Honeywell

# Excel 15
# W7760C Plant Controller

EXCEL 5000 OPEN™ SYSTEM

## SYSTEM ENGINEERING

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CE


74-3079

# INTRODUCTION

## Description of Devices

The Excel 15 W7760C Plant Controller is a device that can be used to monitor and control HVAC equipment and other miscellaneous loads using LONTALK® communications protocol on an Echelon® LONWORKS® network. See Fig. 1. The W7760C Plant Controller communicates via the 78 kilo bits per second (kbps) LONWORKS network, using a Free Topology Transceiver (FTT). The W7760C is compatible with the Excel 15 W7760A Building Manager, the S7760A Command Display, individual Excel 10 Controllers and T7300F/Q7300H Series 2000 Commercial Thermostats and Communicating Subbases. The W7760C monitors and controls both local and remote controller points.

The W7760C also supports configurable control loops for a wide variety of applications.(Each of the following control strategies can be configured with a combination of features, up to the maximum number stated for each type of loop.)

— Scheduling (from a W7760A Building Manager).
— Demand Limit Control (from a W7760A Building Manager).
— Time-of-Day Bypass.
— Setpoint Reset.
— Adaptive Intelligent Recovery™.
— Sequencer.
— Lead/Lag.
— Analog Limit.
— Setpoint Override.
— Setpoint Alarming.
— Start/stop loops (eight maximum). Start/stop loops are used to turn equipment on and off based on a Time Of Day (TOD) schedule or a Demand Limit Control (DLC) situation.
— General Purpose Configurable Proportional Integral Derivative (PID) Control Loops (ten maximum). Modulating or staged output (up to four stages per sequencer). Built-in auxiliary output to coordinate pumps or fans.
— If/Then/Else Logic Loops (32 maximum).
— Math Functions: MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY (36 maximum).

The W7760C is used in conjunction with the following devices:
— Excel 15 W7760A Building Manager.
— Excel 15 S7760A Command Display.
— Excel 10 W7751B,D,F,H VAV II Controllers
— Excel 10 W7750A,B,C Constant Volume AHU Controller.
— Excel 10 W7753A Unit Ventilator Controller.
— Excel 10 W7761A Remote Input/Output (RIO) Device.
— T7300F/Q7300H Series 2000 Commercial Thermostat/ Communicating Subbase.
— Q7760A Serial LONTALK Adapter (SLTA).
— Q7740A,B FTT Repeater (2-way and 4-way).
— 209541B FTT Termination Module.

