Honeywell

Excel 15

W7760A BUILDING MANAGER

SYSTEM ENGINEERING

WARNING: This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the Instruction Manual, may cause interference with radio communication. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case, users at their own expense will be required to take whatever measures may be required to correct the interference. Any unauthorized modification of this equipment may result in the revocation of the owner's authority to continue its operation.

Contents

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74-2969-1

List of Figures

List of Tables

INTRODUCTION

Description of Devices

The Excel 15 W7760A Building Manager is a LonMark® compliant device that provides network management functions for the LonWorks® Bus (E-Bus) in a Light Commercial Building Solutions (LCBS) System. See Fig. 1. The W7760A is compatible with the LonWorks® Bus and uses the free topology transceiver (FTT). Individual Excel 10 Controllers and T7300F/Q7300H Series 2000 Commercial Thermostats and Communicating Subbases distributed on the LonWorks® Bus perform specific HVAC equipment control. The W7760A monitors and controls both local and remote controller points. If bus communications are interrupted, the W7760A is capable of stand-alone operation. The W7760A also supports:

- Stop/start loops for controlling loads on a time of day basis.
- Control loops for controlling loads that use PID control algorithms.
- Thermostat loops for controlling loads in a specific application.
- Control programs that perform lighting control and auxiliary functions.
- A method of collecting and presenting alarm information.

The W7760A is used in conjunction with the following devices:

- Excel 15 S7760A Command Display.
- Excel 10 W7750A,B,C Constant Volume AHU (CVAHU) Controller.
- Excel 10 W7753A Unit Ventilator (UV) Controller.
- Excel 10 W7761A Remote Input/Output (RIO) Controller.
- T7770A,D Wall Modules.
- T7300F/Q7300H Series 2000 Commercial Thermostat/Communicating Subbase.
- Q7752A,B Serial LonTalk® Adapter (SLTA).
- Excel 10 Q7740A,B FTT Repeater.

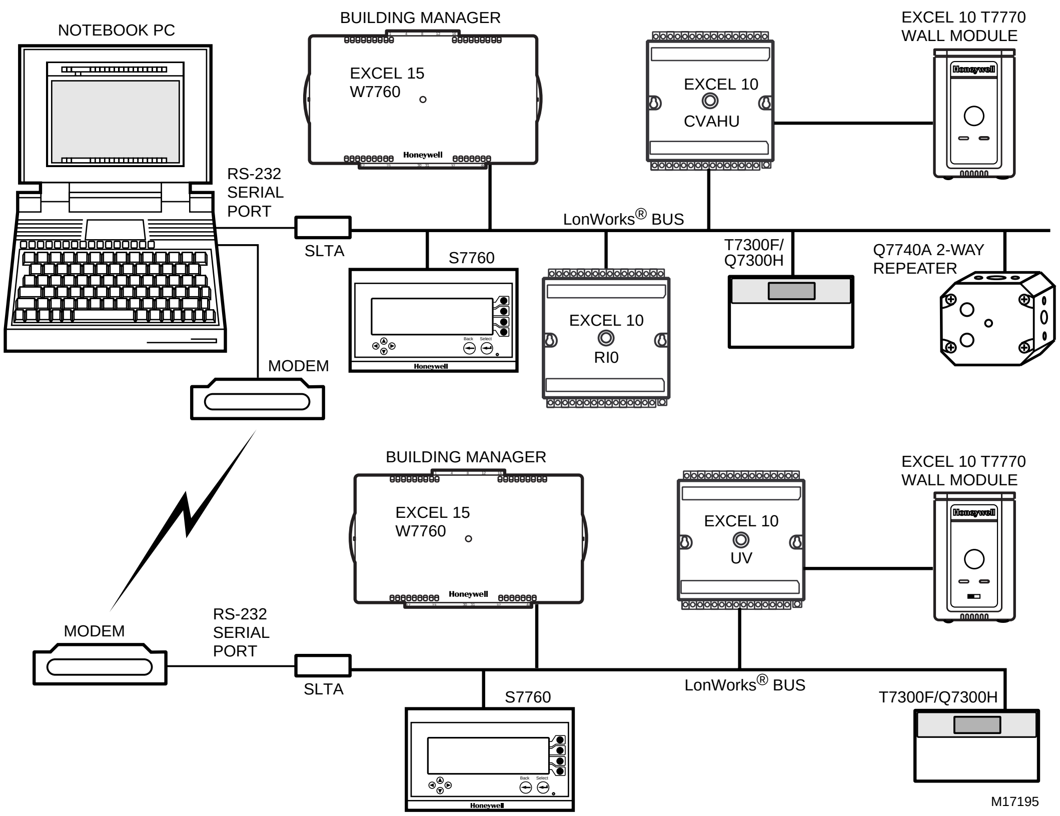


Fig. 1. Typical Building Manager System diagram.

Control Application

Fig. 2 shows a typical W7760A application.

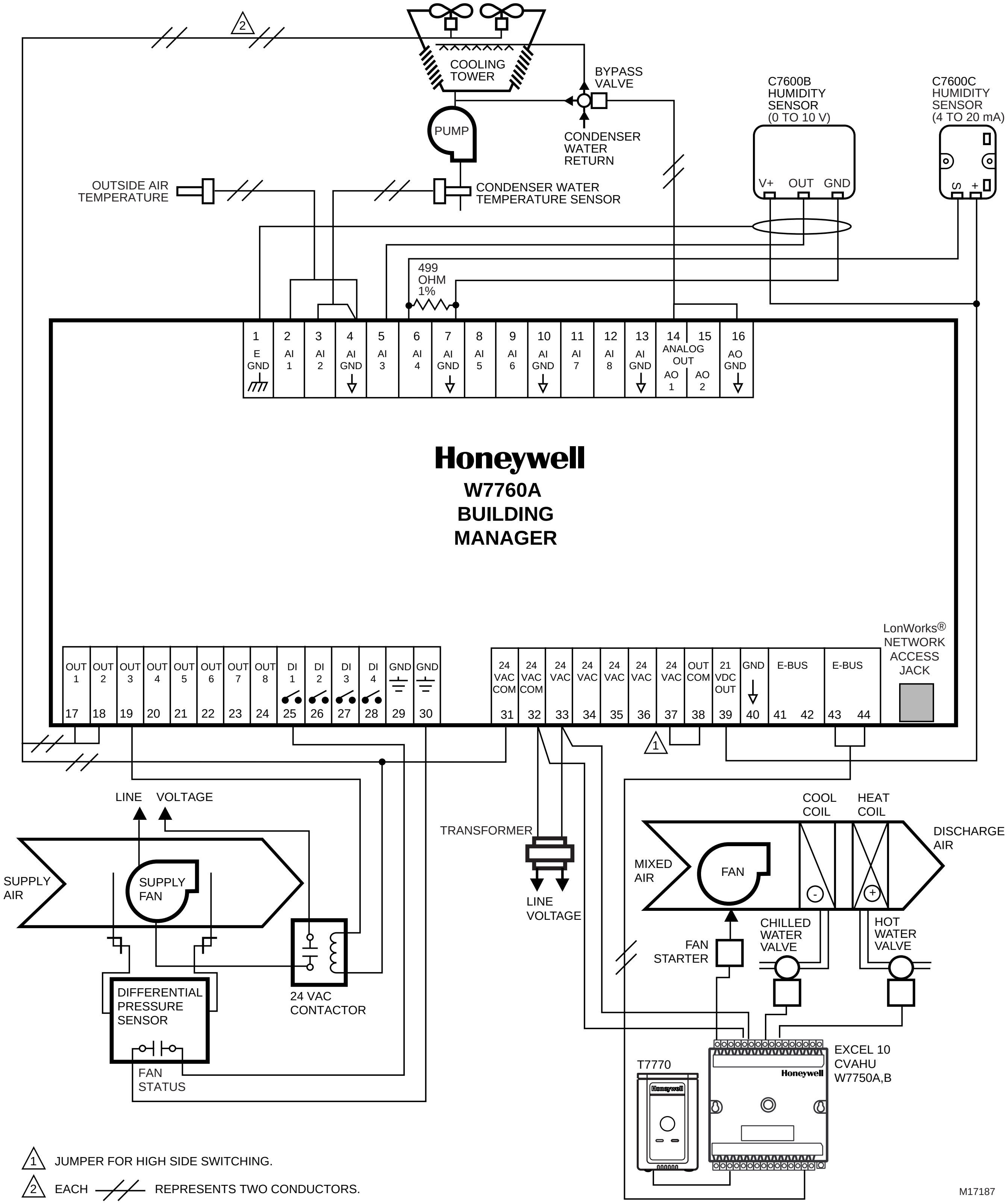


Fig. 2. Typical W7760A application.

Control Provided

The W7760A functions as a network manager between distributed Excel 10 Controllers, T7300F/Q7300H Commercial Thermostat/Communicating Subbases and itself. The W7760A is capable of monitoring its own inputs as well as global inputs from remote Excel 10 Controllers and T7300F/Q7300H Commercial Thermostat/Communicating Subbases. The W7760A has the ability to command both local and remote outputs.

The W7760A is able to:
- Configure stop/start loops for controlling loads on a time of day basis.
- Perform control by PID control loop.
- Accomplish demand limit control by staging off or shedding directly controlled loads or by shifting the setpoints of control loops.

Product Names

The Excel 15 Building Manager is available in 1 model:
- The W7760A2011 Building Manager.

Products Covered

This System Engineering manual describes how to apply the W7760A and related accessories to typical applications. Devices and controllers used in typical applications include:
- Excel 15 W7760A Building Manager.
- Excel 15 S7760A Command Display.
- Excel 10 Controllers:
  - W7750A,B,C Constant Volume AHU (CVAHU) Controller.
  - W7753A Unit Ventilator (UV) Controller.
  - W7761 Remote Input/Output (RIO) Controller.

- Other Devices:
  - T7300F/Q7300H Series 2000 Commercial Thermostat/Communicating Subbase.
  - Q7752A,B SLTA
  - Excel 10 Q7740A,B FTT Repeater.

- Wall Modules:
  T7770A,D Wall Modules.

Organization of Manual

This manual is divided into four basic sections:
1. Introduction: Provides an overview of the W7760A, discusses related devices, lists additional literature, and provides a glossary of abbreviations and definitions.
2. Construction: Describes controller hardware, inputs/outputs, control loops, and other control capability.
3. Application Steps: A step-by-step procedure that provides the information necessary to plan and lay out the W7760A application and accurately order materials.
4. Appendices: Provide information that allows configuration to start using Honeywell's Excel LonSpec™ PC Configuration Tool Software.

The organization of the manual assumes a project is being engineered from start to finish. If changing an existing system, refer to the Table of Contents for relevant sections.

Applicable Literature

Table 1 lists the documents that contain information related to the W7760A and the EXCEL 5000® OPEN™ System.

Table 1. Applicable Literature.

Form No.	Title
74-2976	Excel LonSpec™ Specification Data
74-2977	Excel LonSpec™ Software Release Bulletin
74-2937	Excel LonSpec™ ZL7760A User Guide
74-3069	Excel LonStation™ Specification Data
74-2988	Excel LonStation™ Software Release Bulletin
74-3068	Excel LonStation™ ZL7761A User Guide
74-2865	E-Bus Wiring Guidelines Users Guide
74-2967-1	Excel 15 W7760A Building Manager Specification Data
95-7565-1	Excel 15 W7760A Building Manager Installation Instructions and Checkout and Test
74-2969	Excel 15 W7760A Building Manager System Engineering
74-2970	Excel 15 System Integration Manual
74-2972	Excel 15 S7760A Command Display Specification Data
95-7561-1	Excel 15 S7760A Command Display Installation Instructions
74-2956-1	Excel 10 W7750A,B,C CVAHU Controller Specification Data
95-7521-2	Excel 10 W7750A,B,C CVAHU Controller Installation Instructions and Checkout and Test
74-2958	Excel 10 W7750A,B CVAHU Controller System Engineering
74-2962	Excel 10 W7753A UV Controller Specification Data
95-7520	Excel 10 W7753A UV Controller Installation Instructions and Checkout and Test
74-2964	Excel 10 W7753A UV Controller System Engineering
74-2698	Excel 10 W7761A RIO Controller Specification Data
95-7539	Excel 10 W7761A RIO Controller Installation Instructions and Checkout and Test
74-2699	Excel 10 W7761A RIO Controller System Engineering
63-4365	T7300F/Q7300H Series 2000 Commercial Thermostats and Communicating Subbases System Engineering
63-4366	Q7300H Communicating Subbase System Integration User Address Manual
63-1281	T7300F Series 2000 Commercial Thermostat and Q7300H Communicating Subbase Specification Data
62-0155	Q7300H Series 2000 Commercial Thermostat Communicating Subbases Installation Instructions
62-0125	T7300F Series 2000 Commercial Microelectronic Conventional or Heat Pump Thermostat Installation Instructions
74-2697	T7770A,B,C,D,E,F,G Wall Module Specification Data
95-7538	T7770A,B,C,D,E,F,G Wall Module Installation Instructions
74-2954-1	Q7752A SLTA 10 Serial LonTalk® Adapter Specification Data
95-7511-2	Q7752A SLTA 10 Serial LonTalk® Adapter Installation Instructions
74-3064	Q7752B Type II PC Card PCC-10 PC Card Specification Data
95-7613	Q7752B Type II PC Card PCC-10 PC Card Installation Instructions
95-7555-1	Excel 10 Q7740A,B FTT Repeaters Installation Instructions.
742858-1	Excel 10 Q7740A,B FTT Repeaters Specification Data
95-7554	209541B Termination Module Installation Instructions

Agency Listings

Table 2 provides information on agency listings for the W7760s.

Table 2. Agency Listings.

Device	Agency	Comments
W7760A Building Manager*	UL	UL recognized without panel mounting. Tested and listed under UL916 as Class II device. (File number E4436.)
	cUL	File number E4436.
	CE	Level A
	FCC	Complies with requirements in FCC Part 15 for a Class A Computing Device. Operation in a residential area may cause interference to radio or TV reception and require the operator to take steps necessary to correct the interference.
S7760A Command Display	UL	Tested and listed under UL916. (File number E87741.)
	cUL	File number E87741.
	CE	Emission: EN 55022, Class B; CISPR 22, Class B. Immunity: EN 50082-1, IEC 801-2, IEC 801-3, IEC 801-4, IEC 1000-4-2, IEC 1000-4-4.
	FCC	Complies with requirements in FCC Part 15 for a Class A Computing Device. Operation in a residential area may cause interference to radio or TV reception and require the operator to take steps necessary to correct the interference.

*Enclosures to meet NEMA 1 standards.

Abbreviations and Definitions

AHU - Air Handling Unit; The central fan system that includes the blower, heating equipment, cooling equipment, ventilation air equipment, and other related equipment.

Application - A specific Building Control function.

Binding - The process of logically connecting network variables in one node to network variable(s) in other node(s). Binding is performed by a network management node that writes the binding information into the EEPROM memory of each Neuron® involved. The binding information is saved in the network image of each Neuron®.

Building Manager - A LonMark® compliant device that can be used to monitor and control HVAC equipment and other miscellaneous loads in a distributed network.

CO - Carbon Monoxide; Occasionally used as a measure of indoor air quality.

CO_2 - Carbon Dioxide; Used as a measure of indoor air quality.

Command Display - A device that can be used to monitor and change parameters.

Continuous Trend - A type of log that starts accumulating data after configuration and continues to record data until reconfigured. After a specific number of configured samples are recorded, the data is replaced on a first-in-first-out basis. This results in the most recent data being in the trend at the time of viewing or downloading.

Control Loop - A control function; A type of function in a node that includes processes, loops and programs. A node can contain one or more control loops. (In Excel 10 devices, the control loop occupies the entire node.)

COS - Change of State; COS conditions are used with schedule states such as occupied and unoccupied. Changing from occupied mode to unoccupied mode is a COS.

CPU - Central Processing Unit; an EXCEL 5000® OPEN™ SYSTEM controller module.

cUL - Underwriters Laboratories Canada.

CVAHU - Constant Volume AHU; Refers to a type of air handler with a single-speed fan that provides a constant amount of supply air to the space it serves.

D/X - Direct Expansion; Refers to a type of mechanical cooling where the refrigerant is expanded to its cold state in a heat exchanging coil that mounts in the air stream supplied to the conditioned space.

DDF - Delta Degrees Fahrenheit.

DLC - Demand Limit Control; A function that controls the maximum power demand made on the whole system by shedding some of the demand when power usage exceeds the predefined limit. Shedding requires the turning off of some digital output, or changing a setpoint to a more economical level.

Echelon® - The company that developed the LON® Bus and the Neuron® chips used to communicate on the LonWorks® Bus.

Economizer - Refers to the mixed-air dampers that regulate the quantity of outdoor air that enters the building. In cool outdoor conditions, fresh air can be used to supplement the mechanical cooling equipment saving energy. The dampers are often referred to as economizer dampers.

EEPROM - Electrically Erasable Programmable Read Only Memory; the variable storage area for saving user setpoint values and factory calibration information.

Effective Setpoint - A scheduled setpoint value plus the DLC Bump, plus the Reset amount, plus the Recovery value or occupied setpoint if the system is in TOD Bypass.

EMI - Electromagnetic Interference; Electrical noise that can cause problems with communications signals.

EMS - Energy Management System; Refers to the controllers and algorithms responsible for calculating optimum operational parameters for maximum energy savings in the building.

Enthalpy - The energy content of air measured in BTUs per pound (KiloJoules per Kilogram).

EPROM - Erasable Programmable Read Only Memory; the firmware that contains the control algorithms for the Excel 15 and Excel 10 Controllers.

Excel 10s - A family of application specific HVAC controllers such as the Excel 10 CVAHU, Excel 10 RIO and Excel 10 UV.

Firmware - Software stored in a nonvolatile memory medium such as an EPROM.

Floating Control - Refers to Series 60 Modulating Control of a valve or damper. Floating Control uses one digital output to pulse the actuator open, and another digital output to pulse it closed.

FTT - Free Topology Transceiver.

HVAC - Heating, Ventilating and Air Conditioning.

I x R - I times R or current times resistance; Refers to Ohms Law: V = I x R.

I/O - Input/Output; the physical sensors and actuators connected to a controller.

IAQ - Indoor Air Quality; Refers to the quality of the air in the conditioned space, as it relates to occupant health and comfort.

K - Degrees Kelvin.

Level IV - Refers to a classification of digital communication wire. Formerly known as UL Level IV, but not equivalent to Category IV cable. If there is any question about wire compatibility, use Honeywell approved cables (see Step 5 Order Equipment section).

LonWorks® Bus - Echelon® Corporations LonWorks® Bus network (E-Bus) for communication among Excel 15 Controllers, Excel 10 Controllers and T7300F/Q7300H Commercial Thermostat/Communicating Subbases.

LonWorks® Bus Segment - A LonWorks® Bus network that contains no more than 120 (Excel 15 W7760As, Excel 10s and T7300F/Q7300H Commercial Thermostat/Communicating Subbases). A segment can have a repeater that allows the bus wire length to be doubled.

Mandatory Mechanisms/Objects/Network Variables - Mandatory mechanisms and network variables that are implemented in all the Excel 10 devices.

NamedObject—Objects that have names are called NamedObjects. These objects are visible on the network as functional independent entities and are accessed by name. Typical examples of NamedObjects are Controllers, Control Loops and Logic Function blocks.

NEC - National Electrical Code; The body of standards for safe field wiring practices.

NEMA - National Electrical Manufacturers Association; The standards developed by an organization of companies for safe field wiring practices.

Network Management Node - A LonWorks® node that is responsible for configuring the network, installing the nodes, binding the network variables between nodes, and general network diagnostics.

Network Time Master - A network time master will be the only network device sending out the time/date, all other network devices will use the time/date from the network time master (even if they have their own real time clock). Network time master is chosen/configured from LonSpec™ and remains unchanged until reconfigured, even in the event of a failure on the network time master.

Network Time Scheduler - The network time scheduler sends out current and next state (occupied, unoccupied or standby) and time until next change of state (TUNCOS) to all of its control loops based on the configured schedules.

Network Variables - A class of variables defined in Neuron C that allows communication over the LonWorks® network to other nodes on the network. An output network variable in one node can be bound to corresponding input network variable(s) in other node(s). Changing the value of the output network variable in one node causes the new value to be automatically communicated to the bound input network variable(s) in other node(s). When an input network variable is updated, an nv_update_occurs event is posted at the receiving node(s) so that the application program can take action based on the change. A network management node that explicitly reads and/or writes the network variable can also poll network variables. Network variables can contain one data field (one or two bytes) or multiple data fields (a structure).

Node - A communications connection on a network; For example, an Excel 10 Controller is one node on the LonWorks® Bus network.

NV - Network Variable; An Excel 15 Controller, Excel 10 Controller or a T7300F/Q7300H Commercial Thermostat/Communicating Subbase parameter that can be viewed or modified over the LonWorks® Bus network.

PC - A Personal Computer with a 486 or higher processor that is capable of running Microsoft® Windows® 95.

Pot - Potentiometer. A variable resistance electronic component located on the T7770B,C Wall Modules. It allows the user to adjust setpoints in an Excel 10 Controller or a T7300F/Q7300H Commercial Thermostat/Communicating Subbase.

PWM - Pulse Width Modulated output; Allows analog modulating control of equipment using a digital output on the controller.

RCD - Remote Communication Device: For the Building Manager System, this is a piece of hardware that is functionally compatible to an Echelon® SLTA (Serial LonTalk Adapter) and provides access directly to the LonWorks® Bus.

Recovery Mode or Recovery Period - The time in unoccupied periods when the temperature control is adjusting the control setpoint so that the space temperature reaches the occupied setpoint when the schedule change occurs.

Reset - The reset of a control loop varies depending upon the type of control loop being reset. A reset for a thermostat loop or a control loop changes the setpoint and the algorithm in the energy saving direction. A reset for a start/stop loop causes the digital output to go to the inactive state before returning to its normal scheduled state.

RIO - Excel 10 Remote I/O Device; Additional inputs and outputs that can be configured for use by a Building Manager.

RTC - Real-time clock.

RTD - Resistance Temperature Device; Refers to a type of temperature sensor whose resistance output changes according to the temperature change of the sensing element.

RTU - The Excel 10 CVAHU Roof Top Unit is a W7750 Controller that controls a packaged single zone HVAC unit.

Schedule - The structure that defines the occupancy states, setpoints and the time of the changes between these states.

SLTA - Serial LonTalk Adapter; A serial interface between the RS-232 (serial port on a PC) and a LonWorks® Bus used to adapt transformer-coupled Echelon® messages.

SNVT - Standard Network Variable Type.

TOD - Time-Of-Day; The scheduling of Occupied and Unoccupied times of operation.

TUNCOS - Time Until Next Change Of State is a command that can be sent to other controllers.

UV - Excel 10 Unit Ventilator Controller.

VA - Volt Amperes; A measure of electrical power output or consumption that applies to an ac device.

Vac - Voltage alternating current, ac voltage rather than dc voltage.

VAV - Variable Air Volume; Refers to a type of air distribution system.

VOC - Volatile Organic Compound; Refers to a class of common pollutants sometimes found in buildings. Sources include out-gassing of construction materials, production line by-products, and general cleaning solvents. A VOC is occasionally used as a measure of indoor air quality.

W7750 - The model number of the Excel 10 CVAHU Controllers (also see CVAHU).

W7753 - The model number of the Excel 10 UV Controller (also see UV).

W7760 - The model number of the Excel 15 Building Manager Controller (also see Building Manager).

W7761 - The model number of the Excel 10 RIO Device (also see RIO).

Wall Module - The Excel 10 Space Temperature Sensor and other optional controller inputs are contained in the T7770 Wall Modules. See Application Step 5. Order Equipment for details on the various models of Wall Modules.

CONSTRUCTION

Controller

The W7760A enclosure consists of a subbase and a snap-on cover/electronics assembly (see Fig. 3). The subbase has terminal blocks (for inputs/outputs, communications, and power wiring). There are knockouts (top and bottom) for conduit connections. The cover/electronics module can be installed/removed without interfering with base module wiring terminations. The cover/electronics assembly also includes a diagnostic LED that is visible from the front.

