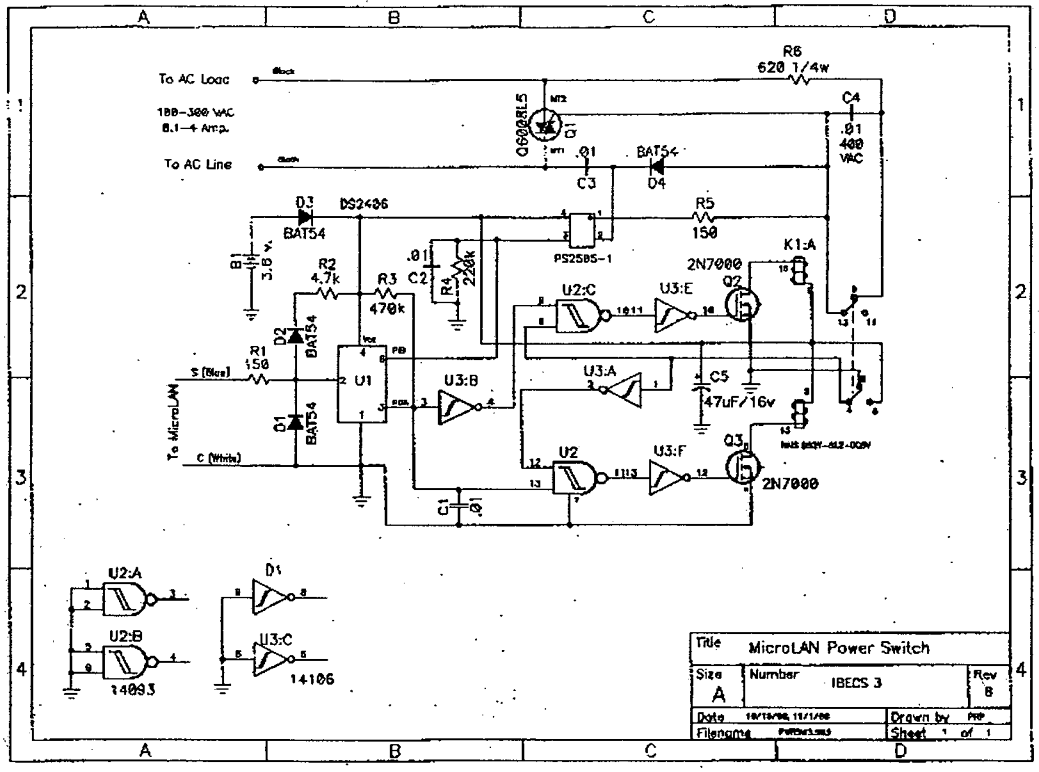


Figure 2. Original circuit diagram for the Title 24 switch proof-of-concept—microLAN Power Switch—showing the various components.

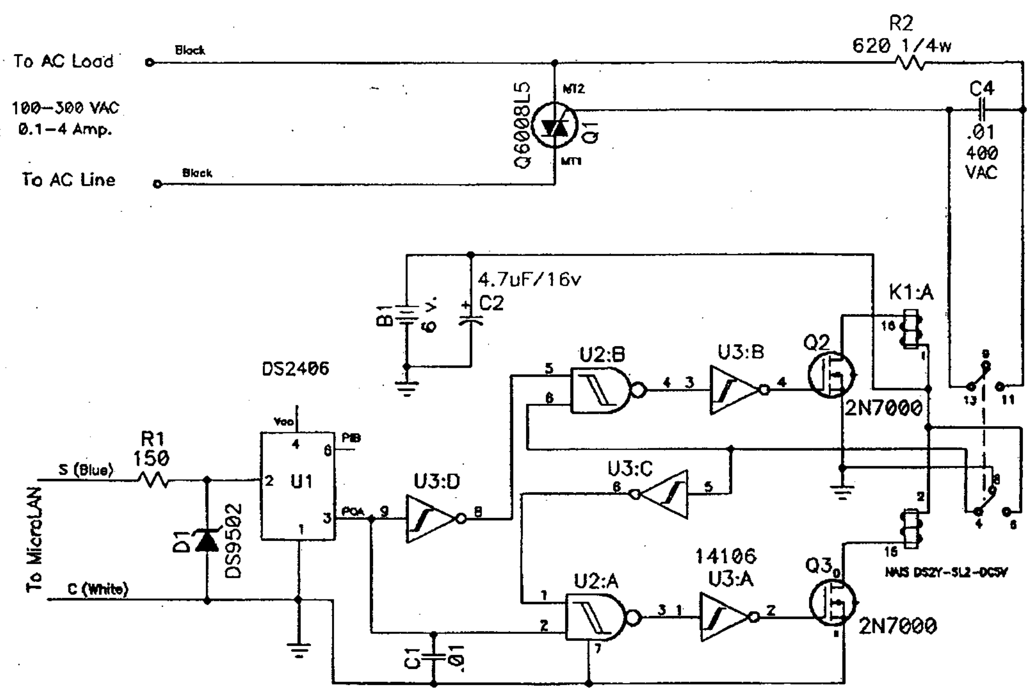


Figure 3. A higher resolution image of the circuit diagram shown in Figure 2 showing additional details and components.

The IBECS Addressable Power Switch (APS) serves as a slave AC contactor, which can be controlled by commands communicated to it over a 1-wire building automation network. In addition to ON-OFF control of lighting loads, it should also have wide Building Automation application for control of HVAC equipment and other mechanical systems. Because of the perceived relative importance of this function in the IBECS system implementation, the design of an Addressable Switch module was given priority in our development schedule.

We originally concluded that a commercially viable APS design would either have to default to a "closed" state during a network interruption or would have to retain its last command state until network integrity was restored. No commercially available product was located with this feature. The ability to perform load confirmation was also deemed to be very desirable. Both design objectives appear to have been attained. Some of the elements developed for this module will also serve as important constituents of the "Title 24 Wall Switch" scheduled to be designed later in this program.

APS Module Features:

1. Self-powered operation
2. Non-volatile memory retains last command state during temporary network outages
3. The flow of current into the load is confirmed to the host
4. Solid state switching element will reliably accommodate high inrush currents
5. Can be configured in a wide range of load ratings
6. Small physical size will fit into standard junction box wiring practices
7. Requires only a two-wire connection to the line and switched load
8. Can be configured in either single-, dual-, or 3-phase versions
9. Modest (1 watt per amp, typical) heat dissipation

Circuit Description

The simplified block diagram below (**Figure 4**) illustrates the interaction of the functional blocks within the APS. The Dallas Semiconductor DS2406 integrated circuit provides the interface to the 1-wire network. Here, one of its two ports is configured as an output, which sends a logic signal representing to the pulse steering circuitry reflecting the state of the most recent ON-OFF command. The second ("B") port of the DS-2406 is used as an input, which monitors a signal from the Triac power switch. This signal indicates the flow of A.C. current into the load. The DS-2406 chip also includes a 1k bit non-volatile memory that is can be used during the commissioning process to store a short plain text identification of the controlled load.

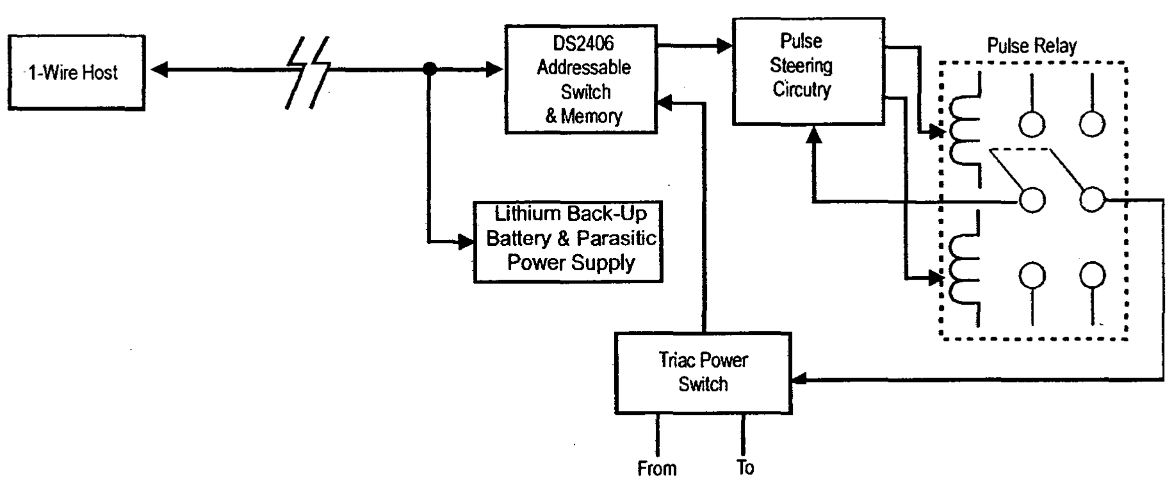


Figure 4. Simplified block diagram illustrating the functional blocks with the Addressable Power Switch (APS).

