1. INTRODUCTION

Eliminating hard wiring in an energy management installation by using Power-Line Carrier (PLC) continues to be one of the best ways to cut energy costs and realize savings immediately. On larger installations the expense of running the wires can amount to 1/3 to 2/3 of the total job cost.

State-of-the-art technology makes it possible to independently control and interrogate digital-in (DI), digital-out (DO), analog-in (AI) and analog-out (AO) points located throughout a large industrial site or a large building without having to run wires to the various pieces of equipment and sensors. It is also possible to communicate with intelligent remote devices containing closed-loop controllers, which we will refer to as Intelligent Responders, located throughout a facility without having to run wires to those devices. All of this is accomplished by taking commands from the controller that would otherwise be hard-wired to a piece of equipment — converting the command to a digitized carrier signal and applying the signal to existing power lines in one location within the building. This signal is then picked up at the equipment to be controlled (HVAC, for example) by a receiver (known as a Responder or Intelligent Responder) that decodes the command and acts upon it. This process is referred to as Power-Line Carrier and is abbreviated as PLC. The medium of transmission can be 120 Vac up to 600 Vac single-phase or three-phase ac power lines or 0 to 24 Vac dedicated lines. The commands can be shunted around voltage step-down transformers to a limited extent.

The choice of which equipment is to be controlled, which sensors are to be interrogated and the requirements of communication to and from the Responders are made by the installer and entered into the program of the energy management equipment (referred to here as Controller). In the conventional PLC system the Controller is point-per-point wired to the Command Synthesizer, which is the line carrier controlling instrument. The Command Synthesizer creates a precise, highly complex signal, which is superimposed (via Signal Couplers) on the ac wiring of the building or onto a dedicated wire run. The point-per-point wiring to the Command Synthesizer can be eliminated in certain proprietary Controllers.

The outgoing PLC commands result in control of a relay or output of an analog voltage at a Responder, which is a PLC remote interface device. Outgoing PLC commands also issue control instructions to the Intelligent Responders. All of this outgoing information originates as DO and AO from the Controller.

Return PLC signals from the Responders report on switch closures, sensed analog values or pulse counts at the Responder and result in control of a relay and/or output of an analog voltage at the Command Synthesizer. Return PLC signals from the Intelligent Responders provide information to the Controller as to the status of the loads being controlled by the Intelligent Responders and the space temperature. All of this incoming information ends up as DI and AI inputs to the Controller.

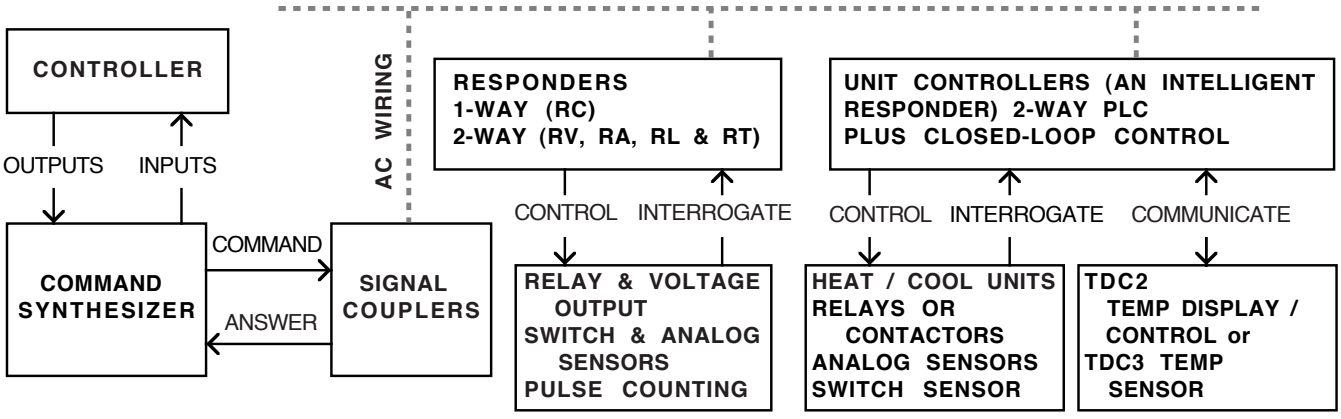
Responders are available in five varieties, which can be selected and mixed for maximum cost savings according to whether or not the application requires transmittal of analog data, switch closure status, command receipt verification, relay output or a combination of these functions.

Intelligent Responders can be intermixed with Responders in a PLC energy management system. Since the Intelligent Responders combine local control of load systems with PLC communication, they provide distributed intelligence without the requirement of running wires throughout the facility.

2. GENERAL OPERATION OF POWER-LINE CARRIER SYSTEMS

This PLC equipment is designed to function properly when it is the only PLC equipment on the electrical service. If it is installed in the same electrical service as other PLC equipment, interference may result. However, many successful systems have been installed in facilities having Simplex Time Clock systems (consult factory).

An energy management system (EMS) utilizing Functional Devices' PLC equipment is composed of as many as eight main components in addition to the building wiring. Referring to the example shown in Dwg. 1, there is a Controller, a Command Synthesizer, one or more Signal Couplers, the ac wiring, many Responders, many loads and sensors, many Unit Controllers (an Intelligent Responder), many Temperature Displays/Controls and many heat pumps or heater/air conditioners (referred to here as Heat / Cool Units).



(Drawing 1) Block Diagram of Possible 2-Way PLC Energy Management System