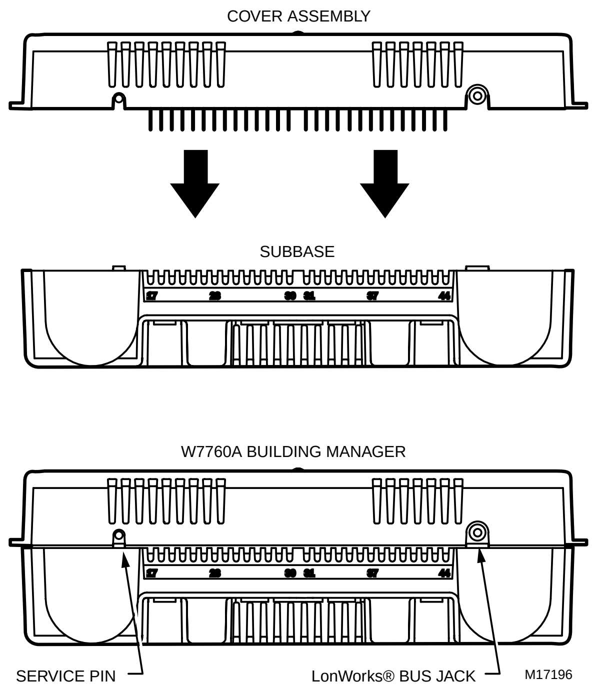


Fig. 3. W7760A enclosure.

The W7760A can mount in any orientation in a surface-mount or DIN rail installation. Ventilation openings enable heat dissipation regardless of the mounting orientation. Surface-mount installations use four screws to secure the base module to the mounting surface. (Use screws appropriate for the mounting surface.) For DIN rail installations, see Fig. 4. Obtain DIN rail from local suppliers, DIN rail standard EN 50 022, 35 x 7.5 mm (1-3/8 x 5/16 in.). Also for every W7760A using DIN rail, purchase locally two each DIN rail adapters part number TKAD from Thomas and Betts.

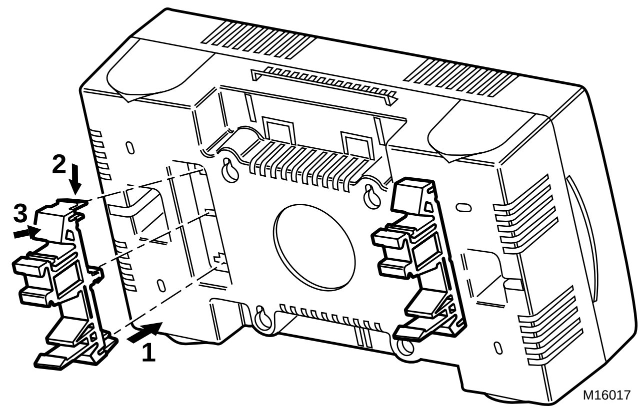


Fig. 4. DIN rail adapters.

The W7760A includes a LonWorks® Bus communication jack to allow a network compatible tool (such as the LonSpec™ configuration tool) to access the LonWorks® Bus (see Fig. 3). A pushbutton switch is available to perform the service pin operation used in the commissioning process (see Fig. 3).

Fig. 5 and 6 shows W7760A dimensions.

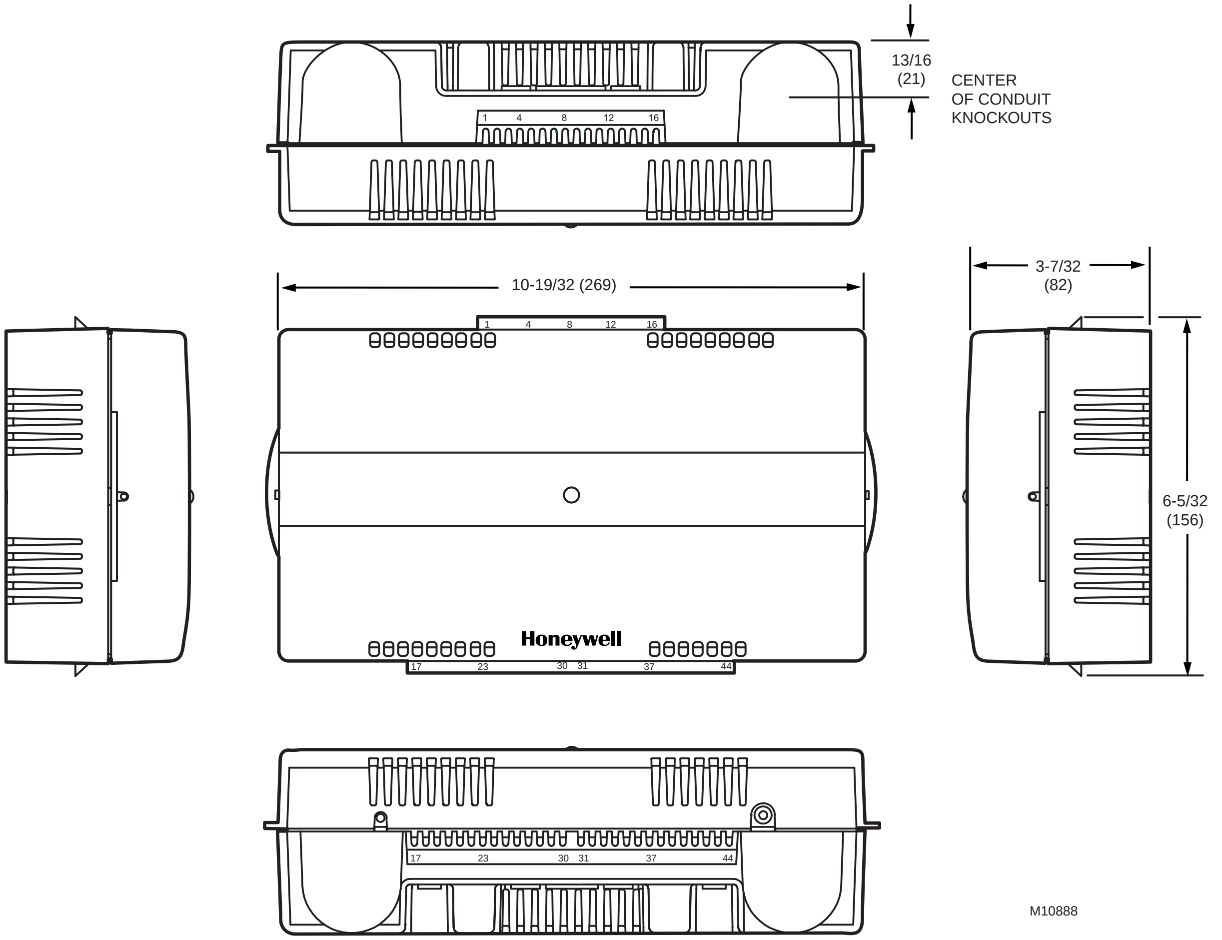


Fig. 5. W7760A dimensions in inches (mm).

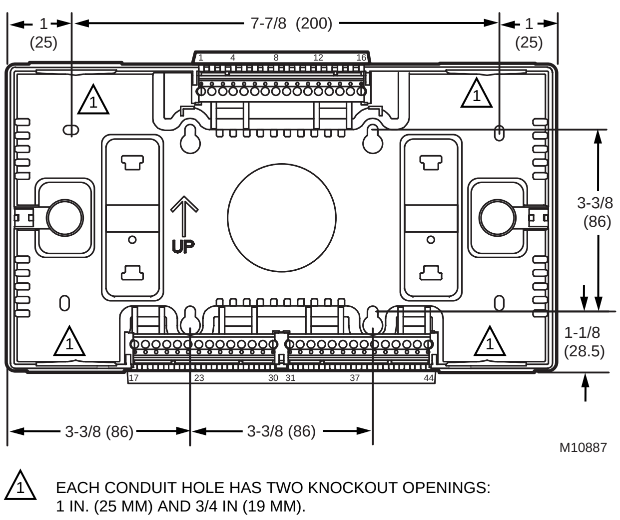


Fig. 6. W7760A subbase mounting dimensions in inches (mm).

Performance Specifications

CPU:
80C51

Memory Capacity:
EPROM for OS and application program.

Input Power:
20 to 30 Vac, 50/60 Hz, 20 VA consumption.
Input power is from a dedicated 24Vac transformer secondary such as a Honeywell AT72D.

Sensor Power Supply:
W7760A provides a 21Vdc (75 mA max.) regulated power supply for powering analog input and output devices.

Triac Outputs:
Current draw for any device (energized) driven by a W7760A Triac outputs must be between 25 mA min. and 500 mA max..

Field Wiring:
Screw terminals accept 14 AWG (2.5 mm^2) wire or smaller.

Environmental Limits:
Operating Temperature: 32 to 113°F (0 to 45°C).
Relative Humidity: 5 to 95 percent non-condensing.
Storage Temp: -4 to 122°F (-20 to 50°C).

Communications:
The W7760A uses a Free Topology Transceiver (FTT) transformer-coupled communications port operating at 78K bps. The transformer-coupled communications interface provides a higher degree of common-mode noise rejection while ensuring dc isolation.

Cable Types:
Cable types for LonWorks® Bus communications wiring: Level IV 22 AWG (0.34 mm^2) plenum or nonplenum rated, unshielded, twisted pair, solid conductor wire.
— Nonplenum areas: Level IV 22 AWG (0.34 mm^2) such as Honeywell Part Number AK3781 (one pair) or Honeywell Part Number AK3782 (two pair).
— Plenum areas: Plenum-rated Level IV, 22 AWG (0.34 mm^2) such as Honeywell Part Number AK3791 (one pair) or Honeywell Part Number AK3792 (two pair).

See Table 20 for a field wiring reference table that lists recommended wire sizes and types.

Contact Echelon® Corp. Technical Support for the recommended vendors of Echelon® approved cables.

Wiring Configuration/Distance:
The FTT supports polarity insensitive free topology wiring. This architecture supports star, bus, mixed, and loop wiring. The maximum LonWorks® Bus length when using a combination of star, loop, and bus wiring (singly terminated) is 1640 ft (500m) with the maximum node-to-node length of 1312 ft (400m).

To extend the bus wiring distance, a Q7740A 2-Way Repeater or a Q7740B 4-Way Repeater can be used. The maximum number of repeaters per segment is one.

When using a doubly terminated LonWorks® Bus structure, use a continuous daisy-chain with no stubs or taps from the main backbone. The maximum LonWorks® Bus length is 4593 ft (1400m) with the maximum node-to-node length of 3773 ft (1150m).

FTT networks are flexible and convenient to install and maintain. However, it is imperative to plan the network layout and to create and maintain accurate documentation. Careful planning and up to date documentation facilitates compliance verification and future FTT network expansion. It also minimizes unknown or inaccurate wire run lengths, node to node (device to device) distances, node counts, total wire length, inaccurate repeater locations, and misplaced or missing terminations. Refer to the E-Bus Wiring Guidelines Users Guide 74-2865 for a complete description of network topology rules.

Input/Output Summary

Table 3 summarizes W7760A inputs and outputs.

Digital Inputs

Digital inputs monitor external conditions by using dry contact closures (10 mA, 5Vdc). The contact closures can be used for initiating alarms, monitoring equipment status, and reading PulseMeters.

The W7760A supports 4 digital inputs (DI1 through DI4):

1. A digital input can sense either maintained or momentary (1 second minimum) contact closures. A maintained contact closure is where the monitored contact input changes condition and remains. A momentary contact closure is where the monitored contact input only needs to stay in one condition for 1 second minimum.
   Normally open (active-short) and normally closed (active-open) contacts are defined in Table 4.

Table 3. W7760A Inputs and Outputs.

Input/Output	Description
Analog inputs	8 analog inputs: — 0 to 10Vdc. — 0 to 20 mA. — PT3000 (platinum 0 to 8,000 ohms), 20K NTC -40 to 240°F (-40 to 116°C) (negative temperature coefficient 810.861K ohms to 0.684K ohms). — digital (contact closure).
Digital inputs	4 digital inputs: (On/off, maintained or momentary counter or PulseMeter.) — 2 capable of utility PulseMeter input. — 2 capable of counter input.
Outputs	— 8 digital outputs: — On/off (maintained or momentary). — PWM (pulse width modulated). — Floating output. — 2 analog outputs: — 4 to 20 mA modulated or (digital 20 mA maximum).
Remote points	Remote points from up to three Excel 10 RIO Devices: — 24 digital outputs. — 12 digital inputs. — 18 analog inputs.

Table 4. Contact states.

Contact	Physical Input State	Logical Input State
Normally open (active-short)	Short	Active
	Open	Inactive
Normally closed (active-open)	Short	Inactive
	Open	Active

2. A maximum of two digital inputs can be configured as counters. A counter can count the number of active inputs within the range of 1 through 65,535 with one pulse resolution. Pulse number 65,536 automatically resets the counter back to 0. A maximum of two digital inputs can be configured as counters.
3. A maximum of two digital inputs can be configured as PulseMeter inputs. PulseMeter inputs are capable of monitoring pulse frequencies for demand meter inputs. If monitoring pulse frequencies for two demand meter inputs, energy from both inputs is summed. There is also the ability to assign one digital input as a synchronization or sync point, which is used with Demand Limit Control.

   The four W7760A digital inputs can read fast/slow pulses. See Table 5.

Table 5. Digital Inputs, Fast/Slow Pulse Capability.

Digital Input	Fast/Slow Pulse Input
DI1 and DI2	Fast or Slow
DI3 and DI4	Only Slow

The W7760A supports 2 fast pulse inputs (see Fig. 7), 2 slow pulse inputs (see Fig. 8), or 1 fast and 1 slow pulse input.

The fast pulse input specifications are:
— Max. frequency: 15 Hz
— Min. Pulse width: 20 ms
— Max. chatter: 5 ms

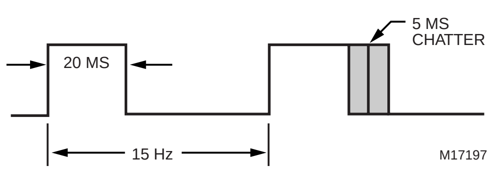


Fig. 7. Fast pulse input.

The slow pulse input specifications are:
— Max. frequency: 4 Hz
— Min. Pulse width: 1.2s
— Max. chatter: 50 ms

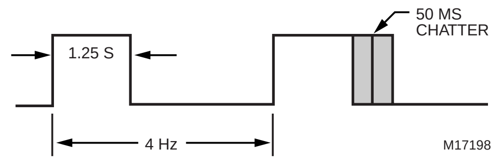


Fig. 8. Slow pulse input.

Fast and slow inputs apply to both PulseMeters and counters.

PulseMeter Scale Factor: Used when the Demand Limit Control (DLC) program uses the input. The scale factor is the KW/Hrs per pulse supplied by the pulsing demand meter (typically provided by the utility company). The DLC program uses the PulseMeter scale factor to determine the current kW demand.

Engineering Units: Kw/Hrs per pulse.

Analog Inputs

Analog inputs monitor external conditions such as temperature, humidity, or pressure. The inputs can be used as inputs to thermostat and control loops or to initiate alarms based on out of range readings.

The W7760A supports up to 8 analog inputs (AI1 through AI8) as follows:
— PT3000 sensor (±10 ohms). The input signal is assumed to be linear over its entire range. The NTC 20K ohm sensor is also selectable over a specific range -40 to 241°F (-40 to 116°C).
— 0 to 10Vdc
— 4 to 20 mA, using an external 500 ohm resistor with a 2 to 10Vdc input
— Digital sensing (contact closure). Analog inputs configured as digital inputs can not be configured as PulseMeter inputs. They are treated as true digital inputs for runtime, alarms, and trends.

Outdoor Air Sensor and Outdoor Humidity Sensor: The LonSpec™ configuration tool provides the ability to define an input as either the outdoor air sensor or the outdoor humidity sensor. If these inputs are selected, the associated values become common to other controllers as an automatic one-to-many function. See Table 6 for Analog Input types.

Table 6. Analog Input Types.

Name	Range
Temp_20KNTC	-40 to 241°F (-40 to 116°C)
Temp_PT3000	-40 to 257°F (-40 to 125°C)
Hum_C7600B	0 to 100 percent
Hum_C7600C	0 to 100 percent

Digital Outputs

Digital outputs can control HVAC equipment, fans, and lighting.

The W7760A supports up to 8 digital outputs (DO1 through DO8). The digital outputs are 24 Vac triacs (500 mA max.) for current sinking. Note that the W7760A is a NEC Class 2 rated device. This listing imposes limits on the amount of power the product can consume or directly control to a total of 100 VA. Interfacing to higher loads requires external relays.

The digital outputs can also be configured as Floating or as PWM outputs for interfacing to third party devices that have PWM to analog converters.

The digital outputs have the following configuration:
— 2 states (output is either energized on or energized off)
— PWM (output is in the range 0.1 to 100.0 sec)
— Floating output

The 2-state output (energized on or energized off) is defined in Table 7.

Table 7. Digital Output States.

Output state	Physical Input State	Logical Input State
Energized On	On	Energized
	Off	De-energized
Energized Off	On	De-energized
	Off	Energized

When an output point is used in a control loop and it is being commanded, the minimum on/off times have highest priority (except when control is in the manual mode).

When control loops are in the manual mode, digital outputs can be manually controlled (commanded on or off) from a network user interface. When in the manual mode, digital output points do not adhere to minimum on/off times.

Analog Outputs

Analog outputs can control variably driven controlled devices such as damper actuators, valve actuators, step controllers, and other transducers.

The W7760A supports up to 2 analog outputs (AO1 through AO2). The analog outputs are 4 to 20 mA current outputs (max. load 600 ohms) with 128 steps, approximately one percent resolution. The analog outputs can be configured as digital outputs with a 20 mA maximum.

The analog outputs have the following default configuration:
— 0 percent equals 4 mA
— 100 percent equals 20 mA

Remote Points

The W7760A can have up to 50 general remote points that can be used to map to Excel 10 Controllers or T7300F/Q7300H Thermostats. The information from these controllers are polled on a regular basis. The polled time is every 5 seconds.

In addition, there are up to 54 remote points that can be associated with up to 3 RIO Devices.

The Remote Points have the following configuration:
— 4 resistive analog inputs and 2 voltage or current analog inputs per RIO.
— 4 digital inputs per RIO
— 8 digital outputs per RIO

These associated remote points are updated 3 times a second.

Configurations

Network Time Master

Overview

Each W7760A includes a real time clock/calendar. However, only one W7760A on a network can be the network time master. The network time master synchronizes the time of day for all other network devices (even if those devices have their own real time clock). The LonSpec™ configuration tool will define which W7760A on the network is responsible for the network time master functions. If the network time master fails, other W7760s on the network operate based on their own real time clock/calendar. A built-in capacitor provides a minimum of 60 hours back-up. (If there are only a T7300F/Q7300Hs and no W7760A in the system, one T7300F/Q7300H can have the time function manually bound to the other thermostats in the system.)

Time Of Day (TOD) Functions

The W7760A real time clock (RTC) runs on either 50/60 Hz line frequency or its internal crystal. The RTC tracks the time of day, day of week, month, and year (including automatic leap year calculations) and synchronizes the time/date for all other network devices.

The LonSpec™ configuration tool enables or disables daylight saving time (DST). To enable DST, from the General configuration tab, check Enable Daylight Savings. Select Day Of The Week from configure Daylight Savings to specify the month and day of the Start Date and End Date. Select the appropriate Start Hour and Stop Hour. In the U.S. DST begins on the first Sunday in April and ends on the last Sunday in October. Once the DST dates are specified, no additional entries are required for subsequent years.

Network Time Scheduler

Overview

Each W7760A is capable of storing and executing time schedules (see Fig. 9) and being a network time scheduler. A network time scheduler issues current and next change of state (occupied, standby, or unoccupied) and time until next change of state (TUNCOS) to all control loops (see Fig. 10). The scheduler also tracks exception/holiday schedules and monitors operating modes. The network time scheduler does not have to be the network time master. It is possible to have multiple network time schedulers on the same network.

The W7760A has 8 schedules with support for assigning these 8 scheduled to a maximum of:

- 8 start/stop control loops
- 6 control loops or thermostat control loops can be configured as either:
  - 6 control loops or
  - 5 control loops and 1 thermostat loop or
  - 4 control loops and 2 thermostat loops
- 20 Excel 10 Controllers or T7300F/Q7300H Thermostats.

Control Loop Schedules

The building blocks for the control loops are the schedules. The W7760A supports up to 8 schedules:

Each schedule contains:

- 7 day schedules for each day of the week
- 3 special exception/holiday schedules
- 2 temporary schedules

Each day schedule has an associated time schedule. (The LonSpec™ configuration tool defines the day and time schedule assignment.) The W7760A supports 8 time of day schedules with up to 6 changes of state (COS) per day. The types of COS include:

- occupied
- standby
- unoccupied

It is not necessary to set up all time schedules; just the ones the user needs.

Special Days

There are three special exception/holiday schedules and two temporary schedule for deviations to the individual day schedules. The exception/holiday schedules define COS times for special days of the year. The temporary schedule accommodates non-permanent operations (used for off-hour maintenance).

Temporary Schedules

Temporary schedules define days or a range of days that will have unusual activity. On these days, temporary events and times are used. An example of a temporary event is staying open 24 hours for inventory or staying in the unoccupied state for a week due to remodeling. The W7760A supports up to two temporary schedules each with up to six events per day.

Exception/Holiday Schedules

Exception/holiday schedules define the special days of the year when building operations are non-standard. Exception/holiday schedules can be recurring or non-recurring. In the U.S., an example of a recurring holiday is Christmas. The date is always Dec. 25th. In the U.S., an example of a non-recurring holiday is Labor Day. The holiday is always the first Monday in September, but the date changes.

The W7760A supports up to 20 Exception/Holiday schedules. The LonSpec™ configuration tool associates each of the holiday schedules with all or specific weekly schedules. It also allows the user to associate on of the weekdays or special days with that holiday.

Continuous Mode

If the W7760A is to be in continuous mode (such as, occupied or unoccupied periods), select one of six events for that particular day and insert a time. Then select the appropriate state for that event. Repeat this step for each day that requires the Continuous Mode.

Scheduler Components

See Fig. 9.