The pulse steering circuitry compares the state of the relay with the last ON-OFF command. This circuitry only energizes one of the relay coils whenever a change of command state is sensed. Because of the feedback arrangement, the circuitry maintains the relay drive current only long enough to complete the required change of state. This feature minimizes the energy used by the relay, while automatically adapting to changes in the relay pull-in time over changes in ambient temperature, etc.

The use of a pulse relay in the design of our module has a historical precedent from the ubiquitous General Electric RR-7, which has been widely employed in building lighting control. In our case, the pulse relay is a miniature signal relay having a DPDT contact arrangement. It requires an approximate 10-millisecond, 70-milliamp pulse from the 5-volt power supply (1.9 x 10-4 milliamp-hours) to change state. In this application, the pulse relay contacts carry only a very small current that is an order of magnitude below their ratings. Commercially available relays suitable for this application are widely used in telecommunications equipment and have a rated MTBF of 1 million operations.

The power switch utilizes a solid-state Alternistor Triac to control flow of current to the load. This type of Triac is commercially available in ratings from 6 to 40 Amps at ratings of up to 800 volts. They will reliably switch inductive loads and will tolerate the high inrush currents, which are typical with lamp ballasts. Included in the Triac interface is circuitry, which generates an isolated logic signal that confirms the flow load current. This scheme is extremely cost-effective, taking advantage of the inherent transfer characteristics of the Alternistor to sense the passage of load current.

The APS incorporates a power supply that derives energy both parasitically from the 1-wire buss and from an internal back-up lithium battery. By employing this dual arrangement the battery lifetime should exceed twenty years under normal usage.

Competitive Products

The only commercial product which has been located to perform power switching on a 1-wire network is offered as the Model T1R by Point Six, Inc. of Lexington, KY. Their unit uses an electromechanical relay, which requires a local isolated D.C. power supply, poorly tolerates high inrush currents and does not incorporate load current sensing. Their unit is priced at $25.00 each. The physical size of the Point Six unit (excluding a power supply) is approximately the same as the 1" x 1" x 2" overall package (approximately 3 in^3 volume) used to house the engineering model of the IBECS version (see **Figure 1**).

Estimated APS Cost

In 1000-unit production quantities we estimate the APS material and assembly labor costs are estimated to total approximately $8.30 per unit.

Design Propriety

Two aspects of the APS design, as detailed in the attached schematic diagram, appear to be unique. The first apparently distinctive feature is the combination of the pulse steering circuitry used in conjunction with the latching relay. The special virtue of this feedback arrangement is that it minimizes the energy consumed by the relay to affect a change of state of its contacts over variations in temperature and supply voltage.

The second apparently unique feature involves the circuitry used to sense when load current is flowing. This is achieved by monitoring the AC voltage potential of approximately 0.7-volt peak, which appears between the MT1 and gate terminals of the Alternistor Triac whenever it is conducting current through the switched load. By employing a rectifying voltage doubler, we able to derive sufficient drive from this low impedance source to provide adequate drive for an isolating LED-based optical coupler.

The author has not found any prior art that duplicates either of these cited arrangements. As such, it may be appropriate to file disclosure briefs for them. Otherwise, it may be desirable to publicize these designs to assure that they can have unencumbered commercial application.

Design Status

The APS design, as documented in the above schematic is a preliminary engineering version, requiring additional verification and review. As a part of that process, we have prepared a printed circuit implementation of the design, which can be subject to more rigorous laboratory testing and some appropriate field trials.

Development of the Refined Title 24 Switch System

Although the above proof-of-concept prototype met the letter of the scope of work, we elected in March 2001 to enhance the capabilities of the switch so that it could replace a standard single wall switch and control fixture-mounted relays over the existing switchleg using powerline carrier control. In other words, we expanded the capabilities of the Title 24 proof-of-concept so that it became a switch that could control individual fixtures even in spaces where bi-level circuiting was not in place. This ambitious expansion in the scope of work was only possible without an increase in budget because we identified that there were off-the-shelf powerline carrier (PLC) components that could provide the desired capabilities without having to perform additional R&D. (Technically, these components use a PLC protocol called A-10. A-10 is a successor to X-10 control, which has been used for many years for simple powerline control in residential buildings. X-10 is not adequate for controlling loads in commercial buildings because of electrical noise in the buildings).

Although this change in scope delayed the completion of this report deliverable, we thought that it was an acceptable trade-off since it would greatly increase the applicability of the IBECS Title 24 switch to existing spaces that, unfortunately, often do not have bi-level switch circuits in place.

Pettler identified powerline carrier control hardware designed for lighting systems that was commercially available. One company in particular, ACT, offers a line of such control products and also maintains an active testing program to qualify lighting ballasts that are "powerline friendly." This company and technical specifications for the specific products used to assemble the demonstration system at LBNL is discussed in more detail in the Appendix A to this report. Note the selection of this company's hardware to construct the demonstration does not imply that there are not other companies that have similar products and capabilities.

Demonstration of the Refined Title 24 Switch System at LBNL Offices

To test the PLC Title 24 switch concept just described, we coupled our initial Title 24 switch proof-of-concept with off-the-shelf PLC controllable relays, transceivers and other devices available from ACT and installed the system in two offices at LBNL in June. Neither of these offices had bi-level switching in-place so they were good candidates for testing the PLC Title 24 switch concept. Additionally, the two offices, though close by, are actually on two different branch circuits so we could test whether the A10 commands could successfully traverse across branch circuits. Finally, the electrical system at LBNL is old and has been modified several times over the years. Thus the test site at LBNL was a realistic one. Pete Pettler supervised the installation of the system, which was performed by LBNL's Plant Maintenance personnel.

Figure 5 below shows how the PLC system was installed at the LBNL test site. The electrician replaced the existing standard wall switches in FR's and JJ's office with two-button wall-mounted transmitters (ACT Part TK324). Powerline carrier relays, called Feed Thru Relay Fixture Receivers (ACT Part RF304), were connected upstream of each of the fixture ballasts (2 in JJ's office, 3 in FR's office). The PLC system was electrically connected to the building lighting electrical distribution system through a transformer (ACT Part AF300 Filter/Transformer) at Branch Circuit #14 which provides lighting power to the lights in Judy's (and neighboring) office. The transformer is in turn connected to a PLC transceiver (ACT Part TU 202 Transceiver), which is connected to a dedicated PC through the PC's serial port (COM1). To keep costs down, an old PC running Windows 98 was used for the PC server. The operation of each of the major system components and necessary software is detailed below.