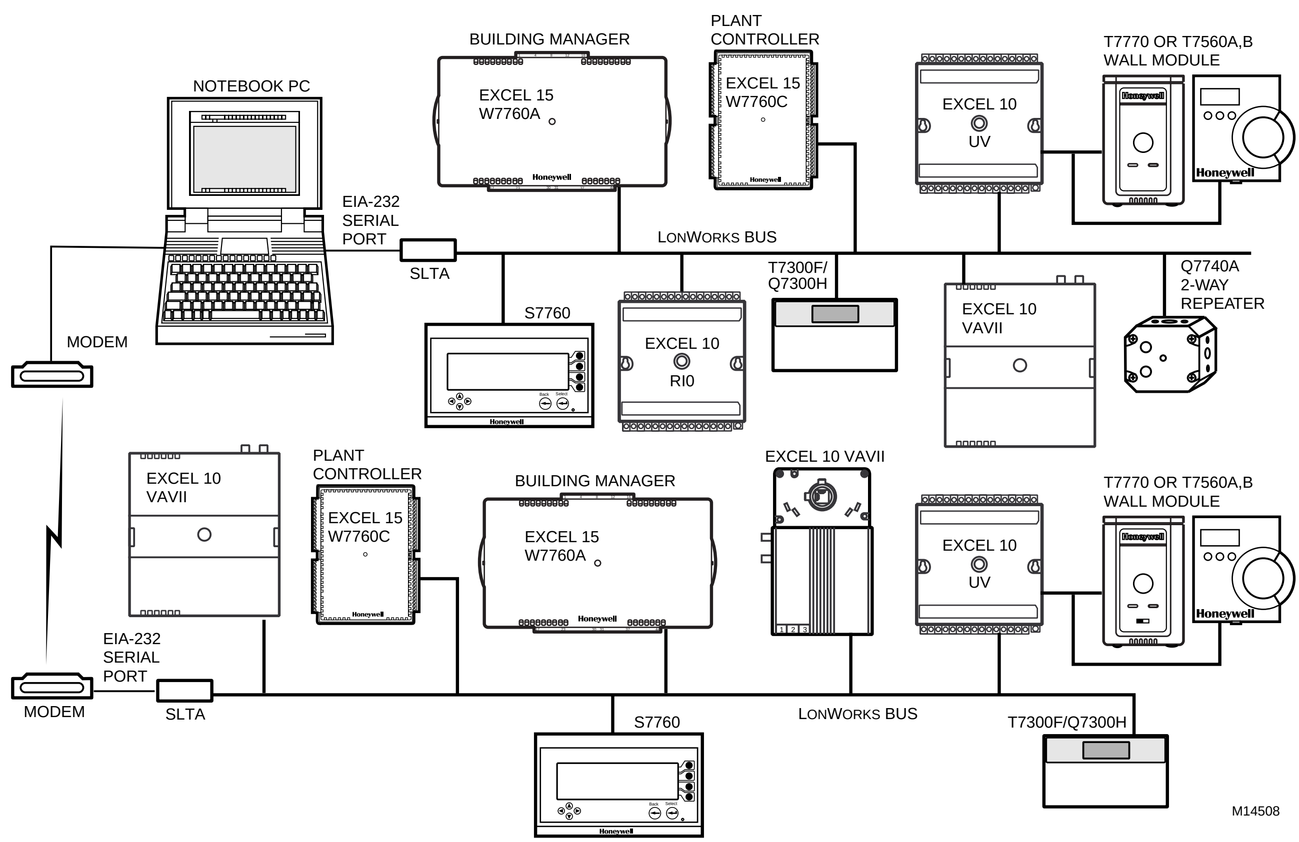


**Fig. 1. Typical system overview.**

The T7770 or T7560 direct-wired Wall Modules are used in conjunction with Excel 10 W7751, W7750 and W7753 Controllers.

## Control Application

Fig. 2 shows a typical W7760C control application.