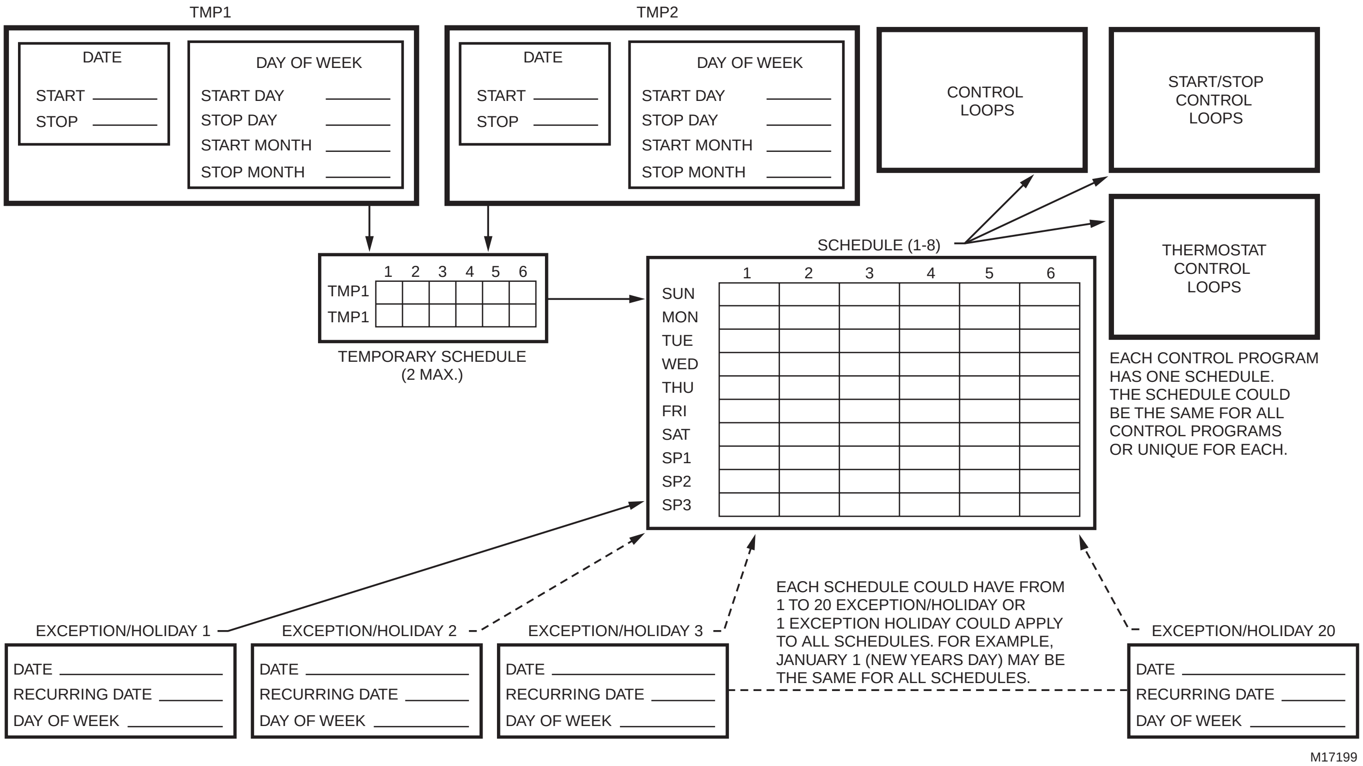
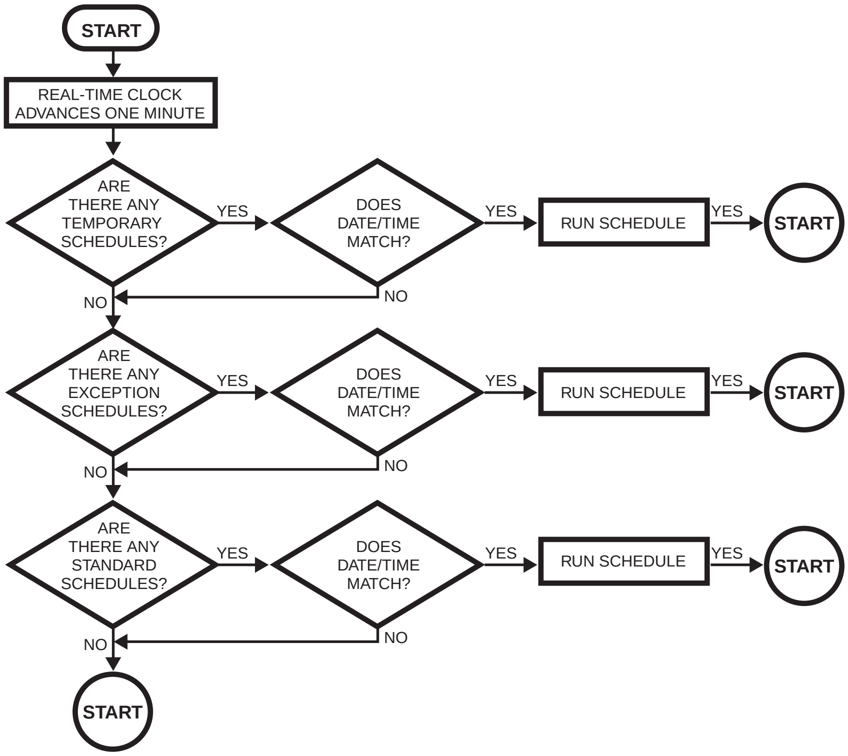


Fig. 9. Scheduler Components.

Time Scheduler Operation

See Fig. 10.



NOTES:
1. THIS FLOWCHART SHOWS THE PRIORITY OF THE VARIOUS SCHEDULES AND HOW THE SOFTWARE APPLIES EACH TYPE.
2. THE TIME SCHEDULER KEEPS TRACK OF ANY TIME DEVIATION, SUCH AS A POWER FAILURE OR A RESET OF THE CURRENT TIME,AND IF AN EVENT SHOULD HAVE OCCURRED THE TIME SCHEDULER ISSUES THE COMMAND.

M17200

Fig. 10. Time Scheduler Operation.

Start/Stop Control Loops

Overview

The start/stop control loops allow direct control of loads based on a time-of-day schedules. The most common applications for start/stop control loops include exhaust fans, pumps, lighting, or any other loads requiring time-of-day control.

Each start/stop loop can command one point digital output either on the W7760A or a remote point.

For simple on/off control, up to eight previously configured local or remote digital output points (or physical or remote analog output points configured as digital output points) can be assigned to a start/stop control loop.

See the following typical procedure:

1. Assign a configured digital output point to the start/stop control loop.
2. Assign the minimum on and off times for the specified output.
3. For each start/stop control loop, assign which schedule it will follow.
4. Assign a Bypass Input (if required)
5. Assign a digital input (Disable Loop), that can turn the loop on or off (if required).
6. Assign an Occupancy sensor input (if required).

Control Loops

Overview

Control loops can be selected as either standard (PID) type or of a non-linear type. Control loops can accommodate many different types of control applications including humidity control, space pressure control, discharge temperature control, and outdoor ambient lighting control. Control loops offer a method to control any single or dual input and single output control loop. See the following:

1. Each loop can have an occupied, unoccupied, and standby setpoint. These setpoints will be used based on the action of the assigned schedule.
2. Automatic control of an auxiliary load, such as a fan or circulating pump that provides continuous or intermittent operation during occupied hours and intermittent operation during unoccupied hours.
3. Selectable PID gains or non-linear parameters as appropriate.
4. Any analog value can serve as the control sensor (a sensor (current, resistance, voltage) an analog logic loop output or loop modulating output.
5. Operation can be direct acting (cooling) or reverse acting (heating), modulating, or a staged output (up to four stages).
6. A second sensor input can reset the setpoint of the control loop.

7. Adaptive Intelligent Recovery™ allows gradual transition from unoccupied to occupied setpoints for any control loop.
8. Demand limit control (DLC) enables selectable setpoint shifts during a demand period. During a demand period the setpoint shifts higher for a direct acting control loop. During a demand period the setpoint shifts lower for a reverse acting control loop. It is also possible to select no temperature setpoint shift.

Analog or Digital Inputs/Outputs

The W7760A provides automatic control of single stage or modulating control loops. LonSpec™ configures the following analog or digital inputs/outputs:

— A digital or analog output can control a device that is a staged or modulation controlled device (for example ModOut1).
— A digital output (for example, AuxOut) can control an auxiliary point such as a supply fan or circulating pump.
— An analog input (for example, MainSensor) can correspond to the sensor input from the controlled area.
— Optionally an analog input (for example, ResetSensor) can be used for reset functions
— An analog Input (for example, RecoverySensor) can be used for Adaptive Intelligent Recovery.

Occupied and unoccupied setpoint assignments are totally flexible. There are no conventions to observe when assigning these setpoints except that they must fall within the sensing range of the sensor being used for control input.

Direct Acting or Reverse Acting Control

Direct-acting or reverse-acting specifies how the controller reacts to a measured change of the monitored process. In direct-acting control, as the measured variable increases, the output of the controller increases. Typical examples of direct acting control are cooling and dehumidification.

In reverse-acting control, as the measured variable decreases, the output of the controller increases. Typical examples of reverse acting control are heating and humidification

Proportional Band

The proportional band determines how a staged or modulating output reacts in relation to the input. In general, if the proportional band is small, the action of the output is fast. However, if the proportional band is large, the action of the output is slow.

If using staged control, the concept of control band can be equated with the stage differential:

— If applying a direct acting or cooling loop, the control action occurs as the measured variable is greater than or equal to the setpoint plus the value of the proportional band. Control action ceases as the measured variable falls below the setpoint.
— If applying a reverse acting or heating loop, the control action occurs as the measured variable is less than or equal to the setpoint minus the value of the proportional band. Control action ceases as the measured variable rises above the value of the setpoint.

If using modulating control, the concept of the proportional band can be equated with the throttling range. The selected proportional band will reflect the total increase or decrease in temperature that will result in the modulating output being in the 100 percent opened position.

— If applying a direct acting or cooling loop, control action begins to open the controlled device as the measured variable rises above the setpoint, until full output is achieved at setpoint plus the proportional band.
— If applying a reverse acting or heating loop, control action opens the controlled device as the measured variable falls below the setpoint, until full output is achieved at setpoint minus the proportional band.

Single Stage Loop Control Using Proportional Control

Determine the extent of control loop action by selecting the setpoint and the proportional band (see Fig. 11).

Direct Acting:

1. As the sensed value exceeds the setpoint plus the value of the proportional band, the digital output is energized.
2. If the sensed value falls below the setpoint, the digital output is de-energized.

Reverse Acting:

1. As the sensed value falls below the setpoint minus the value of the proportional band, the digital output is energized.
2. If the sensed value exceeds the setpoint, the digital output is de-energized.

Single Stage Loop Control Using Proportional Integral Derivative Control (PID)

PID control has three components, which are:

Proportional control - A control algorithm or method in which the final control element moves to a position proportional to the deviation of the value of the controlled variable from the setpoint.

Proportional Integral (PI) control - A control algorithm that combines the proportional control and the integral reset control algorithms. Integral reset virtually eliminates offset by gradually shifting the controlled output in the direction that brings the controlled variable back to the setpoint.

Proportional Integral Derivative (PID) control - A control algorithm that enhances the PI control algorithm by adding a component that is proportional to the rate of change (derivative) of the deviation of the controlled variable. PID compensates for system dynamics and allows faster control response rate reset.

In proportional control, the final control element moves to a position proportional to the deviation of the value of the controlled variable from the setpoint. The position of the final control element is a linear function of the value of the controlled variable. In proportional control systems, the setpoint is typically the middle of the throttling range and the final control element is seldom in the middle of its range, so there is usually an inherent offset between the control point and the setpoint.

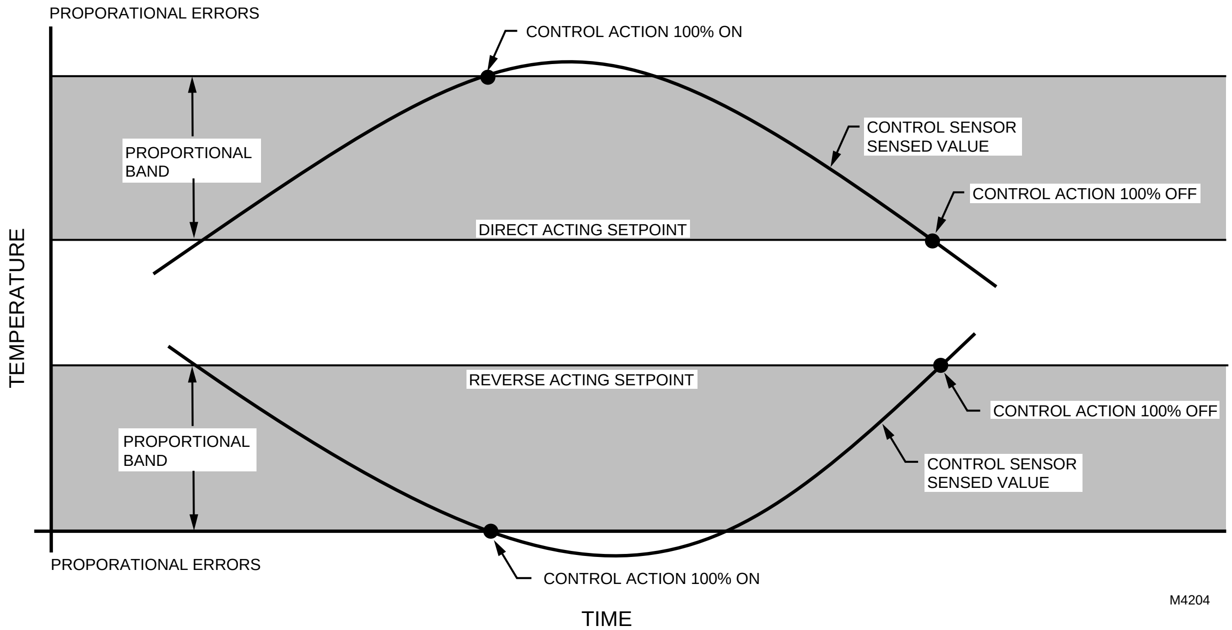


Fig. 11. Single stage proportional control loop.

Although the control point in a proportional control system is rarely at the setpoint, the offset may be acceptable. Generally as a rule, offset is not desired. Proportional Integral (PI) control can be used to eliminate the inherent offset. In the proportional integral (PI) control mode, reset of the control point is automatic and virtually eliminates offset. As soon as the controlled variable deviates above or below the setpoint and offset develops, the proportional band gradually and automatically shifts, and the variable is brought back to the setpoint. The major difference between proportional and PI control is that proportional control is limited to a single final control element position for each value of the controlled variable whereas PI control changes the final control element position to accommodate load changes while keeping the control point at or very near the setpoint. Because offset is eliminated, the proportional band (Throttling Range) is usually set fairly wide to ensure system stability under all operating conditions.

Reset of the control point is not instantaneous. Whenever the load changes, the controlled variable changes, producing an offset. The proportional control makes an immediate correction, which usually still leaves an offset. The integral function tends to make control corrections over time to bring the control point back to the setpoint (see Fig. 12).

With proportional integral control, the position of the final control element depends not only upon the location of the controlled variable within the proportional band but also upon the duration and magnitude of the deviation of the controlled variable from the setpoint.

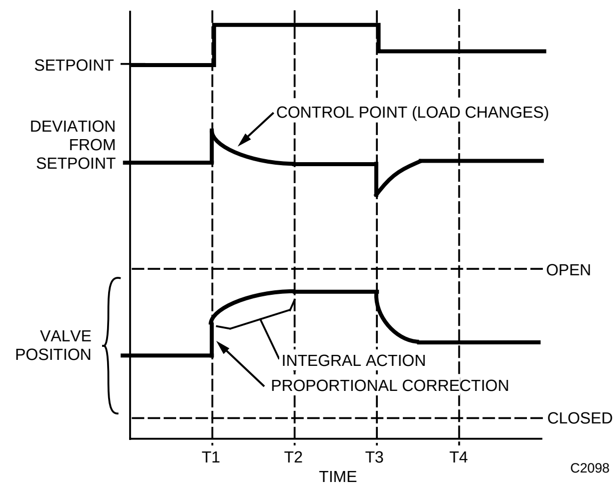


Fig. 12. Proportional Integral Control Response to Load Changes.

Integral windup, or an excessive overshoot condition, can occur in PI control. Integral windup is caused by the integral function making a continued correction while waiting for feedback on the effects of its correction. While integral action keeps the control point at the setpoint during steady state conditions, large overshoots are possible at start-up or during system upsets. On many systems, short reset times also cause overshoot, but the most common cause is when the system being controlled is off or if the heating/cooling medium fails or is not available.

Proportional integral derivative control adds the derivative function to the PI control. The derivative function opposes any change and is proportional to the rate of change. The more quickly the control point changes, the more corrective action the derivative function provides.

If the control point moves away from the setpoint, the derivative function outputs a corrective action to bring the control point back more rapidly than through integral action alone. If the control point moves toward the setpoint, the derivative function reduces the corrective action to slow down the approach to the setpoint, which reduces the possibility of overshoot.

The graphs in Fig. 13, 14, and 15 show the effects of all three modes on the controlled variable at system start-up. With proportional control (see Fig. 13) the output is a function of the deviation of the controlled variable from the setpoint. As the control point stabilizes, offset occurs. With the addition of integral control (see Fig. 14) the control point returns to the setpoint over a period of time with some degree of overshoot. The significant difference is the elimination of offset after the system has stabilized. Adding the derivative element (see Fig. 15) reduces overshoot and decreases the response time.

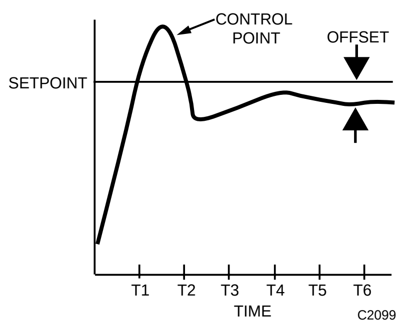


Fig. 13. Proportional Control.

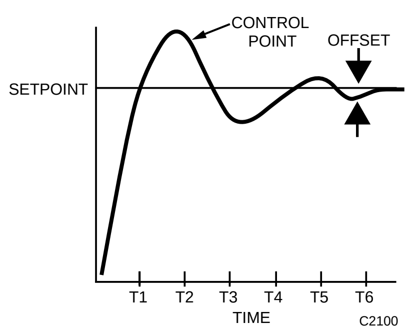


Fig. 14. Proportional Integral Control.

The rate time setting determines the effect of derivative action. The proper setting depends on the time constants of the system being controlled.

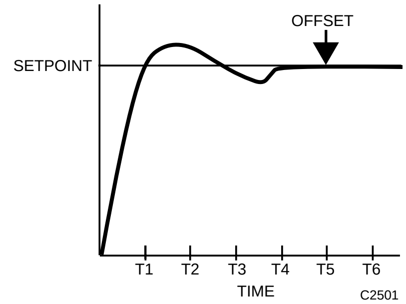


Fig. 15. Proportional Integral Derivative Control.

Determine the components required for the control loop action by selecting the setpoint and the PID gains (throttling range, integral reset time and derivative reset time).

The W7760A is designed to control a wide variety of mechanical systems in many types of buildings. With this flexibility, it is necessary to verify the stability of the temperature control in each different type of application. Occasionally, the PID parameters require tuning to optimize comfort and smooth equipment operation.

The Building Manager is configured by LonSpec™ with default values of PID parameters that are based on the specific mechanical equipment controlled by the W7760A. These default values, see Table 8, are based on past experience with the applications and in most cases do not require further adjustment.

NOTE: A value of 0 for Integ. Gain or Deriv. Gain will disable that function in the PID control.

If the PID parameters require adjustment away from these values, Be careful to ensure that equipment problems do not arise (see CAUTION). If any change to PID control parameters is made, the adjustments should be gradual. After each change, the system should be allowed to stabilize so the effects of the change can be accurately observed. Then further refinements can be made as needed until the system is operating as desired.

⚠ CAUTION

If large or frequent changes to PID control parameters are made, it is possible to cause equipment problems such as short cycling compressors (if the stage minimum run times were disabled). Other problems that can occur include wide swings in space temperature and excessive overdriving of modulating outputs.

Table 8. Recommended Initial Values Of PID Parameters For Control Loop.

Equipment Configuration	Recommended Initial Values		
	Throttling Range	**Integ. Gain**	**Deriv. Gain**
Cooling Tower Bypass Valve Control	25.0	500	0
Hot Water Converter	30.0	300	0

If adjustment of PID parameters is required, use the following. In the items that follow, the term, error, refers to the difference between the measured space temperature and the current actual space temperature setpoint.

— The Proportional Gain (also called Throttling Range) determines how much impact the error will have on the output signal. Decreasing the Proportional Gain amplifies the effect of the error; that is, for a given error, a small Proportional Gain causes a higher output signal value.
— The Integral Gain (also called Integral Time) determines how much impact the error-over-time has on the output signal. Error-over-time has two components making up its value: The amount of time the error exists; and the size of the error. The higher the Integral Gain, the slower the control response. In other words, a decrease in Integral Gain causes a more rapid response in the output signal.
— The Derivative Gain (also called Derivative Time) determines how much impact the error rate has on the output signal. The error rate is how fast the error value is changing. It can also be the direction the space temperature is going, either toward or away from the setpoint, and its speed (quickly or slowly). A decrease in Derivative Gain causes a given error rate to have a larger effect on the output signal.

If the control is not stable using the default values listed in Table 8, then the following method (Ultimate Sensitivity or Ultimate Cycling) can be used to determine the Throttling Range, Integral Gain, and Derivative Gain parameters.

— The Ultimate Sensitivity or Ultimate Cycling method provides an on-site means to set PID parameter values for various Control loops. First, determine the Ultimate Throttling Range (TRu) and the Ultimate Period (Pu). The Ultimate Throttling Range is the largest throttling range that results in a continuous cycling of the process variable. The period of this constant-amplitude cycling is the ultimate period.
— To determine the Ultimate Throttling Range and the Ultimate Period, first remove the integral and derivative modes of control by setting the integral and derivative times to zero. Adjust the throttling range comparatively wide, and insert a small disturbance, such as a slight change in the setpoint. Observe the transient response of the controlled variable. Continue to narrow the throttling range (by 10 percent to 50 percent, depending on the previous trial) until the insertion of the disturbance makes the controlled variable cycle continuously, with cycles of constant amplitude. This throttling range is the Ultimate Throttling Range (TR_u) and the period of oscillation is the Ultimate Period (P_u). Since a throttling range narrower than TR_u will cause unstable operation, the throttling range adjustment must be made in smaller steps once overshooting appears.

Use the equations in Table 9 to calculate the throttling range, integral time, and derivative times. PID control can use three different sets of equations depending on the dynamic responses desired.

In some control loops, operating conditions change considerably over the course of operation. PID parameters obtained at one operating condition may not result in acceptable system performance (or possibly instability) at other operating conditions. Therefore, to determine the most general set of parameters, tune the system at its least stable operating condition. For example, tune a hot water converter at a low steam flow condition. This condition results in a system that requires a wider throttling range, a longer integral time, and a smaller derivative time than a faster system (a higher steam flow condition).

Program and Setpoint Results

The control loop reset provides the capability to construct a program that modifies control over the standard control loop program. Typical applications for reset include outdoor air reset of hot water loop, and space temperature reset of discharge air temperature, and outdoor air reset of chilled water.

The following variables must be configured for each control loop using the reset function:

1. The amount of reset that the primary setpoint is to change is called Maximum Reset Amount. For example, to reset a boiler control setpoint from 180°F to 120°F based on increase in outdoor air temperature, the maximum reset amount is 60°F.
2. The value of the reset or secondary sensor where reset begins is called Start Reset. For example, to reset boiler temperature from 180°F to 120°F when outdoor air temperature is 10°F, the start reset value is 10°F. The W7760A algorithm delivers 180°F discharge water temperature when the outdoor air temperature is 10°F or less.
3. The value of the reset or secondary sensor where reset ends is called Stop Reset. For example, to reset boiler temperature from 180°F to 120°F until outdoor air temperature is 60°F, the stop reset value is 60°F. The W7760A algorithm delivers 120°F discharge water temperature when the outdoor air temperature is 60°F or greater.
4. The reset sensor initiates the resetting action. In an outdoor air reset application, the reset algorithm must have an outdoor air sensor assignment.

Table 9. Equations To Calculate PID Parameters.

Mode of Control	Throttling Range	Integral Time	Derivative Time	Comment
P	2 TR_u	—	—	—
PI	2.2 TR_u	P_u / 1.2	—	—
PID	3.7 TR_u	P_u / 2	P_u / 6	Use to obtain a 1/4-decay ratio curve. In this type of curve, each deviation has one-fourth the absolute value of the preceding deviation.
	5 TR_u	P_u / 3	P_u / 2	Use in applications that cannot tolerate overshoot on start-up; less cycling than with values determined for 1/4-decay ratio curve.
	3 TR_u	P_u / 2	P_u / 3	Use in applications that can tolerate overshoot on start-up; good response to disturbance.

5. The start reset value is always associated with the desired occupied setpoint. The stop reset value is always associated with the desired unoccupied setpoint subject to maximum reset. The setpoint is reset from Start Reset to Stop Reset as the value of the reset sensor changes in the energy saving direction.

Auxiliary Point Operation

Auxiliary point operation is the same for all control loops, whether single stage or modulating control output is used. See Table 10. The auxiliary point can operate in two modes, On or Automatic.

Table 10. Auxiliary Point Mode.