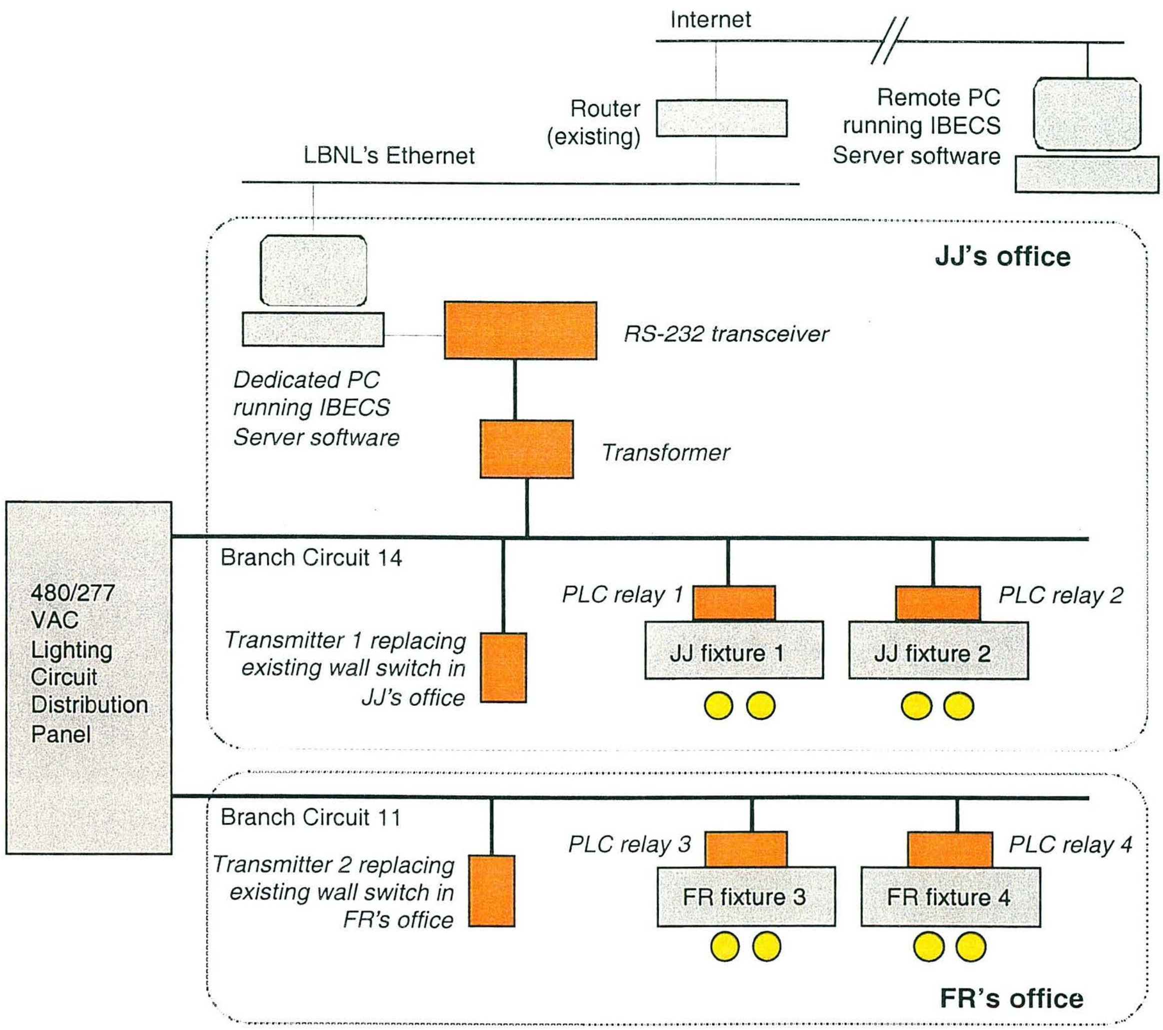


Figure 5. Diagram showing the Powerline Carrier Controlled Title 24 Switch system installed in the two offices at Building 90 at LBNL. The demonstration components are shown in orange.

Dedicated Server

A recycled PC was utilized to operate as a 24/7 host for the system. It was provisioned with TCP/IP access via the LBNL Ethernet LAN. It uses a single Com Port for bi-directional data communication with the PLC transceiver network. Microsoft Windows 98 was utilized as the operating system. Automated scheduling and lighting control routines are performed with a beta version of a real-time IBECS program (called IBECS Server) provided by Smart Buildings Technology Inc. of Lindenwold, N.J. This program performs condition-dependent, time-based scheduling with English-like scripts incorporating powerful IF, AND, OR logical conditional statements. The simple script that is used to control the lights in the offices at Building 90 is given in the Appendix B.

The inclusion of Ethernet/dial-up connectivity permits the remote downloading of program revisions as well a means of accepting control commands or for viewing system status from any authorized workstation connected to the Internet. Since the IBECS Server software is browser-based it is easy to provide a graphical user interface with self-descriptive icons that can run on most web browsers (i.e., Internet Explorer or Netscape Navigator). Future versions of this software will even include provisions for communicating with the host via cellphones or Personal Digital Assistants (PDAs) equipped with the Wireless Access Protocol (WAP). Below (**Figure 6**) is a screen shot taken from the IBECS Sever software from the PC showing the different components of the demonstration system setup at LBNL

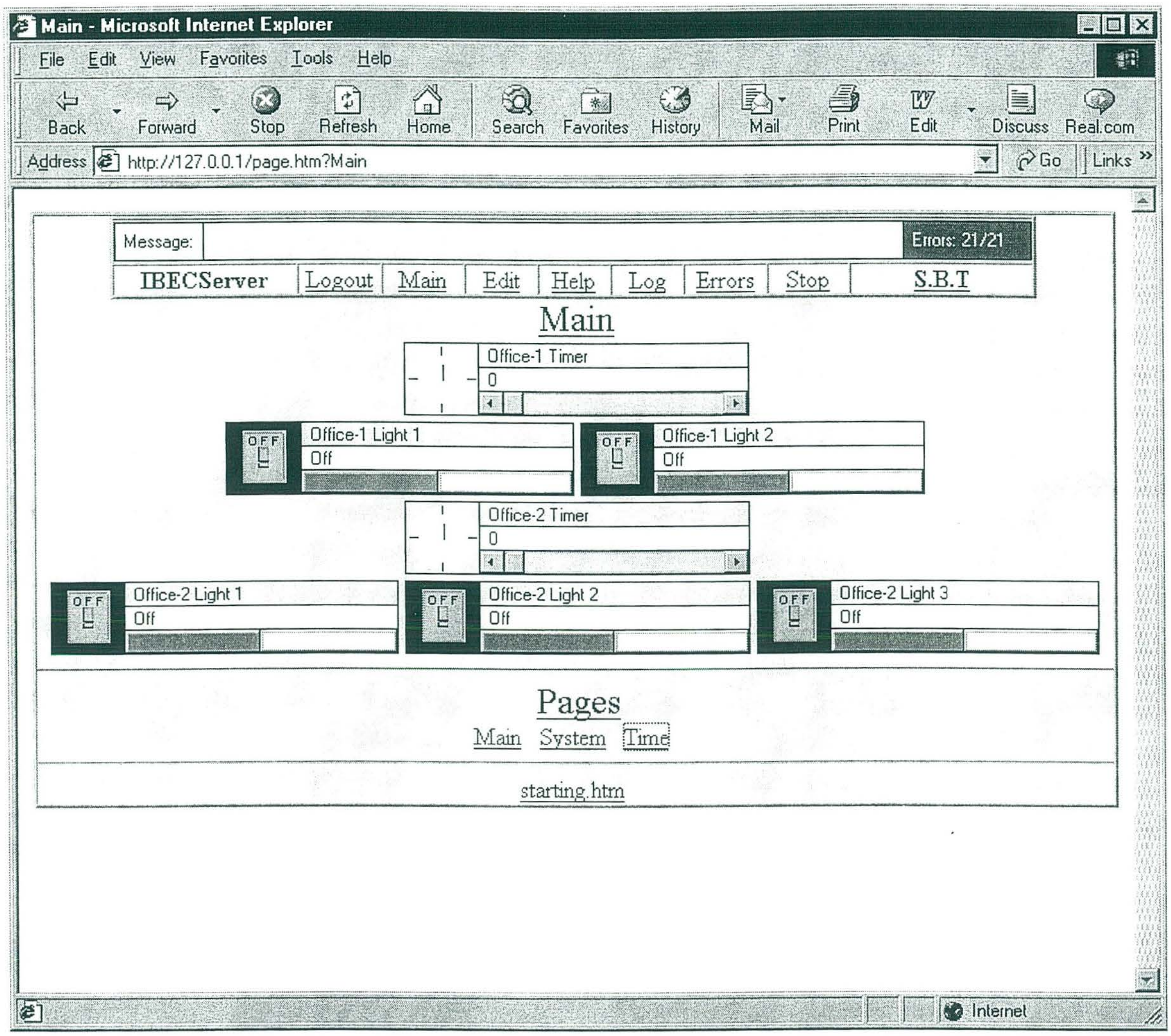


Figure 6. Screen shot from the PC running the IBECS Server software that controls the lights in the demonstration system at LBNL.

RS-232/ RS-485 Converter

A planned future elaboration of the system dictated that the host computer be capable of communicating with both the PLC lighting network and a physical 1-wire IBECS network via a single serial Com Port. The use of a multi-drop RS-485 satisfied this requirement. A Model 485OT9L Serial Interface Converter manufactured by B&B Electronics (www.bb-elec.com) is connected to the PC via a standard 9-pin serial cable. The converter was optioned to operate at a speed of 9600 baud and used an external wall transformer for a power supply. The RS-485 I/O of this model of converter is optically isolated from its connection to the computer. This feature will protect the computer from damage in the event that the RS-485 branch were to accidentally fault to the high voltage lighting branch.

ACT RS-485 Transceiver

The Transceiver is a full-duplex (2-way) device, which translates the ASCII commands and responses from the computer to the A10 powerline carrier modulation signals. In our demonstration installation, the single transceiver was located only a few feet from the Computer and Converter. The multi-drop RS-485 could be up to 4000 feet distant, and there could be as many as 26 individually addressable transceivers, each serving lighting branches connected to individual 277-volt distribution transformers.