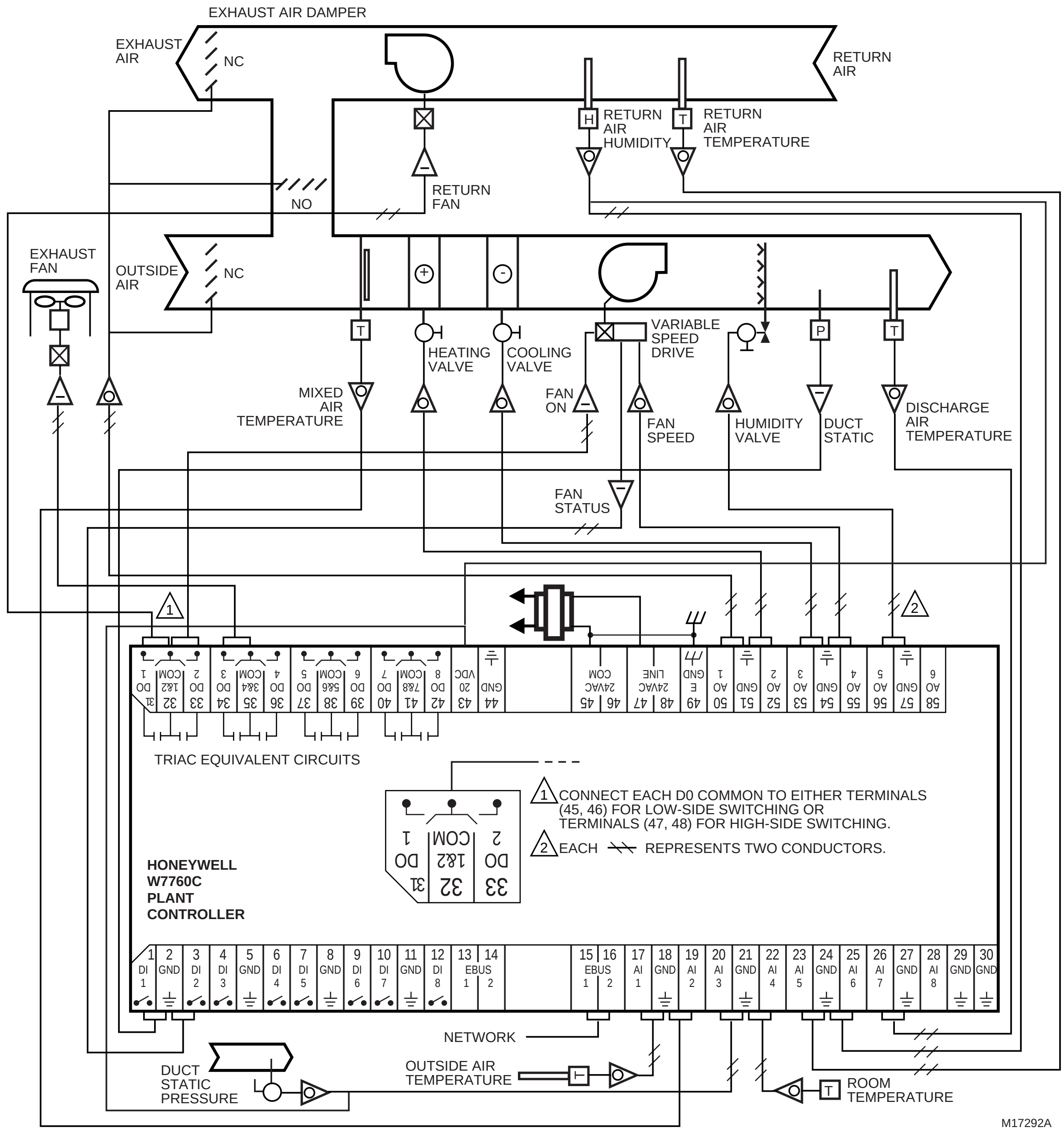


**Fig. 2. Typical air handling unit control application.**

## Control Provided

The W7760C functions to monitor and control HVAC equipment and other miscellaneous loads using a LONWORKS network.

## Product Name

The Excel 15 W7760C Plant Controller is available in one model:

— The W7760C2009 Plant Controller.

## Organization of Manual

This manual is divided into four basic sections:

1. Introduction: Provides an overview of the W7760C, discusses any related devices, lists additional literature and furnishes a glossary of abbreviations and definitions.
2. Construction: Describes controller hardware.
3. Application Steps: A step-by-step procedure that provides the necessary information to plan and lay out the W7760C application and accurately order materials
4. Appendices: Provide information that allows a configuration to start using Honeywells Excel LONSPEC™ PC software.

The organization of the manual assumes a project is being engineered from start to finish. If an operator is adding to, or is changing an existing system, the Table of Contents can provide the relevant information.

## Applicable Literature

The following list of documents contains information related to the Excel 15 W7760C Plant Controller and the EXCEL 5000® OPEN™ SYSTEM.

| Form No. | Title |
|---|---|
| 74-2976 | Excel LONSPEC™ Specification Data |
| 74-2977 | Excel LONSPEC Software Release Bulletin Excel LONSPEC Help is internal to ZL7760A software |
| 74-3069 | Excel LONSTATION™ Specification Data |
| 74-3090 | Excel LONSTATION Software Release Bulletin Excel LONSTATION Help is internal to ZL7761A software |
| 74-2865 | LONWORKS Bus Wiring Guidelines |
| 74-3123 | Light Commercial Building Solution System Communication Guide |
| 74-3080 | Excel 15 W7760C Plant Controller Specification Data |
| 95-7611 | Excel 15 W7760C Plant Controller Installation Instructions and Checkout and Test |
| 74-3079 | Excel 15 W7760C Plant Controller System Engineering |
| 74-2967 | Excel 15 W7760A Building Manager Specification Data |
| 95-7565 | 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 | Excel 15 S7760A Command Display Installation Instruction |
| 74-2974 | Excel 15 S7760A Command Display User Guide |
| 74-2942 | Excel 10 W7751B,D,F VAV II Controllers Specification Data |
| 74-2953 | Excel 10 W7751H Smart VAV Actuator Specification Data |
| 95-7504 | Excel 10 W7751B,D,F VAV II Controllers Installation Instructions and Checkout |
| 95-7553 | Excel 10 W7751H Smart VAV Actuator Installation Instructions and Checkout |
| 74-2949 | Excel 10 W7751B,D,F,H VAV II Controllers System Engineering |
| 74-2956 | Excel 10 W7750A,B,C CVAHU Controller Specification Data |
| 95-7521 | Excel 10 W7750A,B,C CVAHU Controller Installation Instructions and Checkout and Test |
| 74-2958 | Excel 10 W7750A,B,C CVAHU Controller System Engineering |
| 74-2962 | Excel 10 W7753A Unit Ventilator Controller Specification Data |
| 95-7520 | Excel 10 W7753A Unit Ventilator Controller Installation Instructions and Checkout and Test |
| 74-2964 | Excel 10 W7753A Unit Ventilator Controller System Engineering |
| 74-2698 | Excel 10 W7761A RIO Device Specification Data |
| 95-7539 | Excel 10 W7761A RIO Device Installation Instructions and Checkout and Test |
| 74-2699 | Excel 10 W7761A RIO Device System Engineering |
| 63-1281 | T7300F/Q7300H Series 2000 Commercial Thermostats and 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 |
| 63-4365 | T7300F/Q7300H Series 2000 Commercial Thermostats and Communicating Subbases System Engineering |
| 63-4366 | Q7300H Communicating Subbase System Integration User Address Manual |
| 74-2697 | Excel 10 T7770A,B,C,D,E,F,G Wall Module Specification Data |
| 95-7538 | Excel 10 T7770A,B,C,D,E,F,G Wall Module Installation Instructions |
| 74-3097 | T7560A,B Digital Wall Module Specification Data |
| 95-7620 | T7560A,B Digital Wall Module Installation Instructions |
| 74-2954 | SLTA-10 Serial LONTALK Adapter Specification Data |
| 95-7511 | SLTA-10 Serial LONTALK Adapter Installation Instructions |
| 74-3067 | Q7752B PCMCIA LONWORKS PCC-10 Card Specification Data |
| 95-7613 | Q7752B PCMCIA LONWORKS PCC-10 Card Installation Instructions |
| 74-2858 | Excel 10 Q7740A,B FTT Repeaters Specification Data |
| 95-7555 | Excel 10 Q7740A,B FTT Repeaters Installation Instructions |
| 95-7554 | Excel 10 209541B Termination Module Installation Instructions |