Auxiliary Point Mode	Cycle	Call for Control Action	No Call for Control Action
Continuous Operation	Occupied	On	On
	Unoccupied	On	Off
Automatic/ Intermittent Operation	Occupied	On	Off
	Unoccupied	On	Off

System Switch Operation

A system switch can operate in two modes: Off or Automatic. In the Off mode, all relays assigned to the control loop are de-energized (off) and in their normally wired positions, and analog outputs are at their minimum values. In the Automatic mode, the control loop attempts to maintain required control setpoints.

Time Scheduling

Up to six occupied and unoccupied periods can be assigned per schedule, and a schedule can be assigned to one or more control loops. A scheduled occupied (on) event that controls a control loop causes that loop to control to the occupied setpoint. A scheduled unoccupied (Off) event that controls a control loop causes that loop to control to the unoccupied setpoint.

Adaptive Intelligent Recovery

See the section on Adaptive Intelligent Recovery following the Thermostat Control Loop section.

Non-linear Algorithm

The non-linear algorithm is offered as an alternative to the PID algorithm since its characteristics allow it to provide an output that is more stable than PID under many circumstances. PID is the primary choice, but if there is a problem getting a loop stabilize, then non-linear might be the answer.

The non-linear algorithm will develop an error signal and make relative corrections to reach and maintain zero offset. The main advantage of the non-linear algorithm over the PID algorithm is that the non-linear algorithm can not make large changes in the output. One of the parameters for the non-linear algorithm is Max. drive percentage. This value will limit the amount that the output can change each cycle (refer to the example below). If there is a large change in the control point causing a large offset, PID control will make a large change in the output (for example 50 percent). If the valve or damper is being controlled by a 90 second motor, by the next cycle, it may have only moved a few percent so the PID control will make another large change. This means that the output could be commanded to 100 percent, but the actual motor may only be at about 10 percent. This will tend to cause the PID control to overshoot and become unstable. With the non-linear algorithm, limited to Max. drive percentage per cycle, the commanded output will be closer to the actual motor position which will result in a more stable control with very little overshoot. The non-linear algorithm may work better than PID for systems that have a very slow response or long sensor time constants.

The non-linear algorithm is very successful for loops with output instability or where overshoot is not desirable. For this algorithm the PID gain parameters are redefined and used to designate the parameters of a predefined control surface profile. The three parameters used to describe the control surface are:

1. Max. drive band Throttling Range:
   The absolute error, in units of the setpoint and sensor, at which the output changes by the amount equal to the Max.. drive percentage.
2. Max. drive percentage, Max. motor travel time per controller:
   The percentage the output changes when the absolute value of the loop error is equal to the Max. drive band.
3. Deadband:
   The error at which the algorithm does not take any action, that is, the output remains unchanged.

The following parameters are mapped into the PID gain parameters: throttling range, reset time, and derivative time respectively.

Guidelines for choosing these parameters are as follows:

— Max. drive percentage should not be greater than the amount the actual controlled actuator can change in one control interval.
  For example, if a slow (10 sec) non-linear algorithm is controlling an analog output that is driving a 90 second motor (a 90 second motor takes 90 seconds to travel 100 percent or full stroke of its output range), the amount the actuator can change in 10 seconds is 10/90 = 11 percent. 11 percent is the largest and is a good starting value for the max. drive percentage in this application. This value should be made smaller if the process delays or long sensor time constants make the control overshoot too much or become unstable.

— Max. Drive Band is selected about the same as a PID throttling range. However, it should be at least five to ten times the deadband. A good starting point for the above example is 10°F.

— Deadband is chosen based on the resolution of the inputs and outputs and on the stability of the input sensor signal.
  For example, if trying to control a heating valve with an authority of 50°F and the actuator has only 50 possible effective positions, that means that the output can only control to a 1°F resolution (50°F/50 positions). Since the output is not capable of resolving the output finer than 1°F, then without a deadband to tell the control to stop since it is as close as can be done, or as close as necessary, it will continuously cycle the output back and forth by 1°F to try to get the error to zero (which it can not). The minimum deadband for this application should be 0.5°F. The deadband can be widened to further minimize control actions if desired, and also to alleviate problems with noisy sensor inputs.

Thermostat Control Loop

Overview

A thermostat loop controls commercial single zone HVAC equipment. Thermostat loops can be configured as follows:

— Standard Thermostat
— Heat pump control

Thermostat loops control the temperature of heating and air conditioning units as follows:

1. Automatic changeover from heating to cooling.
2. Automatic control of circulating fan, including continuous or intermittent operation during occupied hours and intermittent operation during unoccupied hours.
3. Specifying cycle rates (from 2 to 12 cycles per hour) for heating and cooling.
4. Specify a schedule to follow.
5. Adaptive Intelligent Recovery is used so occupants are comfortable at occupancy times while using a minimum amount of energy.
6. Demand shift which permits a value (DLC Bump) to provide a temperature shift during a demand excursion. In a cooling mode the temperature setpoint shifts higher during a demand excursion. In a heating mode, the temperature setpoint shifts lower during a demand excursion. It is possible to select no shift also.

Typical operation

In a cooling scenario, as the sensed temperature exceeds the cooling setpoint the cooling begins to cycle.

— Cooling is locked on when the sensor value exceeds the cooling setpoint by 2°F.
— If the temperature falls below the cooling setpoint plus 2°F, cooling begins to cycle. Cooling is locked off when the sensor value falls below the cooling setpoint.

In a heating scenario, as the sensed temperature falls below the heating setpoint, heating begins to cycle.

— Heating is locked on when the sensor value falls below the heating setpoint by 2°F.
— If the temperature increases, heating begins to cycle. Heating is locked off when the sensor value exceeds the heating setpoint.

Time Schedule

Up to six periods per schedule can be configured for standby, occupied, or unoccupied mode. Thermostat loops can be assigned to follow any of the schedules that have been configured. When the time schedule is in one of these periods, then the thermostat loop controls to that periods setpoint.

Single Stage Heating and Cooling Temperature Control

The LonSpec™ configuration tool sets up the system to control cooling, heating, and the circulating fan. Configure the circulating fan output by selecting the appropriate fan choice. From the building space being controlled, an analog input must correspond to the main sensor input (MainSensor). Optionally select an analog input (recovery sensor) to perform Adaptive Intelligent Recovery.

Changeover from Heating to Cooling

Heating to cooling changeover is accomplished by an input from the user interface called the Application mode. A user can command this input point to Heat, Cool, or Auto. In Auto mode, heating or cooling is provided based on the space temperature.

In cooling to heating changeover, after all cooling minimum on and off times are satisfied heating can occur. In heating to cooling changeover, after all heating minimum and off times are satisfied cooling can occur.

Multiple Stage Heating and Cooling

A thermostat control loop can have the following stages, see Table 11.

Table 11. Standard And Heat Pump Multiple Staging.

Standard	Heat Pump
Heat 1	Compressor stage 1
Heat 2	Compressor stage 2
Cool 1	Reversing valve
Cool 2	Aux Heat

The standard thermostat control loop has 2 stages, as follows:

— As sensed temperature falls below the heating setpoint or rises above cooling setpoint, the last stage energized for heating or cooling becomes the cycling stage. The former stage is locked on. This process continues until all stages of heating or cooling have been energized. Only the cycling stage observes the convention of cycle rate.

  The cycling effectively provides a variable duty cycle that modulates the output of the stages to match the current load conditions. For example, if the heat loss for a zone was equal to 7500 Btu/hr and you had two stages of heat available at 5000 Btu/hr capacity, the thermostat algorithm locks on the first stage (5000 Btu/hr) and cycles the second stage at a 50 percent duty cycle (using the configured rate in cycles/hr) to provide the equivalent of 2500 Btu/hr from the second stage.

The heat pump has four stages Compressor Stages 1 and 2, reversing valve, and Aux. heat. A heat pump must have at least one compressor stage and a reversing valve as outputs. The reversing valve changes the function of the indoor and outdoor coil. Under normal air conditioning, the evaporator coil is in the supply duct and the condenser coil is outside. If this is reversed such that the condenser is in the supply duct, then heating results.

Aux. heat, if available, becomes the last stage of heat (2nd stage if one compressor, 3rd stage if two compressors). When the application mode is set to Emergency Heat, then the compressor stages are locked out for heat and the Aux. heat stage becomes the one and only heating stage. In all cases the Aux. heat stage will cycle the same as any other stage.

Adaptive Intelligent Recovery

Adaptive Intelligent Recovery can gradually increase or decrease occupant space temperature setpoint before the occupied periods to ensure it is comfortable and to minimize energy use. For Adaptive Intelligent Recovery to work properly, the following information must be known:

1. Approximate design conditions of the building.
2. Operating characteristics of heating and air conditioning equipment under severe conditions.
3. Approximate balance point of the building (approximate outdoor temperature which does not require heating or cooling).

4. Operating characteristics of heating and cooling where outdoor air temperature is approximately equal to the balance point or approximating moderate conditions.

Adaptive Intelligent Recovery (see Fig. 16) has the following parameters:
— Minimum and Maximum Recovery Temperature.
— Minimum and Maximum Recovery Ramp.

Thermostat loops have parameters for both heating and cooling. Control loops are single side and have just one set of parameters for control.

Maximum Recovery Time/Value - Maximum recovery time is the longest lead time required to achieve the desired occupied setpoint. A sensor can determine the severe conditions. Then the time that the system requires to recover from the unoccupied setpoint under severe conditions can be derived. This value will vary for different geographic locations and equipment types.

Minimum Recovery Time/Value - Minimum recovery time is the shortest lead time required to achieve the desired occupied setpoint. A sensor can determine the moderate conditions. Then the time that the system requires to recover from the unoccupied setpoint under moderate conditions can be derived. This value will vary for different geographic locations and equipment types.

Control Loop Demand Setpoint Shift - Demand shift allows selectable temperature shifts during a demand period. During a demand peak the temperature setpoint shifts higher for a direct acting control loop. During a demand peak the temperature setpoint shifts lower for a reverse acting control loop. The Demand Limit Control (DLC) program monitors the length (time) of the demand setpoint shift. Each control loop has an associated maximum shed time. In addition, staging intervals determine the amount of time that must elapse after the setpoint shifts before the next program in the shed rotation initiates its DLC sequence.
- Each control loop with DLC can suspend the setpoint shift if the value of the selected sensor is greater than or less than a specified amount. This value allows the DLC to be overridden during extreme outdoor temperatures.
- When the restoration process starts, the altered setpoints gradually return to the regular occupied setpoint values at the minimum recovery ramp rate.

Control Loop Configuration Considerations - All digital output points in a control loop will follow the assigned minimum on and off times, including digital outputs used for control point operations as well as auxiliary point operations.

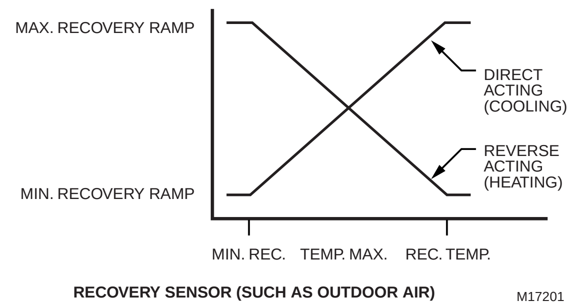


Fig. 16. Adaptive Intelligent Recovery Operation.

Recovery applies to unoccupied to standby, unoccupied to occupied, and standby to occupied modes.

Typically the outdoor air temperature sensor is used as the recovery sensor.

Common Control Loop Inputs/Outputs

The following inputs/outputs are used when configuring control loops and the Demand Limit Control (DLC) program. To clarify which inputs/outputs are associated with a specific type of control loop, each definition includes an S, C, T, or DLC to indicate association with a Start/Stop, Control loop, or Thermostat loop or the DLC program respectively. For complete details on the control loop inputs/outputs, see the LonSpec™ User's Guide form, 74-2937.

Action (C); Action is either Direct or Reverse as follows:

Direct applies to the ModOut1 output. In a control loop, as the sensed value increases above the setpoint the output increases. Typical application is a cooling application. Reverse applies to the ModOut1 output. In a control loop, as the sensed value increases above the setpoint the output decreases. Typical application is a heating application.

Algorithm Type (C); Specifies type of algorithm used by a control loop:

Non-linear; See Non-linear Algorithm in the Control Loops section.
PID; See PID Control in the Control Loops section.

AUX DO. (C**)**; Auxiliary digital output which can have two states (selected by LonSpec™):

Continuous causes the auxiliary output to follow both the Time of Day (TOD) schedule and the output state (see Table 12).

Intermittent causes the output to follow the output state only, that is, stage on or modulated output greater than zero percent.

Table 12 describes the operation.

Table 12. Continuous And Intermittent AUX DO States.

AUX DO Continuous State Operation			
	Call for Heating	**Call for Cooling**	**No call for Temperature Control**
Occupied/Standby	On	On	On
Unoccupied	On	On	Off
AUX DO Intermittent State Operation			
Occupied/Standby	On	On	Off
Unoccupied	On	On	Off

Aux Heat (T); Optional output for the heat pump thermostat selection. If configured, it acts as the final stage of heat, (after the configured compressor stages) or it will be the only stage of heat used if the Application Mode is set to Emergency Heat. (Emergency Heat locks out the compressor.)

Aux Out (C); Digital output intended to turn on a pump or a fan in parallel with outputs. This output is on when the control loop output is enabled.

Binding; See description for Refer Points.

Bypass (S/F/T); A digital input that can be either local or remote. An on condition changes the condition of the loop to use its occupied setpoints for a timed period. When the period (configurable per loop) expires, the setpoints will revert back to the scheduled setpoints.

Bypass Duration (C); 0 to 254 minutes in one minute increments. The amount of time that the control loop is in bypass before it automatically leaves bypass and reverts to the scheduled setpoints.

Bypass Mode (S/C/T); During an unoccupied period, a user can request that the control loop will use the occupied mode setpoints by activating a bypass pushbutton switch on a wall module, or if the loop is currently occupied then it guarantees that the occupied setpoints are followed for the duration period. The bypass switch can be unique to a particular control loop or it can be common to all control loops. On activation of the bypass switch, the control loop(s) remain in bypass mode until:

— Bypass duration setting times out. When configuring the control loop with LonSpec™, the bypass duration time is defined.
— User de-activates the bypass switch and the bypass mode returns to the scheduled mode.
— A manual occupancy command (network input) switches to the occupied mode.

Bypass Time (S/C/T); The time between the activation of the bypass switch, or initiating the occupancy to bypass from the network and the return to the original occupancy state. On activation of the bypass state, the bypass timer is set to the value of 0 to 254 minutes in one minute increments defined on configuration of the control loop.

Change Control Loop Logical Output From 0 to 100 percent to (-50 to +50, use Proportional output bias) (C); If checked, this selection changes the control loop output of 0 to 100 percent from corresponding to a total PID error of 0 to 100 percent to (-50 to +50).

Compressor 1/2 (T); A heat pump term used to identify the heating/cooling operation. A heat pump must have at least one compressor stage and a reversing valve as outputs. The reversing valve changes the operation of the heat pump from cooling to heating or heating to cooling. Therefore, the term compressor becomes universal.

Controlled Output (S); A digital output point, either local or remote, that the loop controls. The actual output action depends on the selection during configuration of the digital output point:
Energized on or de-energized off means the output will be energized (on) in the standby or occupied mode and be de-energized (off) in the unoccupied position.
Energized off or de-energized on causes the opposite operation.

Cool1 (T); Cooling output.

Cool2 (T); Second stage of cooling output (if required).

Cycles per Hour (T); A cycle rate drives the heating and cooling operation. Cycle rate determines the operation of heating and cooling at a 50percent building load. The equipment that is being cycled should be considered when this selection is made. Equipment that is cycled often, is prone to degradation. However, small cycle rates applied to control loops result in wider control swings; larger cycles rates result in smaller control swings and better control. See Table 13.

Table 13. Cycles Per Hour And Operating Off/On Times.

Cycles Per Hour at 50 percent building load	Operating OFF Time	Operating ON Time
2	15.0 minutes	15.0 minutes
3	10.0 minutes	10.0 minutes
4	7.5 minutes	7.5 minutes
6	5.0 minutes	5.0 minutes
8	3.8 minutes	3.8 minutes
10	3 minutes	3 minutes

Some examples of cycle time for various operations; Normal cycle times for DX cooling and Heat pump operation are three to four cycles per hour.

Deadband (DLC); Deadband is a kW range where additional loads are neither shed or restored by the DLC program. Deadband prevents unnecessary cycling of loads when the demand level is close to the setpoint.

Derivative Time (C); The time that the control signal varies according to the rate of change of the error signal.

Disable in Unocc (C); If selected, the system turns off control during unoccupied mode (instead of controlling to the unoccupied setpoints). During unoccupied mode, the modulating output is set to zero (floating drives go to zero) and all stages turn off.

Disable Loop (S); A digital input that can be either local or remote. An on condition disables the control loop.

DLC Assignment (S); Indicates which DLC load will control the shed and restore status of this loop. See Demand Limit Control section for more details.

DLC Bump Value (C); See description for Setpoint DLC Bump Value.

DLC Load Assignment(C); See description for DLC Load Assignment.

Fan (T); An output called AUX DO (auxiliary digital output) which can have two states (selected by the configuration tool):
Continuous causes the fan output to follow both the Time of Day (TOD) schedule and the output state (see Table 12).
Intermittent causes the output to follow the output state only, fan is on.

These outputs function as a fan output and are intended to turn on in parallel with the output of the loop.

Fan Always On Heat (T); Also called Fan On With Heat. Use this option with small furnaces and rooftop units so the fan switches on and off based on supply duct temperature. (The fan will not turn on when there is a call for heat.) This option allows the temperature of the supply air to warm up before being discharged into the space. It also allows the heat remaining in the heat exchanger to be discharged into the space after the stage turns off. Selecting this option disconnects the fan from the heat circuit.

Heat1 (T); Heating output.

Heat2 (T); Second stage of heating output (if required).

Integral Time (C); The time that the control signal varies according to the size and duration of the error signal.

Main Sensor (C/T); Input from the sensor that measures the main building space being controlled.

NOTE: This sensor must be local, not remote.

Max. Rec. Ramp (C/T);Maximum Recovery Ramp. The time associated with the longest cooling or heating lead time required to achieve the desired comfort conditions at occupancy. It is helpful to know how the heating and air conditioning system operate at various outdoor air temperatures, including how long it takes for heating and air conditioning to recover from unoccupied to occupied control under severe conditions.

Max. Rec. Temp (C/T); Maximum Recovery Temperature. The severe condition temperature associated with the longest heating or cooling lead time required to achieve the desired comfort conditions at occupancy. This value varies for different geographic locations.

Max. Reset Amount (C/T); This value determines the maximum value either negative or positive that the setpoint can be reset. It must be in the same engineering units as the setpoint value that is being reset.

Max. Reset Temp. (C/T); This value is the high end of the reset range. It must be in the same engineering units as the setpoint value that is being reset.

Max. Shed Time (DLC); Maximum time that a load can remain shed by DLC.

Min. On Time (DLC); Minimum time that a load must be on before DLC can shed it.

Min. On/Off Times (C/T); Minimum On and Minimum Off times apply to all the digital outputs controlled by the control loop Aux. Out and Stage (1, 2, 3, 4) Out.

Min. Off Time (S); Minimum time that a point can be off before it can turn on. All control loops adhere to this minimum off time except when the loop is in manual mode.

Min. On Time (S); Minimum time that a point can be on before it can turn off. All control loops adhere to this minimum on time except when the loop is in manual mode.

Min. Rec. Ramp (C/T); Minimum Recovery Ramp. The time associated with the shortest cooling or heating lead time required to achieve the desired comfort conditions at occupancy. It is helpful to know how the heating and air conditioning system operate at various outdoor air temperatures, including how long it takes for heating and air conditioning to recover from unoccupied to occupied control under moderate conditions, conditions approaching the building balance point.

Min. Rec. Temp (C/T); Minimum Recovery Temperature. The moderate condition temperature associated with the shortest heating or cooling lead time required to achieve the desired comfort conditions at occupancy. This value for outdoor air would typically be 50°F to 60°F for heating and between 55°F to 65°F for cooling.

Min. shed Time (DLC); Minimum time that load must be shed before DLC can restore it.

Mod Out 1 (C); Analog output that is controlled by this loop.

Modulating Control Loop (C); When the output is greater than zero and any loop stage is on, the Aux Out is on. See AUX DO for more information.

Occupancy Sensor (S/C/T); A digital input that can be either local or remote. This is a device, such as a passive infrared motion detector, that contains a dry contact to indicate whether or not people are present in the space. The Excel 15 W7760A Controller expects a contact closure to indicate the space is Occupied.

Occupied Setpoint (C/T); Desired setpoint during occupancy. The occupied heating setpoint must be equal to or greater than the unoccupied heating setpoint. The Occupied cooling setpoint must be at least 2°F greater than the occupied heating setpoint.

Off Peak Deadband (DLC); Same as peak deadband.

Off Peak Setpoint (DLC); Same as peak setpoint but for off peak hours.

Output Type (C); Specifies type of output used by a control loop:

Modulating; The output changes by small amounts on both increase and decrease.

Override If (DLC); Name of a sensor that causes the DLC program to be disabled. Sensor can be local or remote.

Override Is Above (DLC); A high limit value associated with Override. If the value of the Override is above this value, then DLC is disabled with a 0.9°F (0.5°C) deadband.

Override Is Below (DLC); A low limit value associated with Override. If the value of the Override is below this value, then DLC is disabled with a 0.9°F (0.5°C) deadband.

Override Priority (T); When multiple sources exist for setting occupancy overrides, this input defines the operation. For example, the central or workstation user can command an W7760A loop to unoccupied and the user in the zone can push a configured bypass button to put the same loop into occupied bypass. If the last one wins selection has been made, the override status will be set to whichever of the two was the last to give the command. In the network wins strategy, the override button will have no effect. Only after the override has timed out can the local button override the schedule.

Peak Deadband (DLC); 0 to 1000 kW, 1 kW resolution. A value subtracted from setpoint that creates an area where loads are neither shed or restored.

Peak Setpoint (DLC); The demand limit during the peak time. 0 to 10,000 kW, 1 kW resolution.

Peak Time Schedule (DLC); The times that the power company has determined to be peak and when the charge is the highest for the day. The demand limit or setpoint is different for peak hours and non-peak hours. These values have one minute resolution.

Power Master (DLC); The W7760A defined as the Power Master, is the controller that calculates the final kWh to be used by the DLC programs of all W7760s in that power billing distribution. It also is the W7760A that contains the Energy History log that is valid for the power billing distribution (see the Report section for more information).

Recovery sensor (C/T); A sensor that is used to drive the Adaptive Intelligent Recovery program. It is usually the outdoor air temperature sensor. The outdoor air is a valuable reference to determine how quick a space will warm up or cool down.

Refer Points (C/T); Otherwise known as binding. Refer Points is used to send values from points in one controller (Source) to points in another (Destination) controller(s).

Reset Sensor (C/T); An analog input that can either be local or remote. This sensor resets the setpoint of the control loop.

Reversing Valve (T); The reversing valve output is used with a heat pump application to change the operation from heating to cooling or from cooling to heating. A heat pump configuration must have at least one compressor stage and a reversing valve as outputs.

Reversing Valve Energized (T); This setting determines the output of the reversing valve. If Heating is selected, the reversing valve energizes when commanded to heating. If Cooling is selected, then the reversing valve energizes when commanded to cooling.

Select Schedule (S); Select a predefined schedule of times that defines when the loop is active.

Select Shed Order (DLC); See description for DLC Shed Priority.

Setpoint DLC Bump Value (T); A temperature shift occurs during periods of excessive energy use. The temperature setpoint shifts higher in cooling mode and shifts lower in heating mode. When the critical period ends, the unit returns to normal operation and the setpoint is ramped back to a regular setting over a period of time determined by the field Setback Rate.

Setback Rate (C/T); Rate at which the setpoint changes when the schedule changes from occupied to standby.

Speed (C/T); Specifies frequency that a control loop runs:
Slow, loops runs every 10 seconds.
Fast, loops run every 2 seconds.

Standby Setpoint (C/T); Desired setpoint during standby.