ACT AX000 Coupler

The coupler includes a transformer to supply the plug-in Transceiver with its required 120 volts from the 277-volt lighting branch. An included coupler provides a bi-directional path for the 120 kHz PLC signal around the transformer. In the absence of the coupler, the 60 Hz transformer would effectively block passage of the much higher frequency A10 signal.

Wall Keypad Transmitters

Dual-button keypad wall controls were installed in existing doorway surface switch boxes for Rooms #90-2074 and 90-2082. An initial demonstration program was written that responded to depressions of the uppermost button as a request for more artificial light and would subsequently extinguish the room lighting when the lower keypad was pressed.

Relay Modules

Five ACT RF304 A10 Feed-thru Fixture Modules have been installed for the T24 switching system demonstration. The modules have a pending UL-approval and carry a 277 VAC, 20 Amp rating. Each was associated with one dual-bulb ceiling fixture and was assigned a unique A10 network address. This configuration permitted three-step control of the ceiling lighting in room #90-2074 and 2-step control in Room 90-2082.

An Example of How it Works

To understand how the demonstration system at LBNL works, we give the following example. Rubinstein wants to turn on one of the three fixtures installed in his office. Assuming that all the lights are originally off, he taps the "UP" arrow on the special wall switch (Transmitter 2) once. After the tap, transmitter 2 imposes an encoded A-10 signal on the branch circuit 11 to which it is connected. Referring to **Figure 5**, the signal travels along branch circuit 11 to the 480/277 VAC lighting circuit distribution panel located approximately 100 feet away. Because branch circuits 11 and 14 are on the same side of the lighting circuit transformer, the signal can tranverse from circuit 11 to 14 where it is decoded by the transformer on circuit 14 (physically, this transformer is in JJ's office) and sent to the transceiver. The transceiver relays this command to the PC that is running the IBECS Server software. The server software then translates the signal into another A-10 command, which is outputted via the COM port to the transceiver, then the transformer and back onto branch circuit 14. Following the same path, in reverse, as the original signal, the signal traverses from branch circuit 14 to 11 and finally arrives at PLC relay 3 in Rubinstein's office. This PLC relay interprets the signal and switches the connected fixture on. Since Rubinstein tapped the switch only once in this example, only PLC relay 3 was commanded on and only the one fixture switches on even through all three fixtures are on the same switchleg. In other words, the PLC Title 24 system demonstrated here can provide "virtual switchlegs" to control individual fixtures where none previously existed. At time of this writing the IBECS server software will leave the light on for one hour, then blink the light once to warn the occupant of an impending switch off. If the occupant does nothing to restore his lights, it will switch off five minutes later. All this is, of course, a function of exactly how the software is set-up. We will continue to adjust and modify the controlling software to increase functionality. (At the moment, the software is configured so that each additional tap of the UP arrow with switch on one additional light. In this way Rubinstein could turn on all three of his fixtures by tapping the transmitter three times rather than once as in the example above)

System Operation

After some initial difficulties with defective components, the system works satisfactorily. However, there is a noticeable delay between when you first tap the switch and when the light actually switches on. This delay can be decreased by modifying controlling software appropriately. One unexpected development of this system is that the lights in these offices can actually be controlled remotely from another location over the Internet. It is interesting, and possibly even useful, to have one's lights in Berkeley be controlled from, say, San Diego.

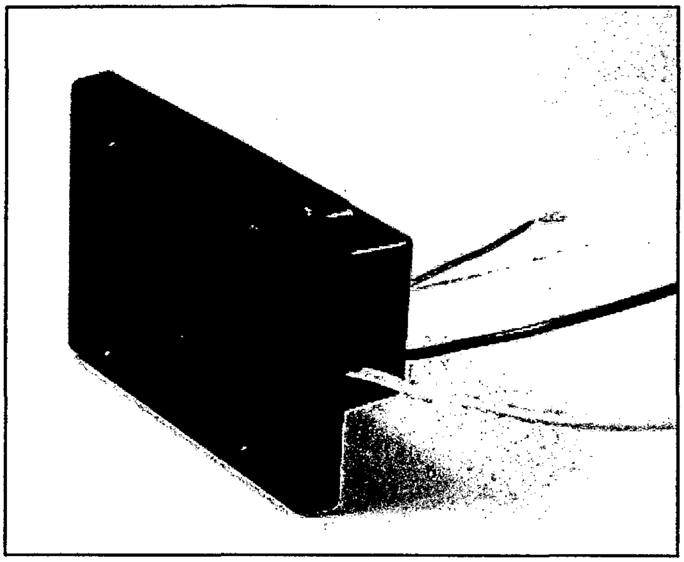
Conclusion

We successfully completed the task objectives by designing, building and demonstrating a new switching system that can provide multiple levels of light which can be triggered either from specially designed wall switches or from a digital communications network. By applying commercially available powerline carrier based technologies that communicate over the in-place lighting wiring system, this type of control can be economically installed even in existing buildings that were not wired for dual-level lighting. The demonstration system installed at LBNL shows that powerline carrier control of building lighting systems can operate satisfactorily in a realistic, electrically noisy environment.

Acknowledgment

This work was supported by the California Energy Commission through its Public Interest Energy Research Program and also by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology, State and Community Programs, Office of Building Research and Standards of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Appendix A: Parts Specifications



AF300

Noise Problems?

In certain PCC applications it may be possible for an electrical appliance to generate electrical interference. This random electrical interference may interfere with the PCC command signal transmission. ACT has designed a group of products to address this problem.

The **AC100** is an HID choke intended for use with any PCC receiver where transient spikes from HID ballast may interfere with PCC command signals to the receivers.

The **AF100** is a passive plug in filter for 120 volt appliances generating electrical noise.

The **AF300** is a Line Isolation Filter which filters out PCC command signals and any strong electric clutter at 120 kHz on the AC line. It provides attenuation at a 40:1 ratio input to output respectively. It prevents passage of the PCC command signals or 120 kHz electronic noise from the line side (primary) to the load side (secondary) and vice versa. The AF300 is for applications up to 277 volts.

The **AF310** is a Line Noise Attenuator which is parallel tuned and, therefore, attenuates noise and unwanted signals of frequencies above or below 120 kHz without attenuating the PCC signal. It attenuates spikes and transients having rise times which are too fast to be affected by conventional spike suppressors.

The **AX000** is a Coupling Transformer designed to impose command signals from 120 volt transmitters directly onto 240V, 277V, and 480V distribution systems. When the transmitter is operated, the command signals are imposed on the higher voltage from which the AX000 draws power by means of an isolating phase coupler built into the AX000. This coupling transformer is only rated for 50 VA, therefore any transmitter that consumes more than 40 watts should not be powered with this unit.

AC100 AF300 AF100 AF310 AX000 — Filters/Transformers

The PCC controls payoff - How it works:

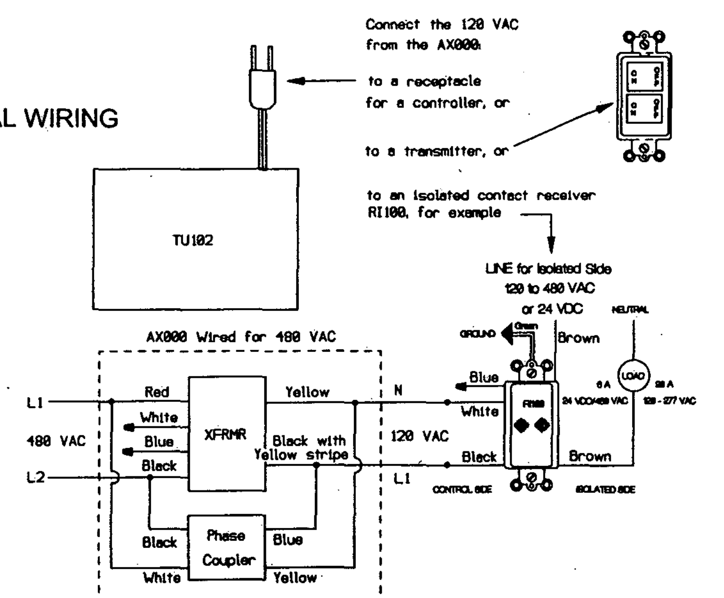
The Powerline Control Components (PCC) are electronic controls designed for industrial and commercial installations. They can be used to provide centralized, automatic remote control of electrical loads by employing a power line carrier signal superimposed upon existing AC power lines supplying the loads. This concept offers a considerable saving in installation cost. Installed PCC components can be operated by utilizing the programming capabilities of a microcomputer which can control 256 separate addresses; each address switches up to 50 receiver modules and their respective loads as a group. With either the microcomputer or programmable controller, manual override can be exercised without affecting programmed memory. Wall mounted manual controllers for localized area control are also available.