Start Reset Temp (C); Also referred to as Zero Reset Temp. This value is the low end or zero value of the reset range. It must be in the same engineering units as the setpoint value that is being reset. The setpoint on control loops can be reset (in occupied mode only) in either the direction of increased energy savings or in the direction of increased comfort.

NOTE: Reset Sensor is assigned in the Input/Output screen.

For example, a loop controlling a hot water valve is reset by the outdoor air to increase comfort. The outdoor air sensor is assigned to the Reset Sensor. If the Zero Reset Temp. is 65°F, the Max. Reset Temp. is -10°F, and the Max Reset Amount is 60°F (see Fig. 17), as the outdoor air becomes colder the setpoint increases.

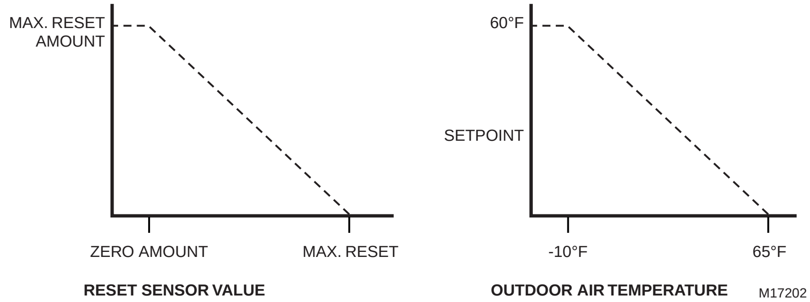


Fig. 17. Reset sensor value.

System Switch (C/T); The system switch can be programmed for two distinct modes. If in off mode, all relays assigned to the thermostat control loop are off in their normally wired positions. If in automatic mode, the thermostat control loop attempts to maintain the required temperature setpoint.

Throttling Range (C); The control point range through which the controlled variable must pass to move the final control element through its full operating range. Express the throttling range as a value of the controlled variable (such as degrees F, percent relative humidity, psi).

Unoccupied Setpoint (C/T); Desired setpoint during unoccupied mode. The unoccupied cooling setpoint must be equal to or greater than the occupied cooling setpoint. See the following descriptions for unoccupied setpoints:
Zero Reset Temp, See the description for Start Reset Temp.
Max. Reset Temp, See the description for Max. Reset Temp.
Max. Reset Amount, See the description for Max. Reset Amount.

Bypass Duration, See the description for Bypass Duration.

Zero Reset Temp); See the description for Start Reset Temp (C).

Logical Operations

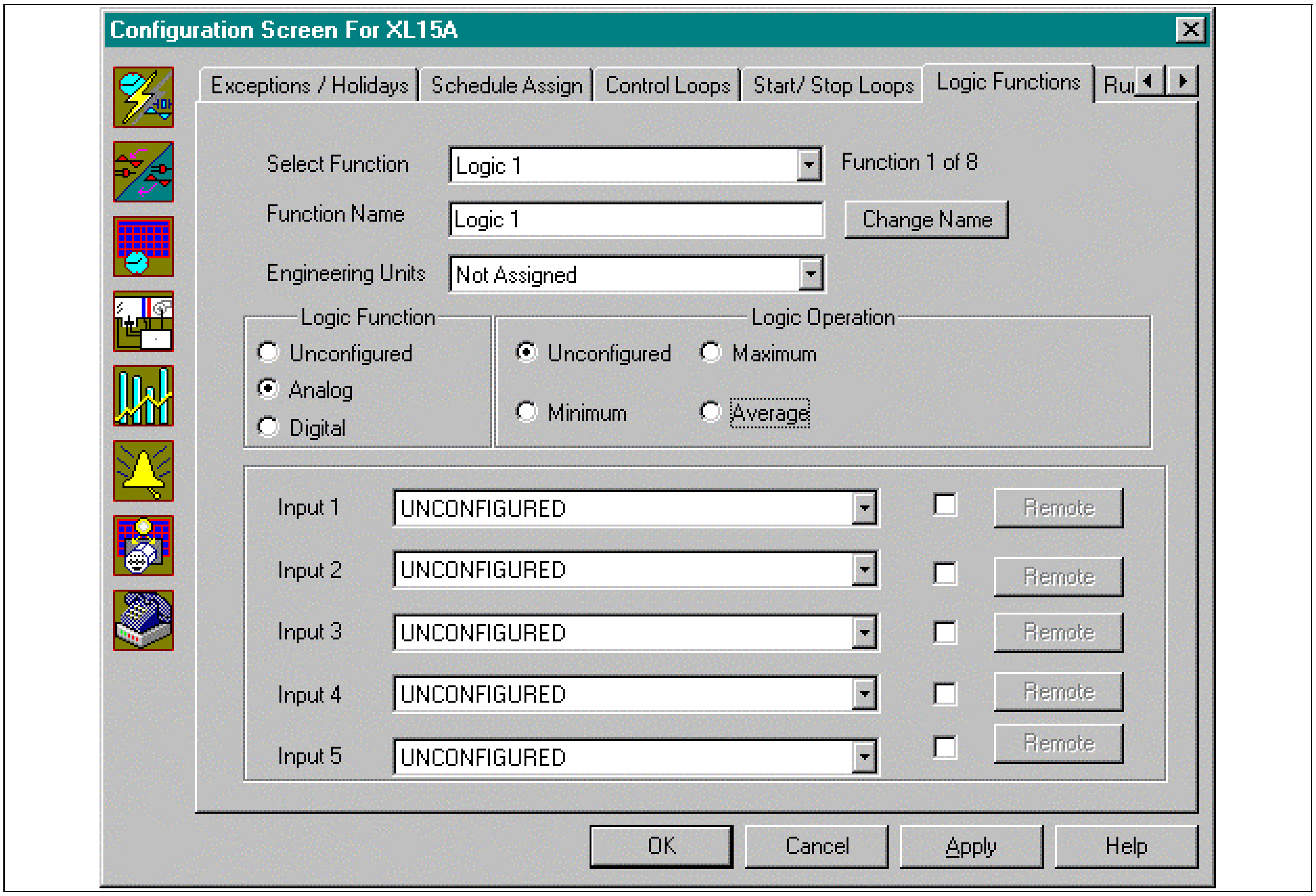
Overview

The W7760A supports both digital (AND, NAND, OR, NOR, XOR, XNOR, NOT) and analog (MINIMUM, MAXIMUM, AVERAGE) logic operations.

The W7760A supports up to eight Logical Functions. They can be any combination of digital or analog functions.

Each Digital Logic Operation (AND, NAND, OR, NOR, XOR or XNOR) can operate on up to five local or remote digital points. Only one local or remote digital point can be selected for a NOT digital logic operation.

Each analog logic operation (Minimum, Maximum or Average) can operate up to five local or remote analog points.



The result of a logic operation can be used as an input to other applications such as control loops or thermostat loops. The output of one logic operation can be used as an input to another logic operation. Results of the logic loops can only be used on local applications (such as control loops or start/stop loops) and cannot be used on external controllers.

Demand Limit Control (DLC)

Overview

The Demand Limit Control program continuously monitors a building's rate of power consumption (kW demand) and sheds/adjusts control loops at times of peak usage. DLC monitors energy consumption by reading a demand meter, typically obtained directly from the local utility company. (If there are more than one W7760A on the bus, then one must be identified as the network master which monitors the PulseMeter and shares the value with the other W7760s.) The goal of DLC is to reduce energy consumption of the overall system at peak usage times.

To prevent demand from exceeding a user specified maximum allowable level (setpoint), DLC automatically sheds/adjusts loads as necessary to maintain demand below setpoint. All loads controlled by DLC are listed in a user defined shed table. The DLC shed table can have 34 loads. The configuration tool assigns variables for each load, including one or more control loops, Min. and Max. Shed Times, and a Min. On Time. Control loops include internal loops (eight start/stop loops plus six control /thermostat loops) and up to 20 external loops for a total of 34 loads. For example:

Load 1 Start/Stop Loop No. 1, Start/Stop Loop No. 2
Load 2 Control Loop No. 1
Load 3 CVAHU No. 1
Load 4 CVAHU No. 2
Load 5 Control Loop No. 2

The Max. Shed Time helps define the shed priority, see Table 14.

Table 14. Maximum Shed Time Definitions.

Max Shed Time	Definition
100	Off Continuous
101	Last Resort Loads
1 through 99	Rotating Loads

— Off Continuous loads are the first loads that DLC can shed. When these loads are shed, they will not rotate back on. They remain off until DLC restores them when demand is below the setpoint minus the deadband.
— Last Resort Loads are shed as a last resort. These loads are shed only if DLC has shed all other possible loads and demand is still not low enough.
— Rotating Loads are shed/adjusted as DLC needs to reduce the demand.

The Min On Time is independent of the shed type and can be zero, if appropriate for the load.

A DLC rotational algorithm determines which loads to shed/adjust first or last according to the order the loads are listed in the shed table and according to the shed priority of the load. For example,

1. Go to load 1 and scan for Off Continuous loads. Shed loads if possible.
2. Repeat for loads 2 through 34. Shed loads if possible.
3. Go to load 1 and scan for Rotating loads. Shed if possible.
4. Repeat for loads 2 through 34. Shed loads if possible.
5. Go to load 1 and scan for Last Resort loads. Shed loads if necessary.
6. Repeat for loads 2 through 34. Shed loads if necessary.

DLC continues to shed/adjust loads until either the demand is below the setpoint (plus deadband) or all loads are shed. (Deadband is a kW range where additional loads are neither shed/adjusted or restored by the DLC. Deadband prevents unnecessary cycling of loads when the demand level is close to the setpoint.) As the energy demand subsides, DLC restores loads in the opposite manner.

DLC is able to shed or reset the setpoint of any or all local control loops (including start/stop loops, control loops, thermostat loops), and 20 groups of Excel 10 loads. As the DLC program requires that energy consumption be reduced, the following happens:

1. Start/Stop control loops assigned to the program have their outputs placed in the off state.
2. Control loops have a Setpoint DLC Bump Value (see Fig. 18) as a parameter assigned by the configuration tool This value can never be less than zero and can never be set beyond the unoccupied setpoint. When the DLC shed input is received by the loop, the controller applies the Setpoint DLC Bump Value amount to the current actual setpoint value that happens to be applied to the current state (occupied, standby).

   When the shed input changes to the restore state, the control loop ramps back to the scheduled setpoint at the Minimum Recovery Rate.

   All remote Excel 10 Controllers perform the same as a control loop when the DLC shed input is received.

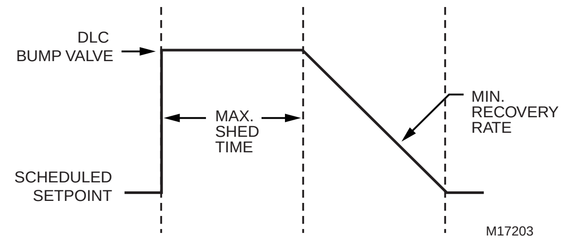


Fig. 18. Setpoint DLC Bump Value Operation.

3. Thermostat control loops have a Setpoint DLC Bump Value as a parameter assigned by the configuration tool. This value can never be less than zero and can never be set beyond the unoccupied setpoint. When the DLC shed input is received by the loop, the controller applies the Setpoint DLC Bump Value amount to the current actual setpoint value that happens to be applied to the current state (occupied, standby). The setpoint is always adjusted in the energy saving direction. When the W7760A is in the heating mode (see Fig. 19) the DLC offset bumps the control point down. When the W7760A is in the cooling mode (see Fig. 20) the DLC offset bumps the control point up.

   When the DLC shed input changes to the restore state, the thermostat loop ramps back to the scheduled setpoint over the specified Minimum Heat or Cool Recovery Rate.

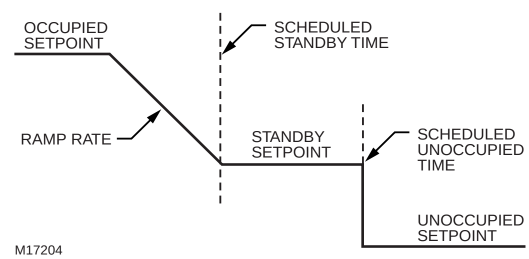


Fig. 19. Intelligent Setback Effective Setpoint Heating.

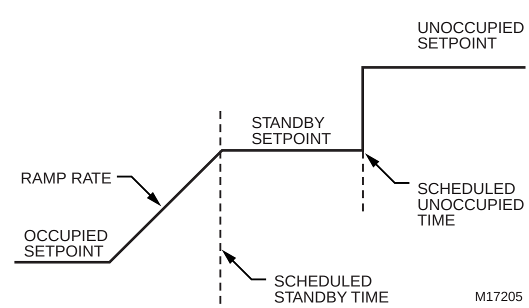


Fig. 20. Intelligent Setback Effective Setpoint Cooling.

The W7760A can sum two on-board (PulseMeter) digital inputs for the total demand as input to the DLC program.

The W7760A defined as the Power Master is the controller that calculates the final kWh to be used by the DLC programs of all W7760s in that power billing distribution. It also is the W7760A that contains the Energy History log that is valid for the power billing distribution (see the Report section for more information).

Dial Out/Dial In

Overview

The W7760A can initiate a dial out to a central work station. This capability allows customers to access remote sites from a central system and provides for remote alarm annunciation at central facilities. In addition, this feature gives personnel remote access during the start up phase of new jobs. Some of the benefits of dial out include:
- Urgent alarms cause dial out to central sites.
- Convenient access to local information.
- Historical data trending and alarm log.

The configuration tool requires information to set up the dial in/out profile, including dial out parameters, dial in parameters, telephone directories, and schedules.

The W7760A will dial out on a periodic basis to indicate normal operation.

The W7760A can be configured to dial out to three phone numbers per time period with a total of three time periods assigned to a 24 hour period.

Reporting

The W7760A supports logs as follows.

Alarm History Log

The W7760A stores an alarm log in capacitor backed RAM (non-volatile) memory. Capacitor memory will hold during power outages for six hours minimum. If it is desired to maintain this log for up to four years, a utility meter battery can be purchased locally (see Order Table 21).The alarm log can maintain the last 50 alarm events. Each alarm in the alarm log includes the date/time, source of alarm, and type of alarm.

TOD Bypass Log

The W7760A supports a TOD bypass log for all scheduled control loops. For each control loop, the W7760A maintains the number of minutes in bypass for the current and previous month, and most recent date/time of bypass.

Runtime Log

The W7760A supports a runtime log for up to 15 digital inputs or outputs. Runtime accumulation has a resolution of ± one minute per I/O activation. Runtime data includes the number of complete hours the input/output has been active (short or open). A user can individually clear each entry in the runtime log.

Trend Log

The W7760A supports trending for up to 16 inputs. (There is a maximum trend sample space of 3072 bytes.) Each trend point includes the following data: input point, sampling interval, type of trend (one-shot, periodic, delta, or continuous), and start/stop date/time. Trend data is stored in capacitor backed RAM for up to six hours in event of a power loss. If it is desired to maintain this log for up to four years, a utility meter battery can be purchased locally (see Order Table 21).

A trend is Continuous when there is no stop time defined and there is a defined number of samples. As new samples are added after the defined number of samples, they overwrite the previously stored values. The samples allow the user to see the last six hours of data. If it is desired to maintain this log for up to four years, a utility meter battery can be purchased locally (see Order Table 21).

A One Shot trend has a start time and a stop time.

A Delta trend refers to the change of state or a particular amount. If the reporting delta is left at zero, any change of state causes a trend sample to be generated.

A Periodic trend means that the point is sampled at a periodic interval (such as once per hour or minute).

Energy History Log

The W7760A maintains an energy history log, with log space for 35 continuous days. Data includes the energy consumed (kWh), peak load (kW), time of peak load, and degree days. For systems with multiple W7760s, the energy history log resides in the W7760A defined as the Power Master.

Alarm Handling

The W7760A handles alarms generated by all control loops that use it as the network time scheduler. An alarm is defined as one or more of the following:
- An analog input exceeding its min. or max. configured value (up to 20 inputs).
- An analog input exceeding the min. or max. delta from a computed setpoint value as defined for flexible and thermostat loops (up to 14 inputs).
- Activation of a digital input (up to 20 inputs).
- A runtime log exceeding a configured value.
- A hardware failure such as power loss, controller reset, and communications failure.

Alarms have user defined pre-delay and post-delay times. The W7760A processes alarms according to alarm priorities. See Table 15.

Table 15. Alarm Routing Priorities.

Routing Priority	Action
DIALOUT, LOG & LOCAL ALARM	Sends out a local bus alarm, initiates a dial out and adds to alarm log.
DIALOUT & LOG	Initiates a dial out and adds to alarm log.
LOCAL ALARM & LOG	Generates a local bus alarm and adds to alarm log.
LOG	Adds to alarm log.
DO NOTHING	None.

NOTE: A numerical alarm priority may be assigned for use by a workstation.

In addition to generating a local bus alarm, the W7760A can be configured to activate a digital output (energized on or off). This function is useful for sites with no Excel 15 Command Display or workstation interface. A digital input (momentary or maintained) can be configured for silencing the digital output. For local bus alarms, the W7760A can re-send the alarm until it is successfully transmitted to all network devices receiving the alarm.

APPLICATION STEPS

Overview

The application steps shown in Table 16 are planning considerations for engineering an Excel 15 W7760A Controller. These steps are guidelines intended to aid understanding of the product I/O options, bus arrangement choices, configuration options, and the role of the W7760A Controller in the overall EXCEL 5000® OPEN™ SYSTEM architecture.

Table 16. Application Steps.

Step No.	Description
1	Plan The System
2	Determine Other Bus Devices Required
3	Lay Out Communication and Power Wiring
4	Prepare Wiring Diagrams
5	Order Equipment
6	Configure Controllers
7	Troubleshooting

Step 1. Plan the System

Plan the use of the W7760A Controllers according to the job requirements. Determine the location, functionality and sensor or actuator usage. Verify that the sales estimate of the number of Excel 15/10 Controllers, T7300F/Q7300Hs, Command Displays, Wall Modules, and other required items is correct. Also check the number and type of output actuators and other required accessories.

When planning the system layout, consider potential expansion possibilities to allow for future growth. Planning is very important to be prepared for adding HVAC systems and controllers in future projects.

The T7770A or T7770D Wall Modules (Remote setpoint input not supported) can be installed as either hardwired I/O only devices or additional wiring can be run to them (for the LonWorks® Bus). This allows a portable PC with the LonSpec™ configuration software to have access to the LonWorks® Bus. The application engineer needs to determine how many T7770 wall modules are required. All T7770 Wall Modules, except the T7770A1006 and the T7770A1014, can be connected via the LonWorks® Bus network access jack. Also the application engineer needs to know how many T7770s without LonWorks® Bus network connections are being installed on the job, and then clearly document which wall modules (if any) have network access. This information is required during installation to ensure that the proper number and type of wires are pulled to the wall modules, and the building operators are informed about where they can plug in to the LonWorks® Bus network with a portable PC (see Fig. 21).

NOTE: For a direct connection of a PC, set the SLTA 10 (FTT) DIP switch number five to on (up).

Refer to Step 4. Prepare Wiring Diagrams for details.

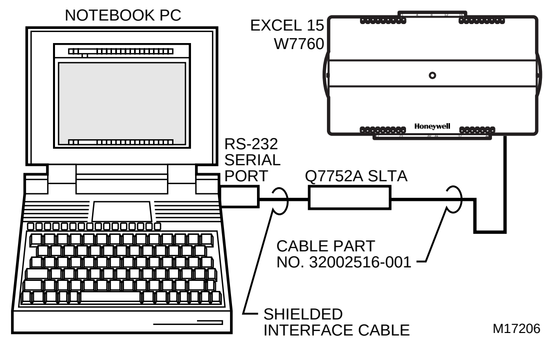


Fig. 21. Connecting the portable PC to the LonWorks® Bus.

The FTT communication wiring, (LonWorks® Bus) between controllers is a free topology scheme that supports star, loop, and/or bus wiring. Refer to the E-Bus Wiring Guidelines form, 74-2865 for complete description of network topology rules. See Application Step 3. Lay Out Communications and Power Wiring for more information on bus wiring layout, and see Application Step 4. Prepare Wiring Diagrams, for wiring details.

The application engineer must review the Direct Digital Control (DDC) job requirements. This includes the Sequences of Operation for the W7760A Controllers, and for the system as a whole. Usually there are variables that must be passed between the W7760A Controllers and other Excel 10 controller(s) that are required for optimum system wide operation. Typical examples are the TOD, Occ/Unocc signal, the outdoor air temperature, the demand limit control signal, and the smoke control mode signal.

It is important to understand these interrelationships early in the job engineering process to ensure implementation when configuring the controllers. (Refer to the LonSpec™ User's Guide form, 74-2937 for configuring information on the W7760A, W7750A/B, W7761, W7753 Controllers and the T7300F/Q7300H Series 2000 Commercial Thermostats and Communicating Subbase.)

Step 2. Determine Other Bus Devices Required

A maximum of 120 nodes can communicate on a single LonWorks® Bus segment. Each LonWorks® Bus device constitutes one node.

Each LonWorks® Bus segment is set up with two unused nodes to allow two portable PCs to be connected to the LonWorks® Bus at the same time. Table 17 summarizes the LonWorks® Bus segment configuration rules.

NOTE: Any LonWorks® Bus can have only one copy of LonSpec™ and one copy of LonStation™ running on that bus.

Table 17. LonWorks® Bus Configuration Rules And Device Node Numbers.

One LonWorks® Bus Segment Example	Maximum Number of Nodes Equals 102
Port for portable PC access	2 nodes
Maximum number of Excel 15s, Excel 10s, and T7300F/Q7300Hs	(For configured controllers and devices with a network schedule:) Up to 4 Excel 15 Building Managers. Up to 80 Excel 10 CVAHU, UV Controllers or T7300F/Q7300H Thermostats/Subbases. Up to 12 Excel 10 RIO Devices. Up to 4 Command Displays. If there are over 60 controllers or devices on a Bus use a Repeater (up to 60 nodes on each side).
Total	102 nodes

NOTE: For a remote connection using modems, set the SLTA 10 (FTT) DIP switch numbers two and six to on (up) and connect the SLTA 10 to the modem using a male DB-9 to male DB-25 cable. This cable should be wired from the DB-9 end to the DB-25 end as follows:

Pin 2	to	Pin 2
Pin 3	to	Pin 3
Pin 4	to	Pin 8
Pin 5	to	Pin 7
Pin 6	to	Pin 20 and 4

Refer to the E-Bus Wiring Guidelines form, 74-2865 for complete description of network topology rules and the maximum wire length limitations. If a longer LonWorks® Bus segment is required, a Q7740A 2-Way or Q7740B 4-Way Repeater can be added to extend its length. Each network segment can have a maximum of one repeater.

All LonWorks® Bus segments require the installation of a 209541B Termination Module for a singly terminated LonWorks® Bus or two 209541B Termination Modules for a doubly terminated LonWorks® Bus. For more details on LonWorks® Bus termination, refer to the E-Bus Wiring Guidelines form, 74-2865, or see Application Step 3. Lay Out Communications and Power Wiring, and the LonWorks® Bus Termination Module subsection in Application Step 4.