The PCC devices are compatible with the various distribution system voltage levels, either single or three-phase AC, that are normally encountered in industrial and commercial applications. PCC devices can be used to implement a spectrum of control strategies enabling time of day switching, duty cycling, and demand limiting to be programmed, and resulting in man-hour savings by relieving personnel from routine, manual switching operations.

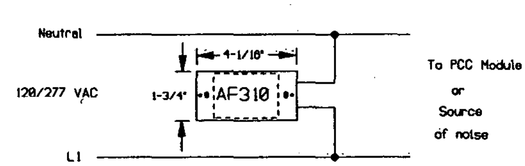
For further information on the ACT Powerline Control Components refer to the PCC Brochure, or contact an authorized Engineered Systems Center.

PRODUCT	DESCRIPTION	RATING
AC100	HID Choke	up to 277 VAC, 5 Amp
AF100	Plug-in Filter Module	120 VAC, 5A
AF300	Blocking Filter, Low Pass	up to 277 VAC, 3-Wire
AF310	Low Pass, Band Pass Filter	up to 277 VAC, 2-Wire
AX000	Transformer/Coupler	120/240, 277, 480 VAC

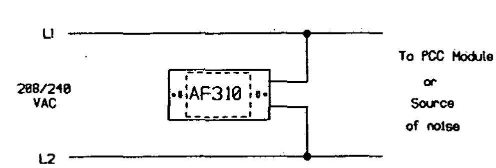
TYPICAL WIRING
AX000



AF310

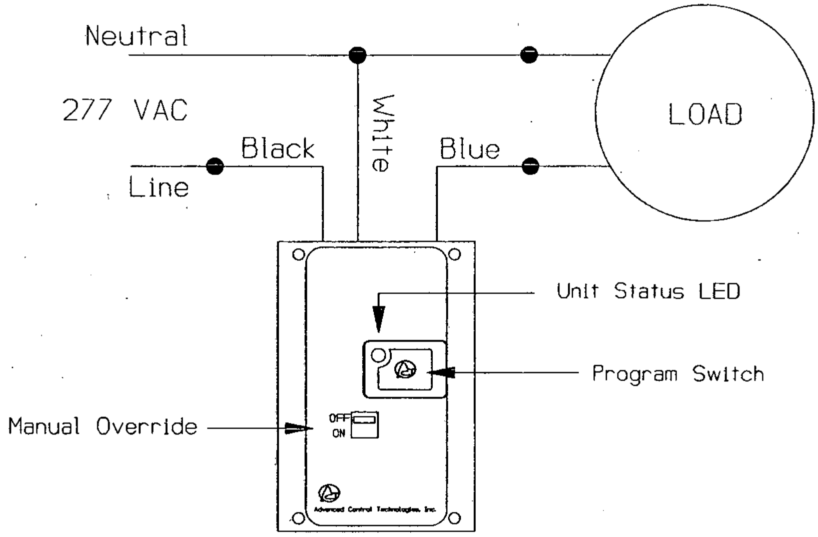


Install AF310 at PCC module, source of noise or both locations



RF304

A10 277 VAC, 20A, Feed-thru Relay Fixture Receiver



BEFORE YOU BEGIN...

READ ALL INSTRUCTIONS

Make sure your installation will conform to all applicable codes and requirements.

TEST FOR SIGNAL STRENGTH AND NOISE...

using appropriate test equipment. It is necessary to test the installation in the actual operating environment. The amount and types of line loads may reduce the strength of the transmitted signal and/or electrical noise may cause interference with the transmitted signal. Proper installation may require additional couplers, filters or repeaters. Special coupling devices are required to allow signal to be distributed to all phases and zero-crossings in multi-phase and multi-transformer distributions.

IF YOU HAVE ANY QUESTIONS...

Consult your nearest Engineered System Center (ESC) for additional information.

There are no field repairable assemblies on this unit. It is covered by a two year limited warranty. If service is needed, the unit must be returned to the ESC where purchased. Contact your ESC for return details.

INSTALLATION

CAUTION! Make all connections with the **POWER OFF** to avoid injury to the installer or damage to the device. WARNING: SHOCK HAZARD. Do not use the manual ON/OFF switch on the RF to disconnect the load for service. Signal can cause it to turn ON.

1. Strip 3/4" of insulation from the ends of the conductors and make connections as shown in the Wiring Diagram. Connect line and neutral to the BLACK and WHITE flying leads. The power is fed through the relay contacts from the BLACK HOT wire to the BLUE LOAD wire. Connect the load between the BLUE and WHITE wires. When the relay turns on or off, the red override switch lever will move indicating that it is on or off.
2. Check connections to be sure they are tight and no bare conductors are exposed.
3. Make sure the load or installation does not exceed the device rating.
4. Install into any appropriately sized electrical box or the fixture itself. Clean the mounting surface, remove the protective film from the adhesive tape and firmly press the module in place.

NOTE! Do not install within four inches of fluorescent ballast.

NOTE! Use only in fixtures where 49 degree C. wiring is permitted. Do not install in fixtures where ambient temperature exceeds 120 degrees F. (49 degrees C.)

CHECKOUT

1. Restore the power.
2. Set the address as follows :

   Connect a PCC transmitter such as the AT004 or any X-10 compatible desktop transmitter to the same power line as the RF304 test setup. Select the desired letter code. Press and hold the PROGRAM push button on the RF304 for just over three seconds and release. The STATUS LED should be ON solid. The RF304 is now in PROGRAM mode. Press the desired number code on the transmitter two times with a half second pause between transmissions to allow six zero crossings to occur. The RF304 STATUS LED should blink two times and come back ON solid, indicating that it is still in program mode. **NOTE:** When a new address is programmed into the device, all the ADDITIONAL PROGRAMMING FEATURES are reset to their default values.

ADDITIONAL PROGRAMMING FEATURES:

RUDE/POLITE PROGRAMMING. The RF304 receivers close and open their relay contacts with standard X-10 ON and OFF commands, respectively. They also may be programmed to respond to other commands. By default, the device operates in polite mode (waits for other powerline transmissions to cease before transmitting and will monitor the powerline for collisions), but may be configured to operate in rude mode (ignores other powerline transmissions when transmitting). To disable Polite mode, after programming the base address, send the address two additional times with a half second pause between transmissions to allow six zero crossings to occur. The Status LED will blink four times to signal the operator that the device will now operate in Rude mode.

Also, the device may be programmed to respond to other commands which may close the relay (AllLightsON), or open the relay (AllUnitsOFF, or AllLightsOFF). These commands are disabled by default when the base address of the device is programmed. To enable these commands, press their respective command button two additional times with a half second pause between transmissions to allow six zero crossings to occur. The Status LED on the RF304 will flash to indicate that the command has been accepted. The table below illustrates the flashing pattern of the Status LED.

Flashing Pattern	Interpretation
¼ second ON, 3 seconds OFF	Normal Operation
Continuous Rapid Flash	EEPROM Error
Two Flashes	Valid base address accepted
Four Flashes	Polite mode disabled
Six Flashes	All Lights ON command enabled
Eight Flashes	All Units OFF command enabled
Ten Flashes	All Lights OFF command enabled

Upon receiving a valid Status Request command, the device will transmit the current relay status, either ON (closed) or OFF (open). Note that there is no feedback from the relay. If the relay is switched manually, this will not be reflected in the software, nor in the Status Reply to the controller.

To exit the PROGRAM mode press the PROGRAM switch on the RF304 briefly. The STATUS LED will go off. The RF304 will now respond to the programmed letter and number code and any other programmed features. NOTE: It will also automatically exit PROGRAM one (1) minute after the last AT004 or X-10 compatible desktop transmitter transmission.

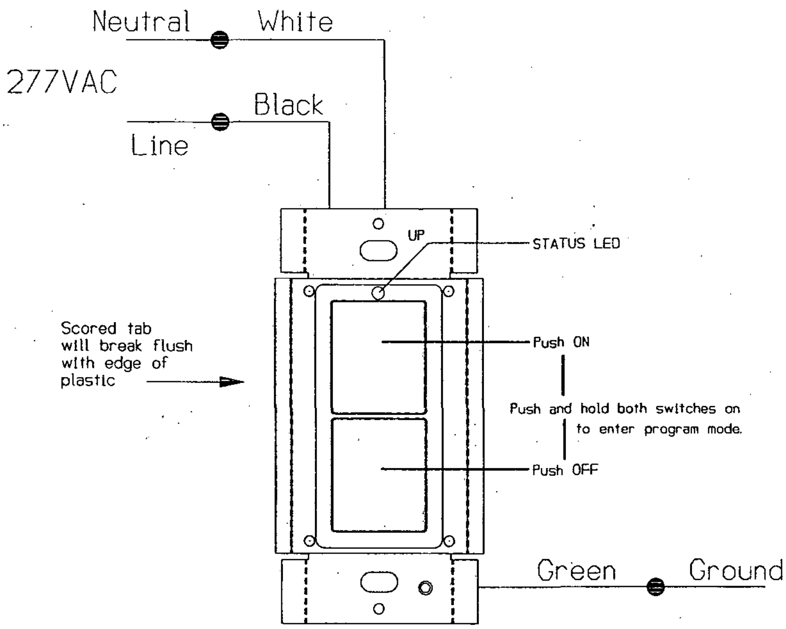
3. Test Remote Operation:

   Using the transmitter, transmit the address and any programmed commands to ensure the module controls the load in response to remote control.
4. Test for Signal Strength and Noise once again using appropriate PCC test equipment.

Supply Voltage	277 VAC, +/-10%, 50 or 60 Hz	Signal Output (Status)	6V peak to peak @ 5 ohms
Power Consumption	Less than 4.5W	Maximum switching capacity	20 Amps or 5000 VA
Signal Input	120 KHz +/- 4 KHz, sensitive to 25 millivolts	Maximum switching voltage	277 VAC

TK324

A10 277 VAC Two Button Wall Mounted Transmitter



BEFORE YOU BEGIN...

READ ALL INSTRUCTIONS

Make sure your installation will conform to all applicable codes and requirements.

TEST FOR SIGNAL STRENGTH AND NOISE...

using appropriate test equipment. It is necessary to test the installation in the actual operating environment. The amount and types of line loads may reduce the strength of the transmitted signal and/or electrical noise may cause interference with the transmitted signal. Proper installation may require additional couplers, filters or repeaters. Special coupling devices are required to allow signal to be distributed to all phases and zero-crossings in multi-phase and multi-transformer distributions.

IF YOU HAVE ANY QUESTIONS...

Consult your nearest Engineered System Center (ESC) for additional information.

There are no field repairable assemblies on this unit. It is covered by a two year limited warranty. If service is needed, the unit must be returned to the ESC where purchased. Contact your ESC for return details.

INSTALLATION

CAUTION! Make all connections with the **POWER OFF** at the source to avoid injury to the installer or damage to the device.

1. Strip 3/4" of insulation from the ends of the conductors and make connections as shown in the Wiring Diagram. Connect line and neutral to the BLACK and WHITE flying leads. Connect the GREEN wire to an appropriate ground.
2. Check connections to be sure they are tight and no bare conductors are exposed.
3. Make sure the installation does not exceed the device rating.
4. Install into an appropriately sized electrical wall box. Scored tabs on both sides can be bent up and down their length with pliers, then removed, to allow fit in a variety of electrical box types.
5. Restore the power. On power-up the LED will flash for a short duration. The TK324 will assume that the receiver is off and will reflect that via its LED. **NOTE:** Upon initial PROGRAM MODE the factory set base address is A1.

The default configurations are as follows:

- Unit will be polite
- Unit will transmit the Status Request command, if applicable to the configuration
- The following are disabled: Auto Refresh, All Lights On, All Lights Off, All Units Off.

TO PROGRAM

Press and hold both buttons simultaneously for 3 seconds or more. Once released, the LED should be lit and remain illuminated. It is now in program mode.

To Set Address: Send two Address packets separated by six zero crossings (or approximately 1/2 second) to set the base address. LED will flash 2 times.

To Invert LED Action: Send the "STATUS ON" command* twice separated by at least six zero crossings (or approximately 1/2 second). LED will flash 1 time.

To Disable Status Request: Send two "OFF" commands separated by six zero crossings (or approximately 1/2 second). LED will flash 3 times.

To Set Rude Mode: Send the Base Address two more times separated by six zero crossings (or approximately 1/2 second). LED will flash 4 times

To Enable Auto Refresh: Send two "Hail Acknowledge" commands* separated by six zero crossings (or approximately 1/2 second). LED will flash 5 times.

To Enable ALL LIGHTS ON: Send two "ALL LIGHTS ON" commands separated by six zero crossings (or approximately 1/2 second). LED will flash 6 times.

To Enable ALL LIGHTS OFF: Send two "ALL LIGHTS OFF" commands* separated by six zero crossings (or approximately 1/2 second). LED will flash 10 times.

To Enable ALL UNITS OFF: Send two "ALL UNITS OFF" commands separated by six zero crossings (or approximately 1/2 second). LED will flash 8 times.

To exit the Program Mode, press both push-buttons or the device will automatically exit one minute after the last valid address or command. Upon leaving the Program Mode, the Status LED will flash one time quickly, and then return to its normal course of operation.

KEYPAD OPERATION

The top button (closest to the LED) is used to send an "ON" command with the address, while the bottom button sends an "OFF" command with the address.

LED OPERATION

In addition to the status of the load, after a button is pressed the LED indicates 1) that a transmission is in progress and 2) any error conditions.

After a button is pressed the LED will flash at a rate of 2 Hz. The LED will continue flashing until the transmission is successful or, if Status Request is enabled, continue until finished. The LED will be updated if: 1) The device is not in Status Request mode or 2) The proper Status Reply was received.

When a Status Reply from an address is received, the LED is updated (i.e., if a "STATUS ON" is returned, the LED will illuminate for the "ON" command, or vice versa if in reverse acting mode).

If the Status Reply fails, then the LED will update to the new state, but will Blip to the opposite state every once in a while. Blips to the opposite state indicate that the Status Reply has failed (a noncritical error) and no Blips occur when Status Request is disabled.

The device can also respond to "ON" and "OFF" commands from other transmitters corresponding to its base address. The LED will be updated accordingly, regardless whether the device is in Status Request mode.

LED ERROR INDICATIONS

Collision Retry Failure: The LED will toggle at a 5Hz rate for 3 seconds then revert to its previous state.

* to send a "status on", "hail request" or "all lights off" command requires the use of an ACT hand held AT004 or a computer connected ACT TI103.

Status Reply Failure: The LED will blink for a short time then resume its appropriate state. This repeats until the proper Status reply is received (i.e. the LED will be on most of time after an ON Command but blink off briefly from time to time, or the LED will be off most of the time after an OFF Command but blink on briefly from time to time.

EEPROM Read/Write Failure: LED will flash quickly with no time limit.

Note that the "ALL LIGHTS ON, ALL LIGHTS OFF or ALL UNITS OFF" commands do not generate a Status Request or receive a Status Reply.

GENERAL COMMUNICATIONS

The TK324 uses the X-10 protocol for Standard Code. It has the added extension of waiting a random 8 to 10 zero crossings before sending the first address in a packet. There are six zero crossings between multiple addresses or between each address and command. This six zero crossing delay will never be polite. The commands that the TK324 can send are as follows:

- ON
- OFF
- STATUS REQUEST

The commands that the TK324 can receive are as follows:

- ON
- OFF
- ALL LIGHTS ON
- ALL LIGHTS OFF
- ALL UNITS OFF
- STATUS OFF
- STATUS ON

STATUS REQUEST

Whenever Status Request is enabled (the default state after the base address is programmed) the TK324 will follow up each command transmitted ("ON" or "OFF" command) to a single address with a "STATUS REQUEST" command. After three seconds the TK324 will expect either a "STATUS ON" or a "STATUS OFF" command back from that address. If it does not get a reply within three seconds or it gets a reply with the wrong ON/OFF state, then it will retransmit the command and the "STATUS REQUEST" again. There will be a total of four transmissions with no more than three seconds delay between each.

AUTO REFRESH

The Auto Refresh period is every 15 minutes. After the TK324 is powered up, pressing either button will initialize and restart the Auto Refresh timer. This helps to skew the Auto Refresh timers when there is more than one Auto Refreshing device on the line. Any status confirmation is suspended during the Auto Refresh if Status Request is enabled. If the unit is in the Polite Mode, it will not generate the Collision Retry Failure Display if there is a collision. This feature will be temporarily suspended if the TK324 sees a conflict. A conflict is defined as any packet addressed to the TK324's address or an "ALL" command to its letter code. If it sees any of these transmissions then it will suspend the Auto Refresh in order to avoid conflicts. The Auto Refresh will be reinstated when a button is pushed.

SELF-DIAGNOSTIC TEST

If the unit is reprogrammed 100,000 or more times there can be failures in the communication to the internal memory. This error will be reported to the user through the Status LED. Remove and reapply power to reset the internal memory. If error still occurs, contact your distributor for return instructions.