Step 3. Lay Out Communications and Power Wiring

Communications

IMPORTANT

*If the W7760A is used on **Heating and Cooling Equipment (UL 1995, U.S. only**) and the transformer primary power is more than 150 volts, connect the transformer secondary to earth ground, see Fig. 22. For these applications,* only one W7760A *Controller can be powered by each transformer.*

The LonWorks® Bus communications bus is a 78-kbps serial link that uses transformer isolation and differential Manchester encoding. Guidelines for communications wiring are as follows:

- All field wiring must conform to local codes and ordinances.
- Approved cable types for LonWorks® Bus communications wiring is Level IV 22 AWG (0.34 mm2) plenum or non-plenum rated unshielded, twisted pair, solid conductor wires. For nonplenum areas, U.S. part AK3781 (one pair) or U.S. part AK3782 (two pair) can be used. In plenum areas, U.S. part AK3791 (one pair) or U.S. part AK3792 (two pair) can be used. Additionally, Echelon® approved cable can be used. Contact Echelon® Corp. Technical Support for the recommended vendors of Echelon® approved cables.
- Unswitched 24 Vac power wiring can be run in the same conduit as the LonWorks® Bus cable.
- Do not bundle output wires with sensor, digital input, or communications LonWorks® Bus wires.
- Do not use different wire types or gauges on the same LonWorks® Bus segment. Using different wire types or gauges can result in line impedance changes that can cause unpredictable reflections on the LonWorks® Bus.
- In noisy (high EMI) environments, avoid wire runs parallel to noisy power cables, motor control centers, or lines containing lighting dimmer switches, and keep at least 3 in. (76 mm) of separation between noisy lines and the LonWorks® Bus cable.
- Each LonWorks® Bus one segment containing up to 102 (see Table 17) Excel 15/10 Controllers, T7300F/Q7300Hs, Command Displays will require the installation of a 209541B Termination Module for a single terminated LonWorks® Bus or two 209541B Termination Modules for a doubly terminated LonWorks® Bus. For more details on LonWorks® Bus termination, refer to the E-Bus Wiring Guidelines 74-2865.
- Make sure that neither of the LonWorks® Bus wires is grounded.
- If a longer LonWorks® Bus segment is required, a Q7740A 2-way or Q7740B 4-way Repeater can be added to extend its length. Each network segment can have a maximum of one repeater.

NOTE: If a 209541B Termination Module is required at a W7760A, connect two of the three termination module wires to the LonWorks® Bus terminals. Selecting the appropriate two wires depends on the LonWorks® Bus network topology. Refer to the E-Bus Wiring Guidelines 74-2865, and the Excel 10 FTT Termination Module Installation Instructions 95-7554. For example, if using a doubly terminated daisy-chained bus topology the devices are on either end of an LonWorks® Bus wire run, mount the termination module on the appropriate terminals as shown in Fig. 23.

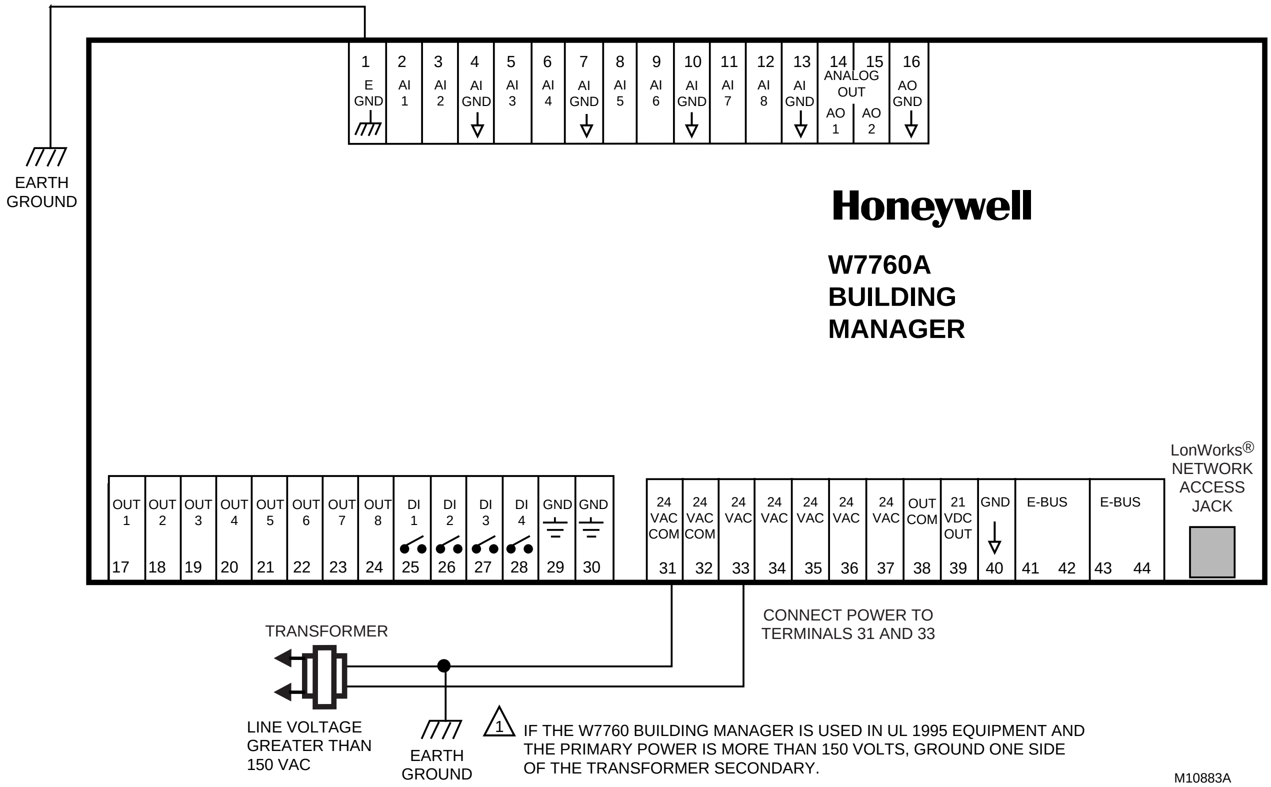


Fig. 22. Transformer power wiring details for one W7760A used in UL 1995 equipment (U.S. only).

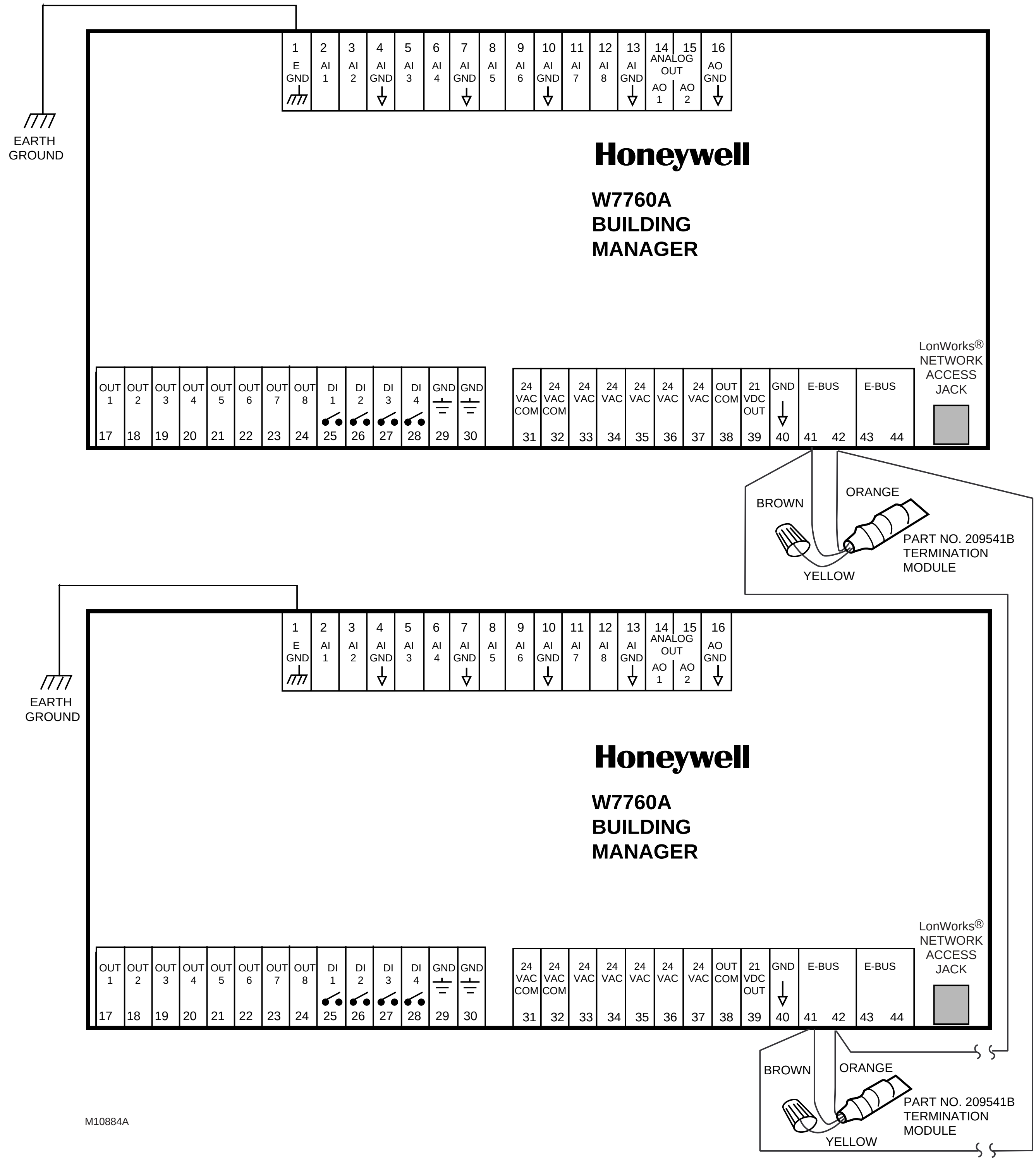


Fig. 23. Termination modules (Doubly Terminated LonWorks® Bus).

Connect the LonWorks® Bus cable to the W7760A communication terminals 41 and 42 or 43 and 44. For daisy chain wiring, see Fig. 27 note 1.

NOTE: If terminals 41 and 42 on the LonWorks® Bus are used as inputs and 43 and 44 are used as outputs (see Fig. 30) and the snap-on cover/electronics assembly is removed from the subbase, then this causes the LonWorks® Bus to have a break in it. To prevent the break from occurring, attach jumpers as shown in Fig. 27 note 1.

Wire to the terminal blocks as follows:

NOTE: When attaching two or more wires, other than 14 AWG (2.0 mm^2), to the same terminal, twist wires together (see Fig. 24). Deviation from this rule can result in improper electrical contact.

1. Strip 1/2 in. (13 mm) insulation from the conductor.
2. Insert the wire in the required terminal location and tighten the screw to complete the termination.
3. If two or more wires are being inserted into one terminal location, twist the wires together a minimum of three turns before inserting them.
4. Cut the twisted end of the wires to 3/16 in. (5 mm) before inserting them into the terminal and tightening the screw.
5. Pull on each wire in all terminals to check for good mechanical connection.

Fig. 25 and 26 show two typical LonWorks® Bus segment network topologies.

Fig. 25 shows a typical LonWorks® Bus segment network topology with one doubly terminated LonWorks® Bus segment that has 120 nodes or less. Fig. 26 shows a typical LonWorks® Bus segment network with one singly terminated LonWorks® Bus segment that has 120 nodes or less. The bus configuration is set up using the LonSpec™ configuration tool.

NOTE: For specific wiring details, see Step 4. For wall module wiring, use U.S. part AK3782 (non-plenum) or U.S. part AK3792 (plenum). For an LonWorks® Bus that is a doubly terminated daisy-chain, these cables contain two twisted pairs (one for the run to the wall module, and one for the run back to the controller) for ease of installation.

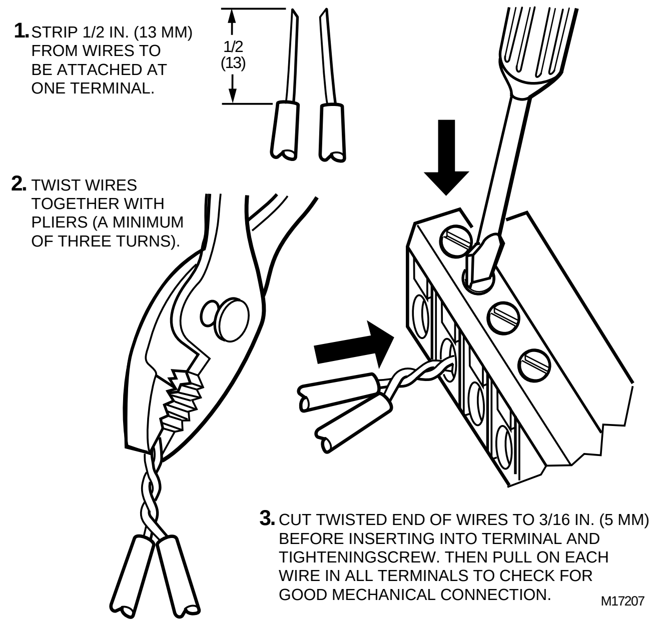


Fig. 24. Attaching two or more wires at terminal blocks.

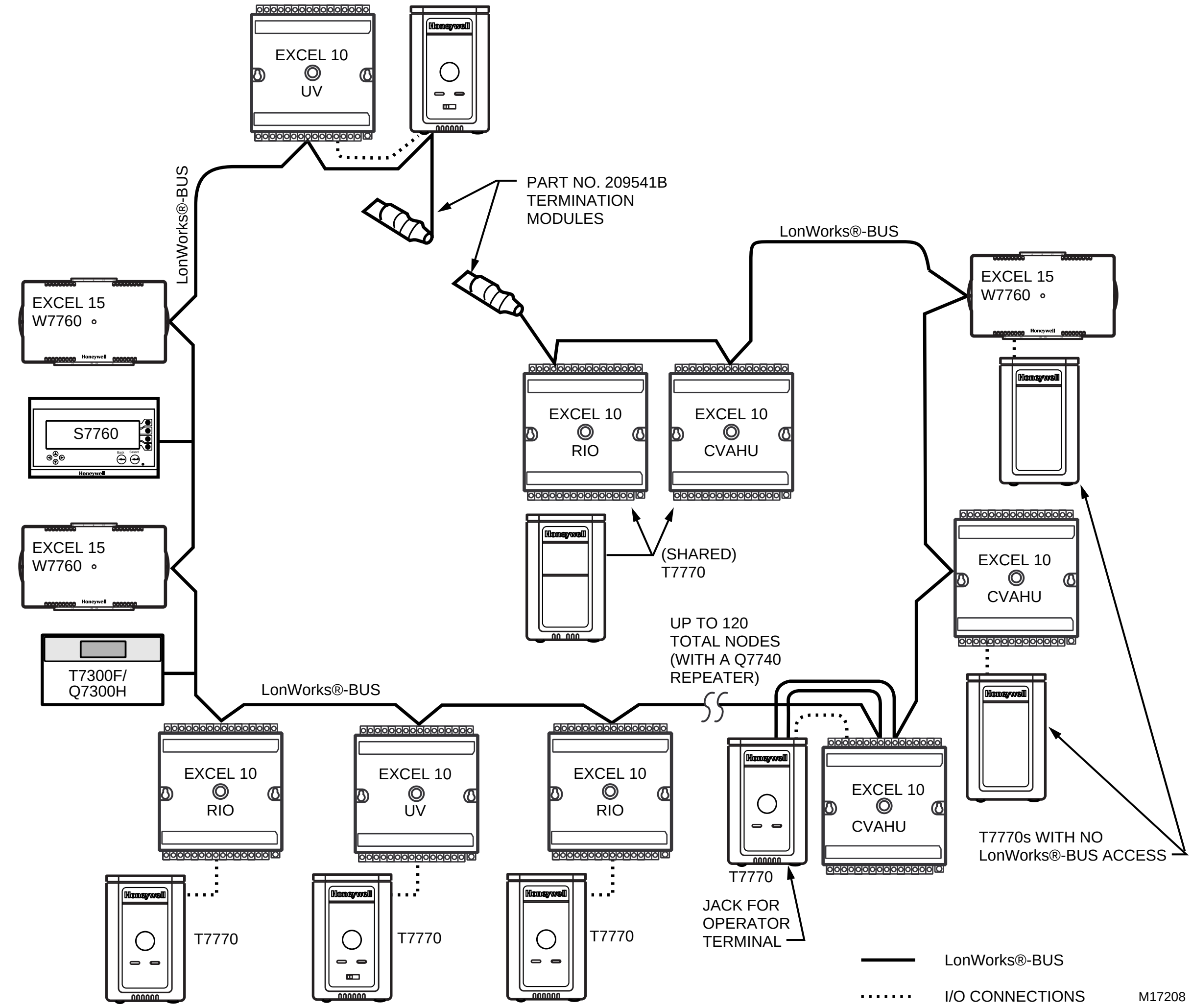


Fig. 25. Wiring layout for one doubly terminated daisy-chain LonWorks® Bus segment.

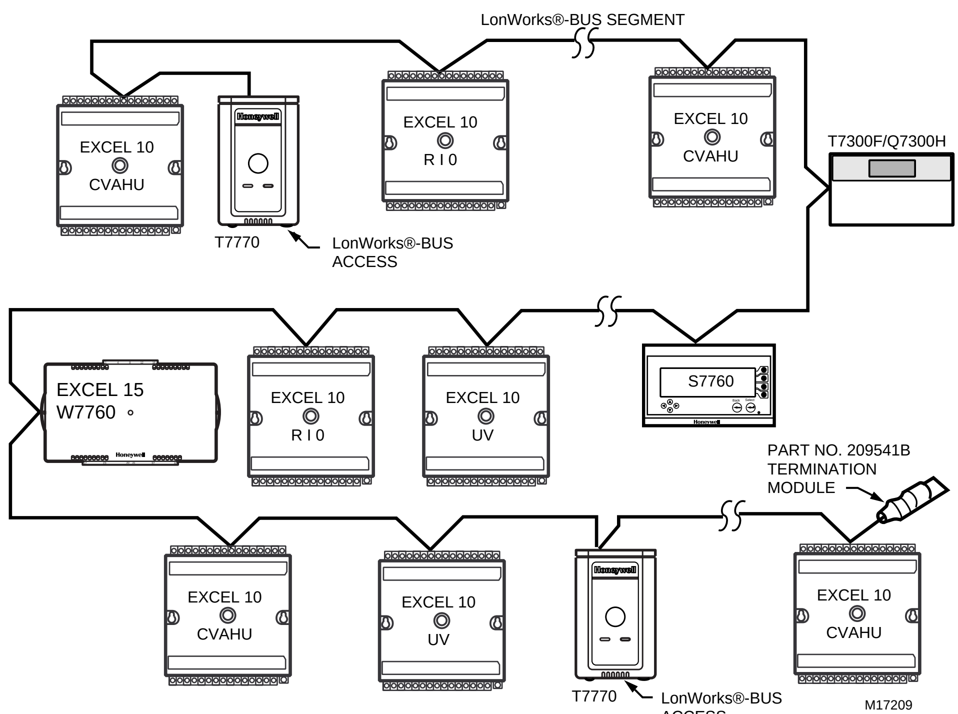


Fig. 26. Wiring layout for one singly terminated LonWorks® Bus segment.

Power

A power budget must be calculated for a W7760A to determine the required transformer size for proper operation. A power budget is simply the summing of the maximum power draw ratings (in VA) of all the devices to be controlled by the W7760A. This includes the W7760A itself, the equipment actuators (ML6161, or other motors) and various contactors and transducers.

Power Budget Calculation Example

The following is an example power budget calculation for a typical W7760A Excel 15 Building Manager.

Assume a W7760A unit with a fan, two stages of D/X cooling, modulating steam valve for heating, and modulating economizer dampers. The power requirements are:

Device	VA	Information Obtained from
Excel 15 W7760A Building Manager	20.0	W7760A Specification Data
ML6161 Damper Actuator	2.2	TRADELINE® Catalog
R8242A Contactor fan rating	21.0	TRADELINE® Catalog in rush rating
D/X Stages	0.0	(NOTE: For this example, assume the cooling stage outputs are wired into a compressor control circuit and, therefore, have no impact on the power budget.)
M6410A Steam Heating Coil Valve	0.7	TRADELINE® Catalog, 0.32A at 24 Vac
TOTAL	43.9	

The Excel 15 System example requires 43.9 VA of peak power; therefore, a 75 VA AT88A Transformer could be used to power one Excel 15 Systems of this type, or a 100 VA AT92A Transformer could be used to power two of these Building Managers and meet NEC Class 2 restrictions (no greater than 100 VA). See Fig. 27 and 28 for illustrations of power wiring details. See Table 18 for VA ratings of various devices.

The Excel 15 System example requires 43.9 VA of peak power; therefore, a 75 VA AT88A Transformer could be used to power one Excel 15 Systems of this type, or a 100 VA AT92A Transformer could be used to power two of these Building Managers and meet NEC Class 2 restrictions (no greater than 100 VA). See Fig. 27 and 28 for illustrations of power wiring details. See Table 18 for VA ratings of various devices.

Table 18. VA Ratings For Transformer Sizing.

Device	Description	VA
W7760A	Excel 15 W7760A	20.0
ML6161A/B	Damper Actuator, 35 lb-in.	2.2
R8242A	Contactor	21.0
R6410A	Valve Actuator	0.7
MMC325	Pneumatic Transducer	5.0
ML684	Versadrive Valve Actuator	12.0
ML6464	Damper Actuator, 66 lb-in.	3.0
ML6474	Damper Actuator, 132 lb-in.	3.0
ML6185	Damper Actuator SR 50 lb-in.	12.0

For contactors and similar devices, the in-rush power ratings should be used as the worst case values when performing power budget calculations. Also, the application engineer must consider the possible combinations of simultaneously energized outputs and calculate the VA ratings accordingly. The worst case, that uses the largest possible VA load, should be determined when sizing the transformer.

Each W7760A requires 24 Vac power from an energy-limited Class II Power Source. To conform to Class II restrictions (U.S. only), transformers must not be larger than 100 VA. A single transformer can power more than one W7760A Controller. Fig. 27 shows power wiring details for a single device and Fig. 28 shows multiple devices using one transformer.

IMPORTANT

Use the heaviest gauge wire available, up to 14 AWG (2.0 mm^2) with a minimum of 18 AWG (1.0 mm^2), for all power and earth ground wiring. Screw type terminal blocks are designed to accept only one 14 AWG (2.0 mm^2) conductor. Two or more wires that are 14 AWG (2.0 mm^2) can be connected with a wire nut. Include a pigtail with this wire group and attach the pigtail to the terminal block.

Guidelines for power wiring are as follows:

— For multiple controllers operating from a single transformer, the same side of the transformer secondary must be connected to the same power input terminal in each device. The earth ground terminal (W7760A Terminal 1) must be connected to a verified earth ground for each controller in the group, see Fig. 27 and 28. Controller configurations are not necessarily limited to two devices, but the total power draw including accessories cannot exceed 100 VA when powered by the same transformer (U.S. only).

— All loads on a W7760A must be powered by the same transformer that powers the W7760A.

- Keep the earth ground connection (W7760A Terminal 1) wire run as short as possible. Refer to Fig. 27 and 28.
- Do *not* connect earth ground to W7760A analog or digital ground terminals (W7760A Terminals 4, 7, 10, 13, and 16, Terminals 29 and 30, and Terminal 40). Refer to Fig. 27 and 28.
- Unswitched 24 Vac power wiring can be run in the same conduit as the LonWorks® Bus cable.
- Maintain at least a 3-in. (76 mm) separation between Triac outputs and LonWorks® Bus wiring throughout the installation.