TRANSMISSION ERROR HANDLING (POLITE/RUDE MODES)

Collision detection is used as a part of Polite mode (the default state after the base address is programmed) to allow for error handling. A total of three attempts will be made to send a packet. After the third try the packet is discarded. If the device is unable to complete the transmission, the LED will not be updated. Whenever there is a retry of a packet, the entire packet (all addresses and the command) will be resent. When in Rude Mode (Polite Mode having been disabled) collisions will not bedetected and the transmissions will continue regardless. There will be no retry attempts due to collisions.

CARE AND CLEANING OF KEYPAD SURFACE

Keypad can be cleaned with the following cleaners without staining:

Top Job	Fantastic	Formula 409	Ajax	Windex

Keypad can be exposed to the following without visible staining, but suggest removing within 24 hours:

Grape Juice	Coffee	Milk

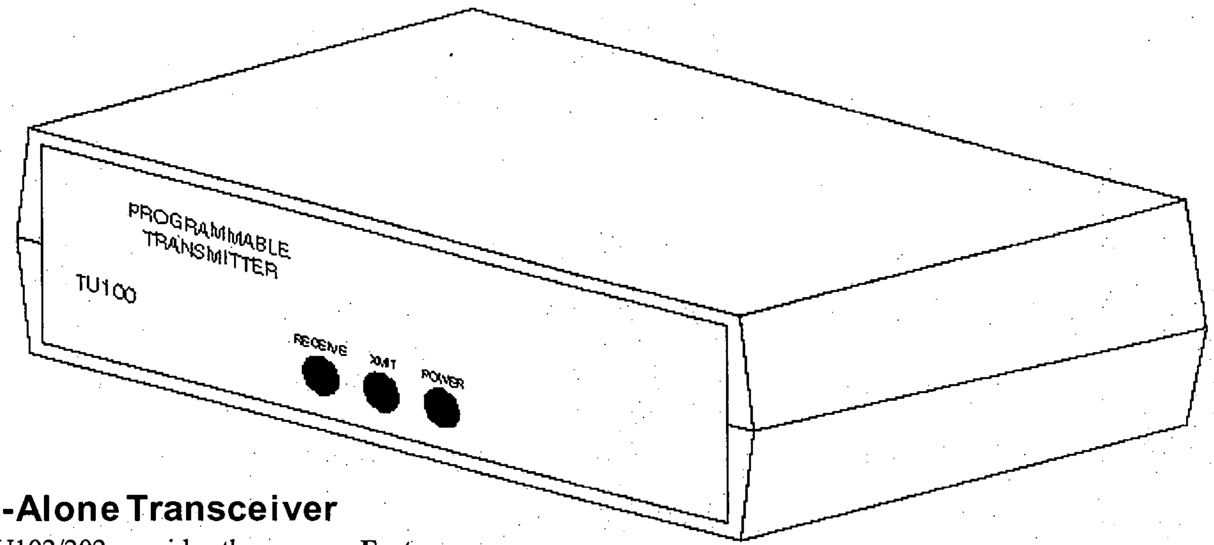
Avoid prolonged contact with:

Tomato Juice	Ketchup	Lemon Juice	Mustard

Supply Voltage	277 VAC, +/-10%, 50 or 60 Hz	Signal Input	120 KHz +/-4 KHz, sensitive to 25 millivolts
Power Consumption	Less than 4.5W	Signal Output (Status)	6V peak to peak @ 5 ohms

PCC POWERLINE CONTROL COMPONENTS

TU102 TU202 Universal Transceiver



Stand-Alone Transceiver

ACT's TU102/202 provides the user with a *versatile, powerful* transmitter that "stands alone" in performance. *Versatile* because it can be set up to handle load switching in many different ways. *Powerful* in that it can carry out an entire year of schedules unattended. Once programmed, it can function detached from the user's computer.

The TU102/202's on-board microprocessor functions independently after schedules have been entered. The clock/calendar allows a scheduling for time-of-day, day-of-week and month/date for up to a year's worth of scheduling. Memory is protected from power failures for up to seven years by a lithium energy source.

The TU102/202 schedule accommodates switching for sixteen letter codes (A-P) each of which has sixteen number codes (1-16). Any of these 256 unique codes can be dialed into individual PCC receivers, or multiple receivers can be set to the same code.

NEED EVENTS TRIGGERED BY EXTERNAL CRITERIA?

The TU102/202 has analog and digital inputs, which, through the "IF/THEN" statements in the software can turn electrical loads on or off based on a predetermined logic.

Features:

- ❑ Visual Indicator
  Three LED's indicate if the Transceiver is powered, and whether it is sending or receiving signals.
- ❑ Receiver Scheduling
  Up to 100 receiver groups with separate schedules
- ❑ Holiday Schedules
  Up to 12 holidays per group
- ❑ ON/OFF Events
  Up to four ON/OFF pair events for each group for each day of the week, with each event controlling from 1 to 256 point addresses. Holidays provide alternate schedules.
- ❑ Overrides
  Each point address may be overridden to a specific time, for a specific time period, or indefinitely.
- ❑ Computer Connection
  The Transceiver communicates with the host computer through its RS232 connection and a serial cable. Using your software or ours, you have all the power of your computer to set up, retrieve, and print your schedules. Once programmed, the Transceiver does not require connection to the computer, except for the convenience of changing schedules.
- ❑ "User Friendly" Software
  ACT supplies powerful energy management software. This software allows your IBM PC or PC compatible computer to communicate with the Transceiver. It supports the setup of all schedule data and can control all functions of the Transceiver. It enables the user to write data to the Transceiver memory, read it back, store and retrieve the data on the computer's disk, or provide hard copies from a printer. In addition, the software supports modem operations for the TU102/202, including phone number lists for auto-dial modems. Software operation and application guidelines are completely described in the Operator's Manual for the transceiver. Technical assistance is available for those who choose to write their own software.
- ❑ Modem Connection
  Although the most common use

for the TU102/202 is to be connected directly to the computer, TU's at remote installations can be connected to an auto-answer modem.

With another modem at the computer end, communication with the Transceiver can be accomplished over telephone lines - whether around the block or around the world. The Transceiver communicates at 1200 or 2400 baud.

- ❑ 50/60 Hz selectability
  A simple software command allows the Transceiver to transmit signals appropriate for 50 Hz power systems.
- ❑ P1 Test
  On command, "P1 Test" transmits continuous P1 ON and P1 OFF signals for testing signal strength with the AR300 Signal Strength Indicator.
- ❑ Peripheral Connection
  An RS485 connection is provided for input from ACT peripheral devices such as the Phone Override Decoder (POD).
- ❑ Analog/Digital Inputs
  The TU102/202 can accept up to eight 0-5 volt analog or digital inputs. When utilized by the unit's logic statements, these inputs allow for greater control versatility.

Applications

- ❑ Dedicated Control
  Since the Transceiver can be commanded to transmit and receive PCC signals directly from the keyboard, it may be permanently connected to a PC computer or mainframe and work with the computer in "real time." It may also be programmed with schedules for a day, week, month or year at a time, and left connected but "off-line" for instant "on-line" communication at any time.
- ❑ Set It and Forget It
  Because the Transceiver does not need an external computer for operation, it can be programmed for up to a year (longer if no data-dependent overrides are used) then disconnected from the computer and installed at any 120 volt outlet on a separate circuit that has been examined and suitably coupled by the installer. Its small size allows it to fit under a counter or on a bookshelf. For reprogramming, just unplug the unit (the battery backup keeps the schedules saved) and bring it back to the computer.
- ❑ Distributed Control
  If the PCC installation has areas of electrical isolation from the PCC signal (which may occur if the building has several separate electrical feeds), more than one Transceiver can be used. Each isolated area can then have 256 points of control and reduces the need for signal boosting and coupling services.
- ❑ Remote Communication
  The Transceiver can be connected to an auto-answer modem. It requires only power and a nearby telephone outlet jack for the modem. In fact, if several Transceivers are in use, in one facility or across an entire chain of facilities, it is possible to communicate with all of them (one at a time) from a single central computer. When an installation is dialed up, the modem answers the phone and makes available the same versatility of a Transceiver connected directly to the computer. The following are suggestions as to how a dealer might utilize the TU102/202 as a service to his customer.
- ❑ Programming Services
  Since the Transceiver can be programmed at the computer before installation, the dealer might provide computer time to a customer who has none, or sell the unit to the customer pre-programmed. The customer or the dealer would then install it.
- ❑ Remote Operation
  The dealer could then monitor and control the operation of one or several installations. Using a customer or dealer-owned Transceiver, the dealer can monitor each installation from his central computer. Using this method the building owner could FAX or phone changes in the schedule to the contractor. The contractor would download the schedule changes as necessary. In addition, the contractor could accomplish any troubleshooting of the system over the phone line.

Versatility: ACT's TU102/202, when integrated with other PCC components, offers the building operator an unmatched level of cost-effectiveness and versatility for on/off control. The adaptability of the TU102/202 to any host computer, combined with the diversity of the types of PCC receivers, lets managers expand or upgrade control of electrical loads in their facility very quickly and inexpensively.

SPECIFICATIONS:

Operating Voltage:
TU102: 120 VAC, 50/60 Hz
TU202: 240 VAC, 50 Hz

PCC Signal:
2-4 volts, 120kHz superimposed on the power supply

Dimensions:
8-1/8" L x 6-1/4" W x 2-5/8" H

Appendix B: Control Script for Title 24 Switching System Demonstration at Building 90

```
Name:             Owner-Password
Class:                 Password
Password:
Access:                Owner
Knowledge-Level:  Novice
Client-Address:


Name:             Owner-Password/Expert
Class:                 Password
Password:         O
Access:                Owner
Knowledge-Level:  Expert
Client-Address:


Name:             Starting
Class:                 Choice
File:             false_true.chc
Check:                 Yes
Init:             True
Persistent:            No


Name:             Message
Class:                 Message


Name:             TI103
Class:                 TI103
Port:             COM1


Name:             Michael
Class:                 Michael
Port:             Disconnected


Name:             Office-1 Timer
Class:                 Second-Timer
Maximum:          300


Name:             Office-1 Light 1
Class:                 X10-Appliance
House-Code:            O
Unit-Code:        1
```

```
Name:           Office-1 Light 2
Class:              X10-Appliance
House-Code:         O
Unit-Code:      2

Name:           Office-2 Timer
Class:              Second-Timer
Maximum:        300

Name:           Office-2 Light 1
Class:              X10-Appliance
House-Code:         M
Unit-Code:      1

Name:           Office-2 Light 2
Class:              X10-Appliance
House-Code:         M
Unit-Code:      2

Name:           Office-2 Light 3
Class:              X10-Appliance
House-Code:         M
Unit-Code:      3

Name:           X10:HC
Class:              Choice
File:           x10_house_code.chc
Check:              Yes
Init:           (none)
Persistent:         No

Name:           X10:Last-HC
Class:              Choice
File:           x10_house_code.chc
Check:              Yes
Init:           (none)
Persistent:         No

Name:           X10:UC
Class:              Choice
File:           x10_unit_code.chc
Check:              Yes
Init:           (none)
```

Persistent: No

Name: X10:Last-UC
Class: Choice
File: x10_unit_code.chc
Check: Yes
Init: (none)
Persistent: No

Name: X10:FNC
Class: Choice
File: x10_function_code.chc
Check: Yes
Init: (none)
Persistent: No

Name: X10:Last-FNC
Class: Choice
File: x10_function_code.chc
Check: Yes
Init: (none)
Persistent: No

Name: Icon-Click
Class: Icon-Click

Name: Updated-Property
Class: Updated-Property

Name: Integer-A
Class: Integer
Base: Decimal
Minimum: -10000
Maximum: 10000
Init: 1
Persistent: No
:
Read-Acc: None

Name: Hex-Text
Class: Text
Init:
Persistent: No
:
Read-Acc: None

```
Name:           Hex-A
Class:               Integer
Base:           Hex
Minimum:        X0
Maximum:        X400
Init:           X0
Persistent:          No
:
  Read-Acc:          None


Name:           Character-A
Class:               Character
Init:           <NUL>
:
  Read-Acc:          None


Name:           Clock
Class:               Clock
Time-Zone:      Eastern
Latitude:       35
Longitude:      85


Name:           Sound-Card
Class:               Sound-Card
TTS-Engine:          Microsoft Speech Synthesis Engine:Mary

Name:           Text-A
Class:               Text
Init:
Persistent:          No


Name:           Text-B
Class:               Text
Init:
Persistent:          No


Name:           Main
Class:               Page
Property-1:          Office-1 Timer
Property-2:          (none)
   Applet-1:         line_break.app
Property-3:          Office-1 Light 1
Property-4:          Office-1 Light 2
Property-5:          (none)
   Applet-1:         line_break.app
Property-6:          Office-2 Timer
```

```
Property-7:           (none)
   Applet-1:          line_break.app
Property-8:           Office-2 Light 1
Property-9:           Office-2 Light 2
Property-10:          Office-2 Light 3

Name:            System
Class:                Page
Property-1:           Sound-Card.Status
    Applet-1:         name_value.app
Property-2:           Sound-Card.Play
    Applet-2:         name_value.app
Property-3:           Sound-Card.Speak
    Applet-3:         name_value.app
Property-4:           Sound-Card.Record
    Applet-4:         name_value.app
Property-5:           Sound-Card.Volume
    Applet-5:         name_value.app
Property-6:           Sound-Card.Control
    Applet-6:         name_value.app
Property-7:           TI103.Status
    Applet-7:         name_value.app

Name:            Time
Class:                Page
Property-1:           Clock.Year
    Applet-1:         name_value.app
Property-2:           Clock.Month
    Applet-2:         name_value.app
Property-3:           Clock.Date
    Applet-3:         name_value.app
Property-4:           Clock.Day
    Applet-4:         name_value.app
Property-5:           Clock.Hour
Property-6:           Clock.Minute
Property-7:           Clock.Second
Property-8:           Clock.Time
Property-9:           Clock.MTime
Property-10:          Clock.Weekday/Time
Property-11:          Clock.Weekday/MTime
Property-12:          Clock.Sunrise
Property-13:          Clock.Sunset
Property-14:          Clock.Daylight-Savings
    Applet-14:        name_value.app

Name:            Command
Class:                Command
Init:
```

```
Name:              Startup
Class:                  Script
Description:            Startup
Control:           Enabled
Called:                 No
Begin:
If  Starting  Is  True
     {
     Do  Starting  Set  False
     If  Sound-Card.TTS-Engine  Is Not  (none)
     ;Then  Sound-Card.Speak  Set  "Hello. Welcome to IBEC Server"
     }


Name:              Office-1
Class:                  Script
Description:            Office-1 light control
Control:           Enabled
Called:                 No
Begin:
; Respond to TK224 SRQ (so it won't send a 2ND O2/ON or O2/OFF):
If  TI103.X10-RxBtn  Is  O/1/Status Request
     {
     Do  TI103.X10-Tx  Set  O/1
     If  Office-1 Light 1  Is  Off
     Then  TI103.X10-Tx  Set  O/Status=Off
     Else  TI103.X10-Tx  Set  O/Status=On
     }

If  TI103.X10-RxBtn  Is  O/1/On
     {
     If  Office-1 Timer  >  240
     Then  Office-1 Light 2  Set  On
     Do  Office-1 Timer  Set  300
     }

If  Office-1 Timer  Is Now  60
Then  Office-1 Light 1  Set  Off
Then  Office-1 Light 1  Set  On

If  Office-1 Timer  Is Now  0
Or  TI103.X10-RxBtn  Is  O/1/Off
Then  Office-1 Light 2  Set  Off
Then  Office-1 Timer  Set  0


Name:              Office-2
Class:                  Script
Description:            Office-2 light control
Control:           Enabled
Called:                 No
Begin:
```

```
; Respond to TK224 SRQ (so it won't send a 2ND M1/ON or M1/OFF):
If   TI103.X10-RxBtn   Is   M/1/Status Request
     {
     Do   TI103.X10-Tx   Set   M/1
     If   Office-2 Light 1   Is   Off
     Then   TI103.X10-Tx   Set   M/Status=Off
     Else   TI103.X10-Tx   Set   M/Status=On
     }

If   TI103.X10-RxBtn   Is   M/1/On
     {
     If   Office-2 Timer   >   240
          {
          If   Office-2 Light 2   Is   Off
          Then   Office-2 Light 2   Set   On
          Else   Office-2 Light 3   Set   On
          }
     Do   Office-2 Timer   Set   300
     }

If   Office-2 Timer   Is Now   60
Then   Office-2 Light 1   Set   Off
Then   Office-2 Light 1   Set   On

If   Office-2 Timer   Is Now   0
Or   TI103.X10-RxBtn   Is   M/1/Off
Then   Office-2 Light 1   Set   Off
Then   Office-2 Light 2   Set   Off
Then   Office-2 Light 3   Set   Off
Then   Office-2 Timer   Set   0
```

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