IMPORTANT

If the W7760A is used on ***Heating and Cooling Equipment (UL 1995, U.S. only)*** *and the transformer primary power is more than 150 volts, connect the transformer secondary to earth ground, see Fig. 22. For these applications,* only one W7760A *Controller can be powered by each transformer.*

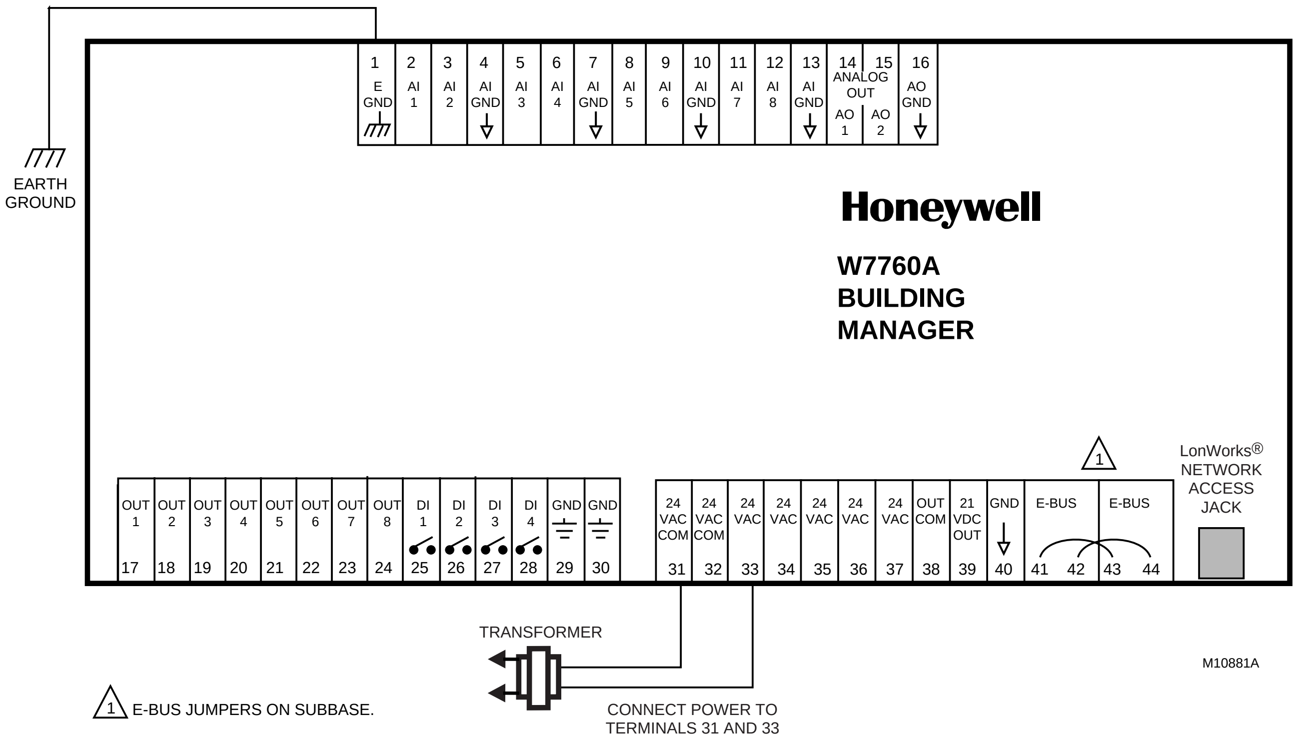


Fig. 27. Power wiring details for one W7760A per transformer.

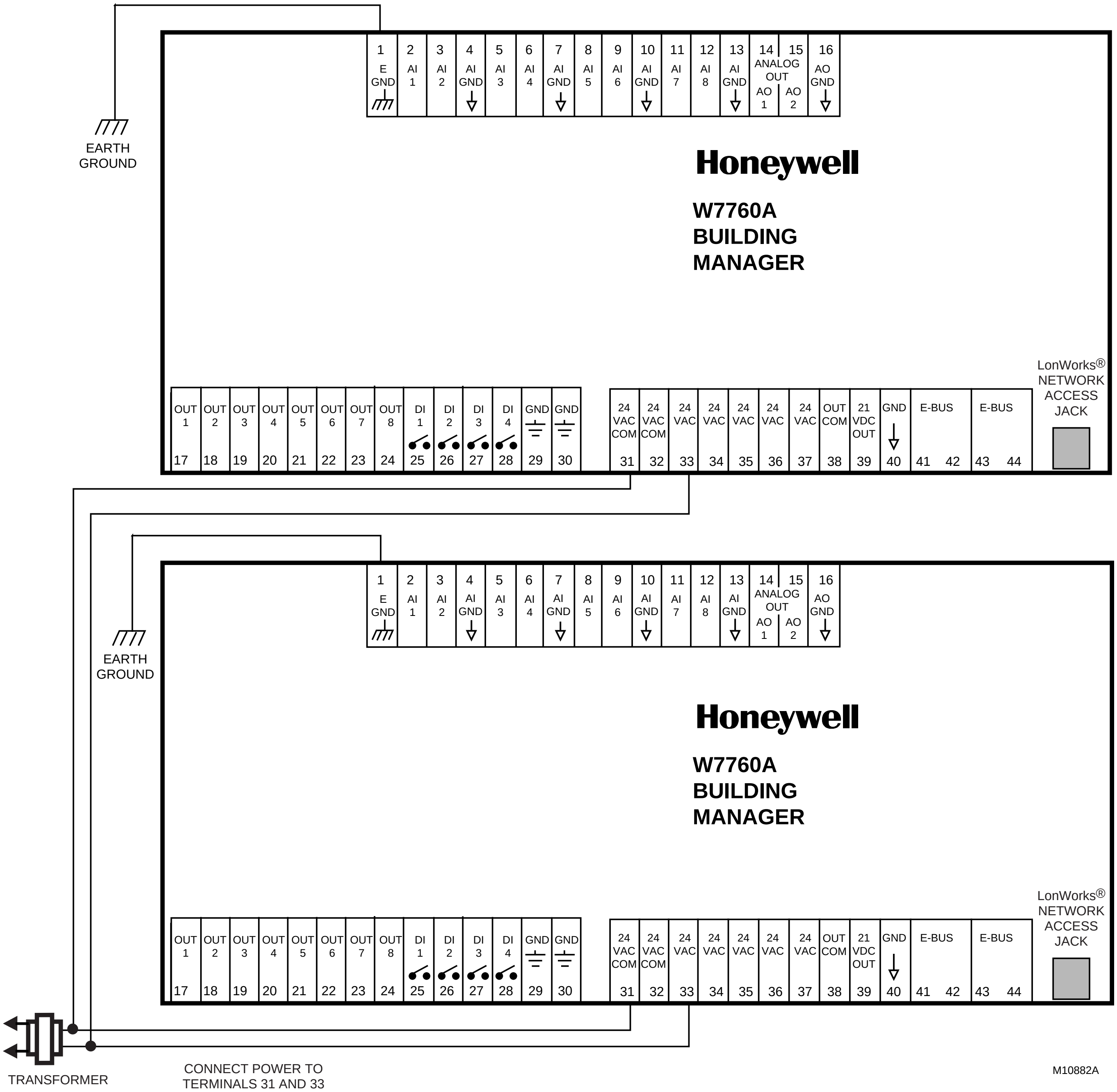


Fig. 28. Power wiring details for two W7760s per transformer.

Line Loss

Excel 15 Controllers must receive a minimum supply voltage of 20 Vac. If long power or output wire runs are required, a voltage drop due to Ohms Law (I x R) line loss must be considered. This line loss can result in a significant increase in total power required and thereby affect transformer sizing. The following example is an I x R line loss calculation for a 200 ft (61m) run from the transformer to a W7760A Controller drawing 37 VA using two 18 AWG (1.0 mm^2) wires.

The formula is:

Loss = [length of round-trip wire run (ft)] x [resistance in wire (ohms per ft)] x [current in wire (amperes)]

From specification data:

18 AWG (1.0 mm^2) twisted pair wire has 6.52 ohms per 1000 feet.

Loss = [200ft) x (6.52/1000 ohms per ft)] x [(37 VA)/(24V)] = 4.02 volts

This means that four volts are going to be lost between the transformer and the controller; therefore, to assure the controller receives at least 20 volts, the transformer must output more than 24 volts. Because all transformer output voltage levels depend on the size of the connected load, a larger transformer outputs a higher voltage than a smaller one for a given load. Fig. 29 shows this voltage load dependence.

In the preceding I x R loss example, even though the controller load is only 37 VA, a standard 40 VA transformer is not sufficient due to the line loss. From Fig. 29, a 40 VA transformer is just under 100 percent loaded (for the 37 VA controller) and, therefore, has a secondary voltage of 22.9 volts. (Use the lower edge of the shaded zone in Fig. 29 that represents the worst case conditions.) When the I x R loss of four volts is subtracted, only 18.9 volts reaches the controller, which is not enough voltage for proper operation.

In this situation, the engineer basically has three alternatives:

1. Use a larger transformer; for example, if an 80 VA model is used, see Fig. 29, an output of 24.4 volts minus the four volt line loss supplies 20.4V to the controller. Although acceptable, the four-volt line-loss in this example is higher than recommended. See the following ***IMPORTANT***.
2. Use heavier gauge wire for the power run. 14 AWG (2.0 mm^2) wire has a resistance of 2.57 ohms per 1000 ft which, using the preceding formula, gives a line-loss of only 1.58 volts (compared with 4.02 volts). This would allow a 40 VA transformer to be used. 14 AWG (2.0 mm^2) wire is the recommended wire size for 24 Vac wiring.
3. Locate the transformer closer to the controller, thereby reducing the length of the wire run, and the line loss.

The issue of line-loss is also important in the case of the output wiring connected to the Triac digital outputs. The same formula and method are used. The rule to remember is to keep all power and output wire runs as short as practical. When necessary, use heavier gauge wire, a bigger transformer, or install the transformer closer to the controller.

IMPORTANT

No installation should be designed where the line loss is greater than two volts to allow for nominal operation if the primary voltage drops to 102 Vac (120 Vac minus 15 percent).

To meet the National Electrical Manufacturers Association (NEMA) standards, a transformer must stay within the NEMA limits. The chart in Fig. 29 shows the required limits at various loads.

With 100 percent load, the transformer secondary must supply between 23 and 25 volts to meet the NEMA standard. When a purchased transformer meets the NEMA standard DC20-1986, the transformer voltage regulating ability can be considered reliable. Compliance with the NEMA standard is voluntary.

The following Honeywell transformers, see Table 19, meet this NEMA standard (Fig. 29):

Table 19. Honeywell Transformers VA Rating.

Transformer Type	VA Rating
AT40A	40
AT72D	40
AT87A	50
AK3310 Assembly	100

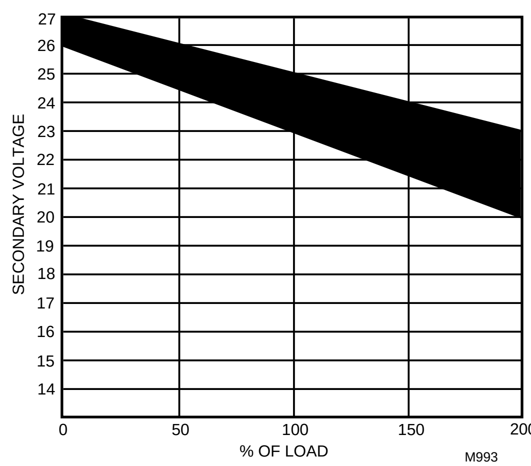


Fig. 29. NEMA Class II transformer voltage output limits.

Step 4. Prepare Wiring Diagrams

Wiring Details

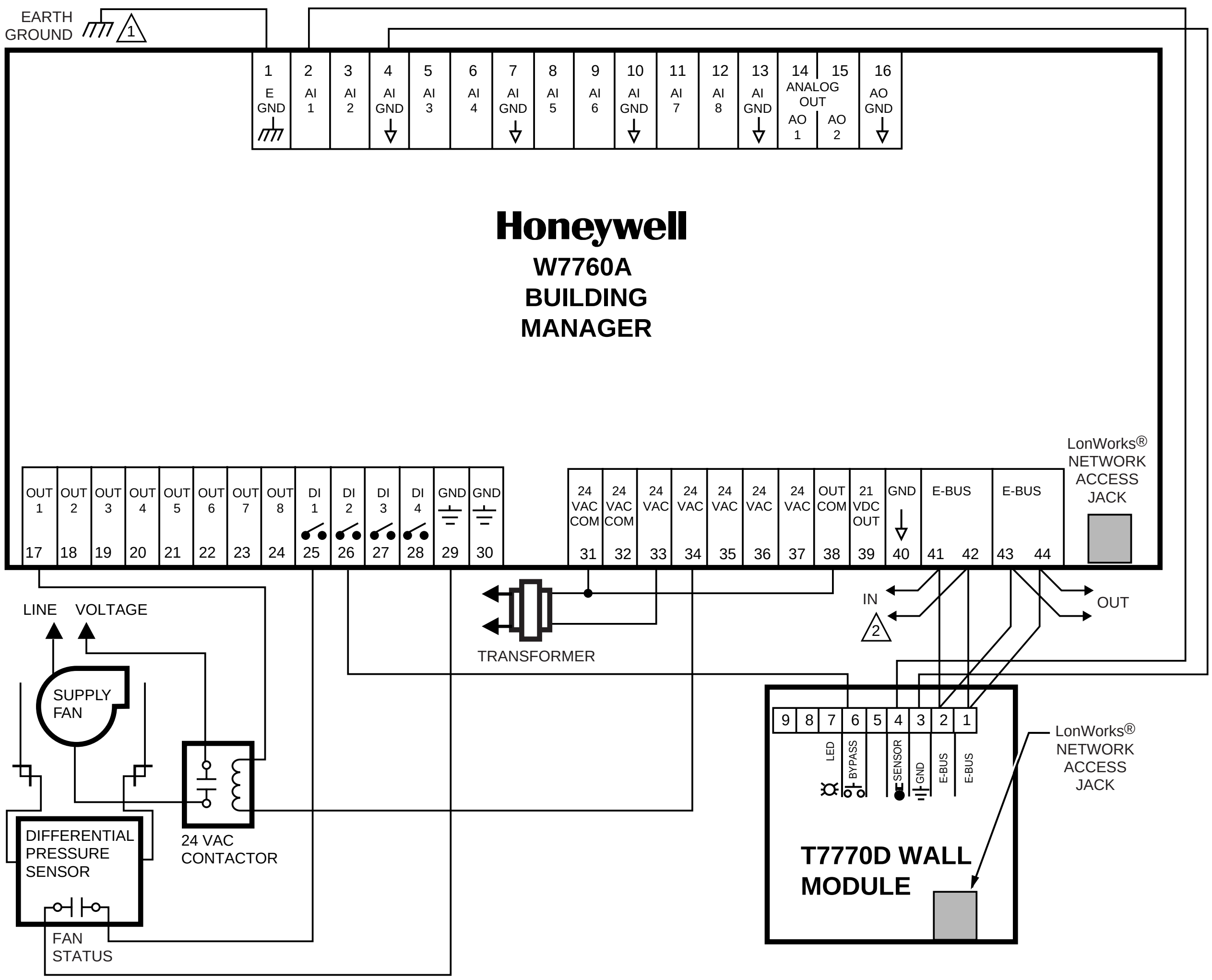
Fig. 30 through 35 show W7760A terminal arrangement and provide detailed wiring diagrams. Reference these diagrams to prepare site-specific job drawings.

Plugging a Serial LonTalk Adapter (SLTA) connector into the LonWorks® Bus jack provides operator access with a portable PC to the LonWorks® Bus.

When wiring is complete, the W7760A activates by plugging into the subbase.

CAUTION

The W7760A must connect to a good earth ground. If not, the device internal transient protection circuitry is compromised and the W7760A is susceptible to noise and power line spikes. Circuit board damage can occur, which will require device replacement.



1. EARTH GROUND WIRE LENGTH SHOULD BE HELD TO A MINIMUM. USE THE HEAVIEST GAUGE WIRE AVAILABLE, UP TO 14 AWG (2.O MM^2) WITH A MINIMUM OF 18 AWG (1.O MM^2), FOR EARTH GROUND WIRE.

2. TO ASSURE PROPER ELECTRICAL CONTACT, WIRES MUST BE TWISTED TOGETHER BEFORE INSERTION INTO THE TERMINAL BLOCK.

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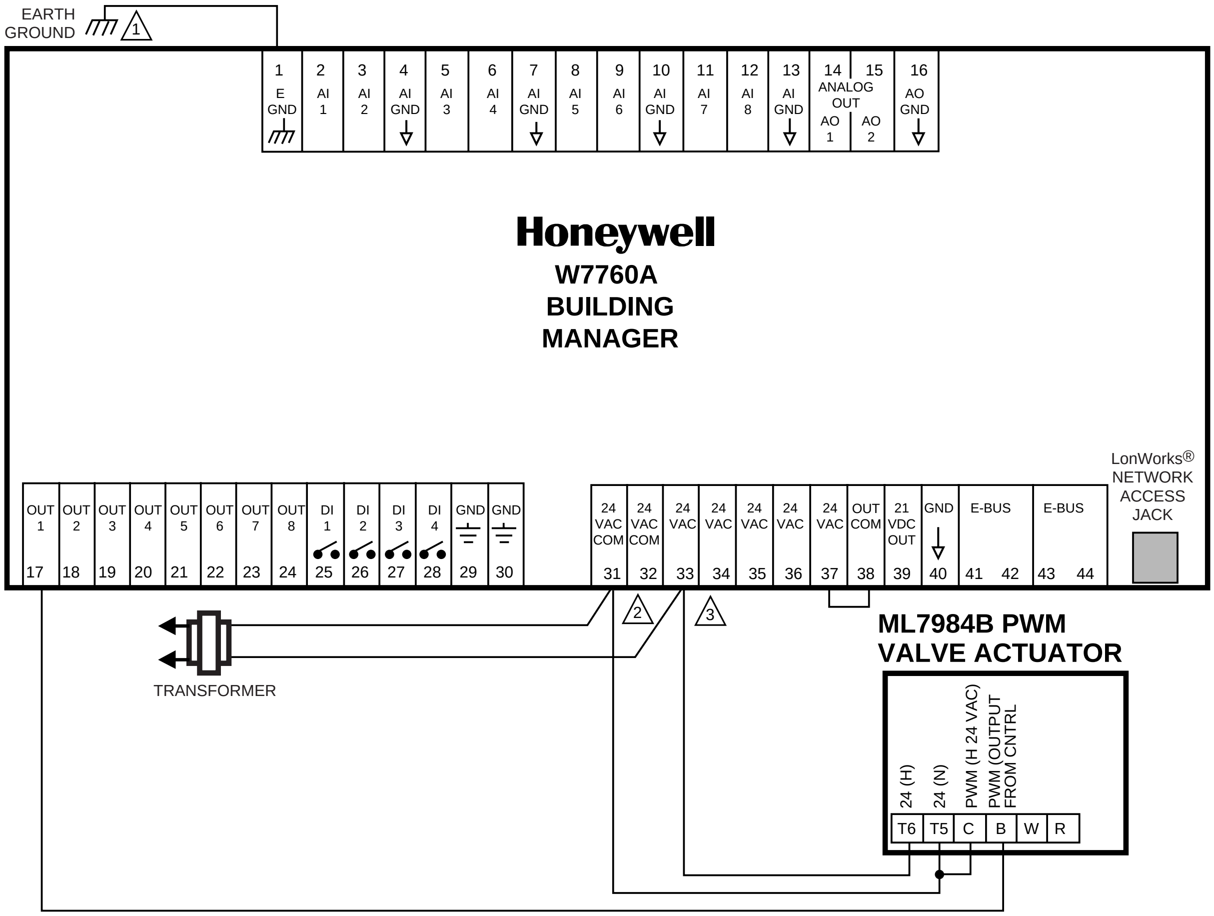
Fig. 30. Typical W7760A wiring diagram with a T7770D Wall Module (see transformer wiring for example of Low-Side switching).



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2. TO ASSURE PROPER ELECTRICAL CONTACT, WIRES MUST BE TWISTED TOGETHER BEFORE INSERTION INTO THE TERMINAL BLOCK.

3. MAKE CERTAIN ALL TRANSFORMER/POWER WIRING IS AS SHOWN; REVERSING TERMINATIONS WILL RESULT IN EQUIPMENT MALFUNCTION.

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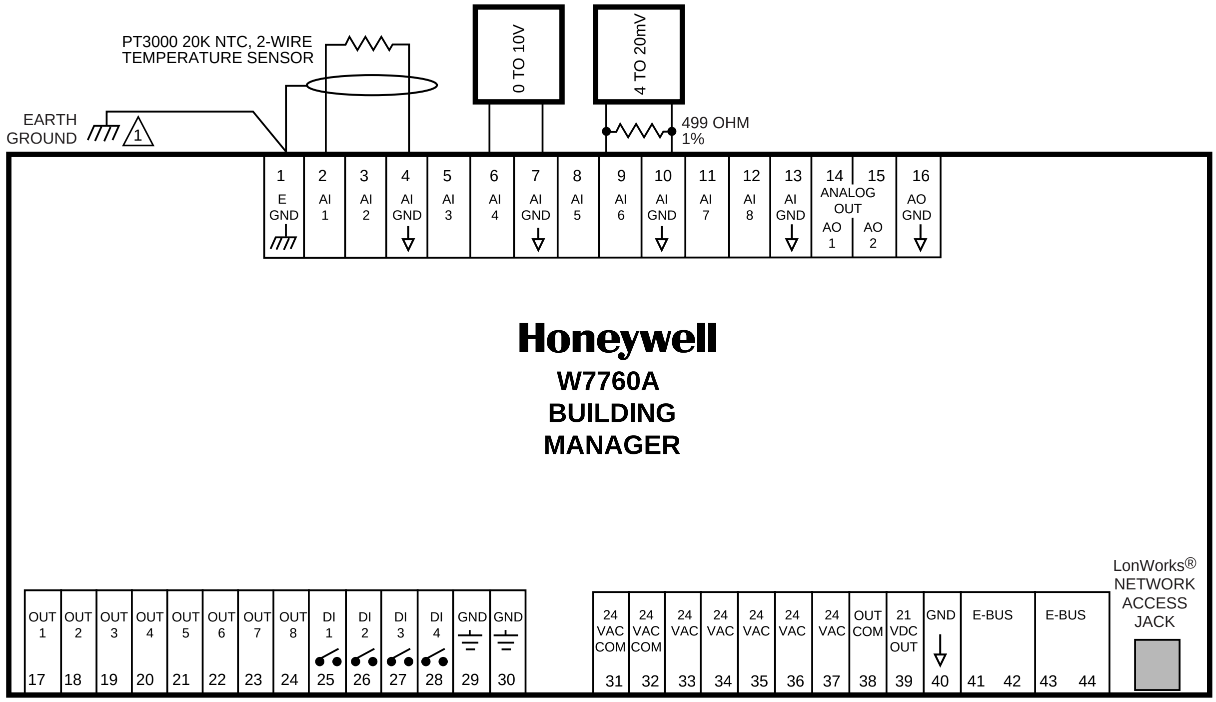
Fig. 31. Typical PWM Valve Actuator to W7760A.



1. EARTH GROUND WIRE LENGTH SHOULD BE HELD TO A MINIMUM. USE THE HEAVIEST GAUGE WIRE AVAILABLE, UP TO 14 AWG (2.O MM^2) WITH A MINIMUM OF 18 AWG (1.O MM^2), FOR EARTH GROUND WIRE.

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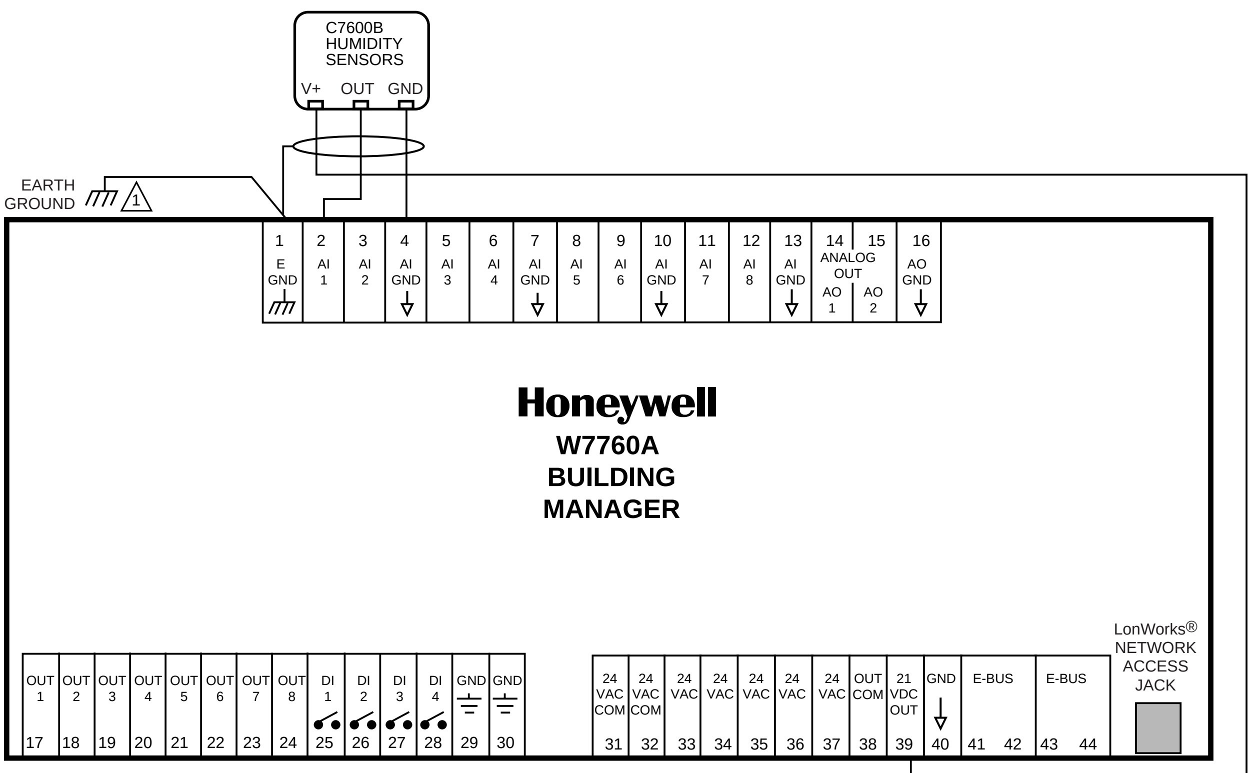
Fig. 32. Typical Analog Input to W7760A.



1. EARTH GROUND WIRE LENGTH SHOULD BE HELD TO A MINIMUM. USE THE HEAVIEST GAUGE WIRE AVAILABLE, UP TO 14 AWG (2.O MM^2) WITH A MINIMUM OF 18 AWG (1.O MM^2), FOR EARTH GROUND WIRE.

M17214

Fig. 33. Typical 2 to 10 Volt Humidity Sensor to W7760A (C7600B is 3 wire device).

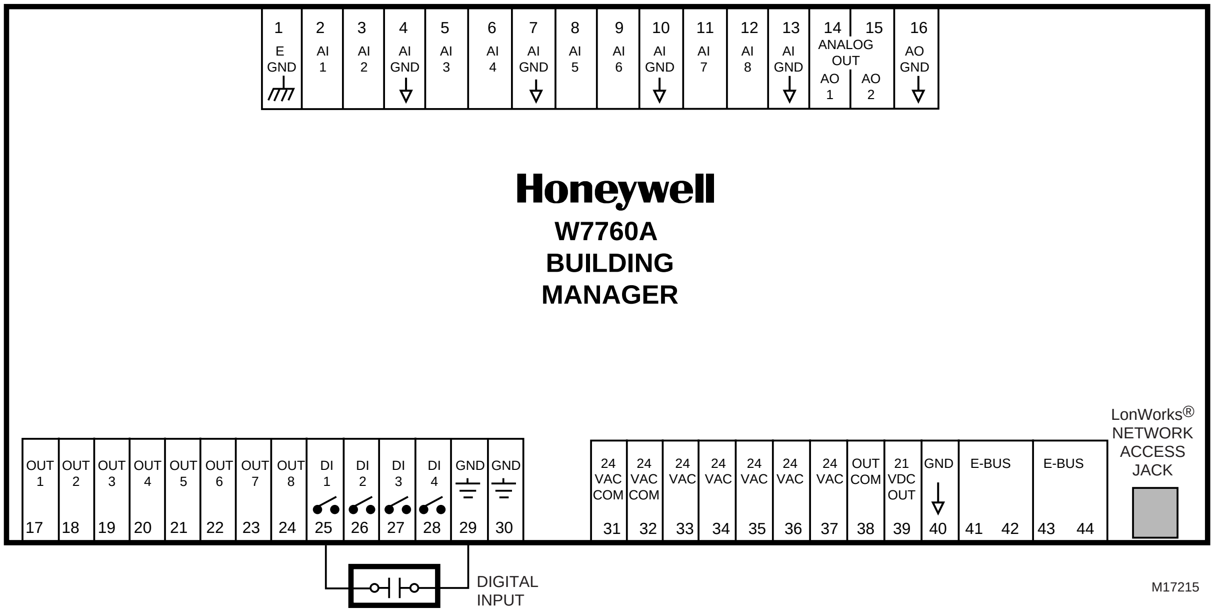


Fig. 34. Typical Digital Input to W7760A.

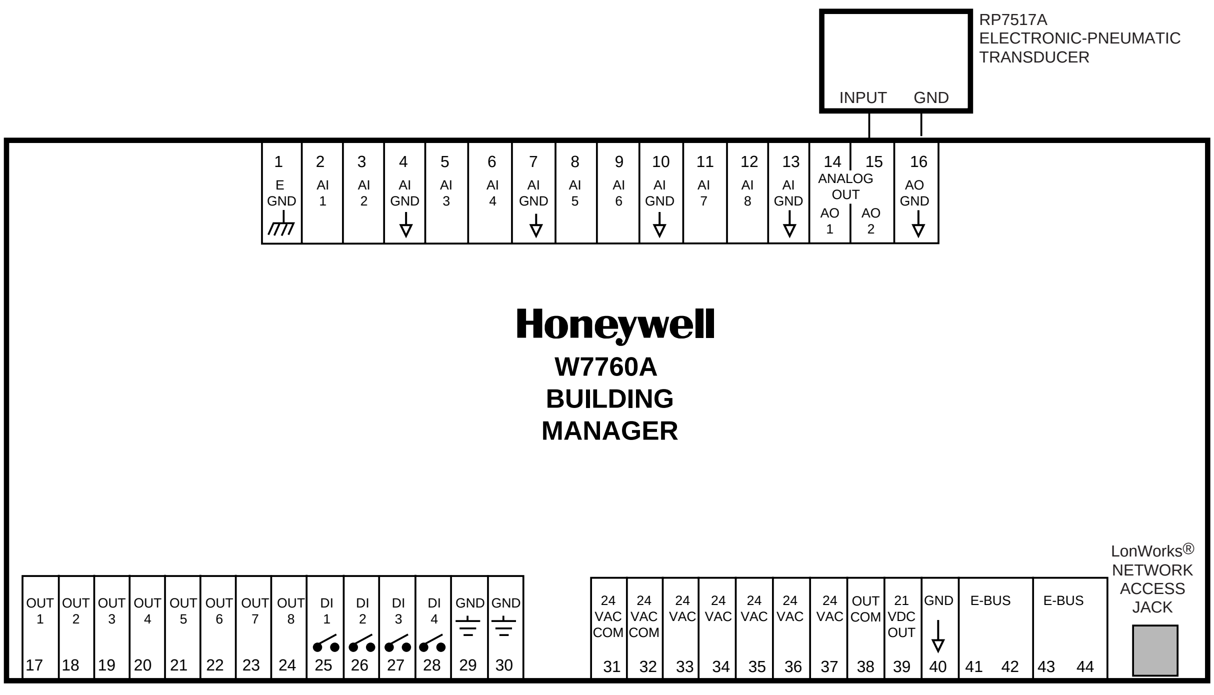


Fig. 35. Typical RP7517A Electronic Pneumatic Transducer to W7760A.

General Considerations

NOTE: For field wiring, when two or more wires attach to the same terminal twist them together per Fig. 24. Deviation from this rule can result in improper electrical contact.

Table 20 lists wiring types, sizes, and distances for Excel 15 products. The terminals on the W7760A, W7750, W7753, W7761, and T7770 accept 14 through 22 AWG (2.0 to 0.34 mm^2) wire. The T7300F/Q7300H Commercial Thermostat/Communicating Subbase accept 18 through 22 AWG (1.0 to 0.34 mm^2) wire.

Table 20. Field Wiring Reference Table.

Wire Function	Recommended Minimum Wire Size	Construction	Specification or Requirement	Vendor Wire Type	Maximum Distance ft (m)
LonWorks® Bus (Plenum)	22 AWG (0.34 mm^2)	Twisted pair solid conductor, nonshielded or Echelon® approved cable.	Level IV 140°F (60°C) rating	Honeywell AK3791 (one twisted pair) AK3792 (two twisted pairs)	Refer to E-Bus Wiring Guidelines Users Guide 74-2865 for maximum length
LonWorks® Bus (Non-Plenum)	22 AWG (0.34 mm^2)	Twisted pair solid conductor, nonshielded or Echelon® approved cable.	Level IV 140°F (60°C) rating	Honeywell AK3781 (one twisted pair) AK3782 (two twisted pairs)	Refer to E-Bus Wiring Guidelines Users Guide 74-2865 for maximum length
Input Wiring Sensors Contacts	18 to 22 AWG (1.0 to 0.34 mm^2)	Multiconductor (usually five-wire cable bundle). For runs >200 ft (61m) in noisy EMI areas, use shielded cable.	140°F (60°C) rating	Standard thermostat wire	1000 ft (305m) for 18 AWG 200 ft (61m) for 22 AWG
Output Wiring Actuators Relays	14 AWG (2.0 mm^2) (18 AWG (1.0 mm^2) acceptable for short runs)	Any pair nonshielded (use heavier wire for longer runs).	NEC Class II 140°F (60°C) rating	Honeywell AK3702 (18 AWG) AK3712 (16 AWG) AK3754 (14 AWG) or equivalent	Limited by line-loss effects on power consumption. (See section on Line Loss.)
Power Wiring	14 AWG (2.0 mm^2)	Any pair nonshielded (use heavier wire for longer runs).	NEC Class II 140°F (60°C) rating	Honeywell AK3754 (14 AWG) twisted pair AK3909 (14 AWG) single conductor or equivalent	Limited by line-loss effects on power consumption. (See section on Line Loss.)

Step 5. Order Equipment

After compiling a bill of materials through completion of the previous application steps, refer to Table 21 for ordering information. Contact Honeywell for information about Controllers and Wall Modules with no logo.

Table 21. Excel 15 W7760A Ordering Information.

Part Number	Product Description	Comments
W7760A2011	Excel 15 Building Manager	Excel 15 Controller
W7750A2005	Excel 10 Constant Volume AHU Controller (W7750A) Base model	Three Analog Inputs, Three Digital Inputs and Six 24 Vac Relay Outputs
W7750B2003	Excel 10 Constant Volume AHU Controller (W7750B) Expanded model	Six Analog Inputs, Five Digital Inputs and Eight Triac Digital Outputs
W7753A2002	Excel 10 Unit Ventilator Controller (W7753A)	Six Analog Inputs, Five Digital Inputs and Eight Triac Digital Outputs
W7761A2002	Excel 10 Remote Input/Output Device (W7761A)	Six Analog Inputs (Four Resistive and Two Voltage/Current), Four Digital Inputs, Eight Triac Digital Outputs and One 20 Vdc Output Power Terminal (50 mA Max.)
T7300F2002 T7300F2010	Series 2000 Commercial Microelectronic Conventional or Heat Pump Thermostats	Revision 3 or later
Q7300H2003 Q7300H2011 Q7300H2029 Q7300H2037	Series 2000 Commercial Thermostat Communicating Subbases	
T7770 Wall Modules		
T7770A1006	Sensor with Honeywell Logo (Not used with RIO)	Used with Excel 10 Controllers
T7770A1014	Sensor with No Logo (Not used with RIO)	Used with Excel 10 Controllers
T7770A2004	Sensor with Network Jack and Honeywell Logo	Used with Excel 10 Controllers
T7770A2012	Sensor with Network Jack and No Logo	Used with Excel 10 Controllers
T7770D1000	Sensor with Bypass/LED, Network Jack and Honeywell Logo	Degrees F Absolute
T7770D1018	Sensor with Bypass/LED, Network Jack and No Logo	Degrees C Absolute
Echelon® Based Components and Parts		
Q7752A2019	FTT 10 Serial LonTalk® Adapter	Connects via cable (32002516-001) to LonWorks® Bus on Excel 15
Q7752B2009	PCC-10 Serial LonTalk® Adapter	Connects PCC 10 SLTA to LonWorks® Bus jack on Excel 15, Excel 10 or other devices.
Q7740A1008	Excel 10 2-Way Repeater	Used to extend the length of the LonWorks® Bus. Contains built-in termination modules.
Q7740B1006	Excel 10 4-Way Repeater	Used to extend the length of the LonWorks® Bus. Contains built-in termination modules.
209541B	Termination Module	One or two required per LonWorks® Bus segment
32002516-001	Operator Terminal Cable for LonWorks® Bus	Serial interface to wall module or controller
Sensors		
EL7680A	Wall Mounted Wide View Infrared Occupancy Sensor	
EL7628A	Ceiling Mounted Infrared Occupancy Sensor	
EL7611A EL7612A	Ultrasonic Occupancy Sensor	
EL7630A EL7621A	Power supply control units for Occupancy Sensor	

(continued)

Table 21. Excel 15 W7760A Ordering Information. (Continued)

Part Number	Product Description	Comments
Sensors (Continued)		
C7400A1004	Solid State Enthalpy Sensor (4 to 20 mA) use a 499 ohm one percent resistor across the analog input.	For outdoor and return air enthalpy(4 to 20 mA) use a 499 ohm 1 percent resistor
C7600B1000 C7600B1018	Solid State Humidity Sensors	For outdoor and return air humidity
C7770A1006	Air Temperature Sensor. 20K ohm NTC nonlinearized	Duct-mounted sensor that functions as a primary and/or secondary sensor.
Accessories:		
MMC325-010, MMC325-020	Pneumatic Retrofit Transducers. Select pressure range: (010) 0 to 10 psi (68.97 kPa) or (020) 0 to 20 psi (137.93 kPa).	Use to control Pneumatic reheat valves
MMCA530	DIN rail adapter for MMC325 Transducers	—
MMCA540	Metal enclosure for MMC325 Transducers	—
ML7984B3000	Valve Actuator Pulse Width Modulation (PWM)	Use with V5011 or V5013 F and G Valves
V5812A	Two-way terminal unit water valve; 0.19, 0.29, 0.47, 0.74, 1.2, and 1.9 C_V 1/2 in. npt (13 mm) or 2.9 and 4.9 C_V 3/4 in. npt (19 mm)	Use with M6410 Valve Actuator. Closeoff rating for 0.19 to 1.9 C_V is 65 psi; for 2.9 and 4.9, C_V is 45 psi. (Coefficient of volume or capacity index C_V = gallons per minute divided by the square root of the pressure drop across the valve.)
V5813A	Three-way mixing terminal unit hot water valve; 0.19, 0.29, 0.47, 0.74, 1.2, and 1.9 C_V 1/2 in. npt (13 mm) or 2.9 and 4.9 C_V 3/4 in. npt (19 mm)	Use with M6410 Valve Actuator. Closeoff rating for 0.19 to 0.74 C_V is 55 psi; 1.2, and 1.9 C_V is 22 psi; 2.9 and 4.9 C_V is 26 psi.
R8242A	Contactor, 24 Vac coil, DPDT	—
AT72D, AT88A, AK3310, etc.	Transformers	—
EN 50 022	DIN rail 35 mm by 7.5 mm (1-3/8 in. by 5/16 in.)	Obtain locally: Each controller requires 5 in.
—	Thomas and Betts part number TKAD DIN rail adapter	Purchase locally two DIN rail adapters for each controller using DIN rail.
—	Tadiran Telecommunication Ltd. lithium utility metering battery, model number TL-5267/W	Optional battery backup is not included with an Excel 15 (do not use a substitute).
Cabling:		
—	Serial Interface Cables, male DB-9 to female DB-9 or male DB-25.	Obtain locally from any computer hardware vendor.
Honeywell AK3791 (one twisted pair) AK3792 (two twisted pairs)	LonWorks® Bus (plenum): 22 AWG (0.34 mm^2) twisted pair solid conductor, nonshielded or Echelon® approved cable.	Level IV 140°F (60°C) rating
Honeywell AK3781 (one twisted pair) AK3782 (two twisted pairs)	LonWorks® Bus (nonplenum): 22 AWG (0.34 mm^2) twisted pair solid conductor, nonshielded or Echelon® approved cable.	Level IV 140°F (60°C) rating
Honeywell AK3725	Inputs: 18 AWG (1.0 mm^2) five wire cable bundle	Standard thermostat wire
Honeywell AK3752 (typical or equivalent)	Outputs/Power: 14 to 18 AWG (2.0 to 1.0 mm^2)	NEC Class II 140°F (60°C) rating
Honeywell AK3702 (typical or equivalent)	18 AWG (1.0 mm^2) twisted pair	Non-plenum
Honeywell AK3712 (typical or equivalent)	16 AWG (1.3 mm^2) twisted pair	Non-plenum
Honeywell AK3754 (typical or equivalent)	14 AWG (2.0 mm^2) two conductor	Non-plenum

Step 6. Configure Controllers

LonSpec™ software is used to configure W7760A Controllers to match their intended application. The LonSpec™ User Guide 74-2937 provides details for operating the PC software.

Step 7. Troubleshooting

Step 1. Check Installation and Wiring:
Inspect all wiring connections at the W7760A terminals, and verify compliance with job drawings. If any wiring changes are required, *first* be sure to remove power from the device *before* starting work. Pay particular attention to:

— 24 Vac power connections. Verify that multiple devices powered by the same transformer are wired with the transformer secondary connected to the same input terminal numbers on each W7760A. See Fig. 28. Controller configurations are not necessarily limited to two devices, but the total power draw including accessories cannot exceed 100 VA when powered by the same transformer (U.S. only).

— Device wiring. Be sure that each device is wired (terminal 1) on the W7760A to a verified earth ground using a wire run as short as possible with the heaviest gauge wire available, up to 14 AWG (2.0 mm^2) with a minimum of 18 AWG (1.0 mm^2) for each controller in the group. See Fig. 27.

— Verify Triac wiring to external devices uses the proper load power/24 Vac hot terminals (terminals 33 through 37 on the W7760A). Check for 24 Vac with a meter.

NOTE: All wiring must comply with applicable electrical codes and ordinances or as specified on installation wiring diagrams.

Verify Termination Module Placement
The installation wiring diagrams should indicate the locations for placement of 209541B Termination Module(s). Refer to the E-Bus Wiring Guidelines form, 74-2865, and the Excel 10 FTT Termination Module Installation Instructions form,
95-7554. Correct placement of the termination module(s) is required for proper LonWorks® Bus communications.

Step 2. Startup
W7760A Controller Status LED
The LED on the front and center of a W7760A Controller provides a visual indication of the status of the device. See Fig. 36. When the W7760A receives power, the LED should appear in one of the following allowable states:

1. Off - no power to the processor.
2. Continuous On - processor is in initialized state.
3. Slow Blink - controlling, normal state.
4. Fast Blink - when the W7760A has an alarm condition.

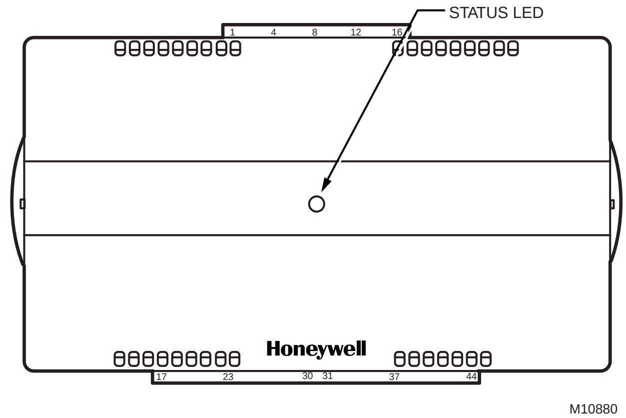


Fig. 36. LED location on W7760A.

Troubleshooting Excel 10 Controllers and Wall Modules:
In addition to the following information, refer to the Installation Instructions and Checkout and Test manual for each product. See the Applicable Literature section for form numbers.

Temperature Sensor Resistance Ranges:
The T7770 or the C7770A Air Temperature Sensor has the following specified calibration points, which are plotted in Fig. 37:

Temperature (°F)	Resistance Value (ohms)
98	11755
80	18478
70	24028
60	31525
42	52675

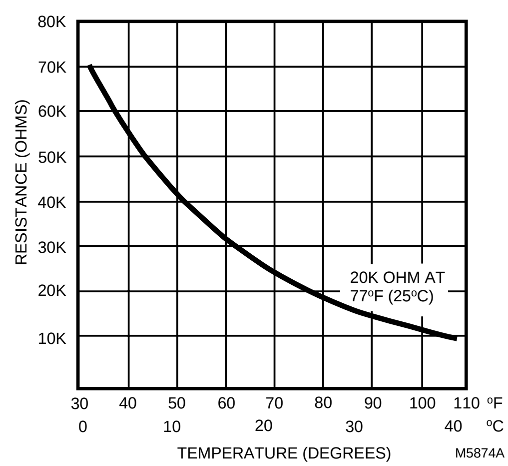


Fig. 37. Temperature sensor resistance plots.

Alarms

When an Excel 15 W7760A has an alarm condition, it reports it to the central node on the LonWorks® Bus (typically, a W7760A). See Table 22. Information contained in an alarm message is:

- Subnet Number:
  LonWorks® Bus segment that contains the node that has the alarm condition.
- Node Number:
  Node that has the alarm condition (see Network Alarm).
- Alarm Type:
  Specific alarm being issued. An Excel 15 can provide the alarm types listed in Table 22.

Table 22. Excel 15 System Alarms.

Building Manager alarm type number	Building Manager return to normal number	Meaning of Building Manager system alarm for a controller used with a Building Manager
125	253	XL10 DEVICE 01 FAILED
124	252	XL10 DEVICE 02 FAILED
123	251	XL10 DEVICE 03 FAILED
122	250	XL10 DEVICE 04 FAILED
121	249	XL10 DEVICE 05 FAILED
120	248	XL10 DEVICE 06 FAILED
119	247	XL10 DEVICE 07 FAILED
118	246	XL10 DEVICE 08 FAILED
117	245	XL10 DEVICE 09 FAILED
116	244	XL10 DEVICE 10 FAILED
115	243	XL10 DEVICE 11 FAILED
114	242	XL10 DEVICE 12 FAILED
113	241	XL10 DEVICE 13 FAILED
112	240	XL10 DEVICE 14 FAILED
111	239	XL10 DEVICE 15 FAILED
110	238	XL10 DEVICE 16 FAILED
109	237	XL10 DEVICE 17 FAILED
108	236	XL10 DEVICE 18 FAILED
107	235	XL10 DEVICE 19 FAILED
106	234	XL10 DEVICE 20 FAILED
105	233	SETPOINT ALARM LOOP 1
104	232	SETPOINT ALARM LOOP 2
103	231	SETPOINT ALARM LOOP 3
102	230	SETPOINT ALARM LOOP 4
101	229	SETPOINT ALARM LOOP 5
100	228	SETPOINT ALARM LOOP 6
99	227	INPUT NV FAILURE
98	226	SENSOR FAILURE
97	225	CONFIG BAD CHECKSUM

NOTE: The node can be reset by switching the node to MANUAL and then to the normal operating mode.

Current alarm history is available through LonSpec™ Reports function.

Assigning Neuron® ID

Assigning an Neuron® ID allows a device on the LonWorks® Bus to be positively identified. The controller Neuron® ID number can be used to confirm the physical location of a particular Excel 15, Excel 10, and T7300F/Q7300H. See Table 22 for information contained in an alarm message.

There are two methods of assigning a Neuron®ID from an Excel 15 W7760A Controller. One uses a hardware service pin button on the side of the controller and manually entering the Neuron® ID is the second.

When an *Assign ID* command (use the service pin button, see Fig. 3) is issued from LonSpec™, the node goes into the SERVICE_MESSAGE mode for five minutes. In the SERVICE_MESSAGE mode, pressing the hardware service pin button on the bottom of the controller causes the Service Message to be broadcast on the network. All other functions are normal in the SERVICE_MESSAGE mode. When manually entering the Neuron® ID and issuing the Assign ID command, LonSpec™ locates and communicates directly with the controller (the controller does not go into the SERVICE_MESSAGE mode in this case). Refer to the LonSpec™ User's Guide form, 74-2937, for more information on the ID assignment process.

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