## Other Product Model Numbers

- **Q7760A** Serial Adapter.
- **Q7740A,B** FTT Repeaters.
- **209541B** FTT Termination Module.

Refer to Table 22 in Application Step 5. Order Equipment for a complete listing of all available part numbers.

## Agency Listings

Table 1 provides information on agency listings for Excel 15 products. Be sure to always follow Local Electrical Codes.

**Table 1. Agency Listings.**

| Device | Agency | Comments |
|---|---|---|
| **W7760C Plant Controller** | UL | Tested and listed under UL916 (file number E14480). NEC Class 2 rated. |
| | cUL | Listed E14480. NEC Class 2 rated. |
| | CE | Level A general Immunity per European Consortium Standards EN50081-1 (CISPR 22, Class B) and EN 50082-1:1992 (based on Residential, Commercial, and Light Industrial).<br>EN 61000-4-2: IEC 1000-4-2 (IEC 801-2) Electromagnetic Discharge.<br>EN 50140, EN 50204: IEC 1000-4-3 (IEC 801-3) Radiated Electromagnetic Field.<br>EN 61000-4-4: IEC 1000-4-4 (IEC 801-4) Electrical Fast Transient (Burst). Radiated Emissions and Conducted Emissions:<br>EN 55022: 1987 Class B.<br>CISPR-22: 1985. |
| | FCC | Complies with requirements in FCC Part 15 rules for subpart J Class A Computing Device. Operation in a residential area can cause interference to radio or TV reception and require the operator to take steps necessary to correct the interference. |

## 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 of each Neuron® involved. The binding information is saved in the network image of each Neuron.

**Building Manager**—A LONMARK® certified device that can be used to monitor and control HVAC equipment and other miscellaneous loads in a distributed network.

**Bypass**—Temporary override of the scheduled occupancy state to the occupied mode. At the end of the bypass time, the control returns to the scheduled occupancy state.

**CO**—Carbon Monoxide. Occasionally used as a measure of indoor air quality.

**$CO_2$**—Carbon Dioxide. Often used as a measure of indoor air quality.

**Command Display**—A device that is used to monitor and change parameter in a LONWORKS HVAC application.

**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 the occupied mode to the unoccupied mode is 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.

**CZS**—Commercial Zoning System.

**DDF**—Delta Degrees Fahrenheit.

**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.

**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 turning off some digital output, or changing a setpoint to a more economical level.

**Echelon**—The company that developed the LONWORKS 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. Because this action saves energy, the dampers are often referred to as *economizer dampers*.

**EEPROM**—Electronically Erasable Programmable Read Only Memory; The variable storage area for saving user setpoint values and factory calibration information.

**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).

**EPID Control**—An Enhanced Proportional Integral Derivative control algorithm that improves the PID control algorithm by compensating for system dynamics and allows faster control response rate reset. It also incorporates a sequencer, AI limit, deadband, start ramp and setpoint override.

**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 the 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 utilizes one digital output to drive the actuator open, and another digital output to drive it closed.

**FTT**—Free Topology Transceiver.

**HVAC**—Heating Ventilation and Air Conditioning.

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

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

**I x R**—I times R or current times resistance; refers to Ohms Law: V = I x R.

**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**—Echelons LONWORKS network for communication among Excel 15 Controllers, Excel 10 Controllers and T7300F/Q7300H Commercial Thermostat/Communicating Subbases.

**LONWORKS Bus Segment**—An LONWORKS Bus network that contains no more than 120 total (Excel 15 W7760A,Cs, Excel10s 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, object and network variables that are implemented in all of 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 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. (The Excel 15 W7760C can not be the network time master.)

**Network Time Scheduler**—The network time scheduler sends out current and next state (occupied, unoccupied or standby) and time until the 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 allow communication over the LONWORKS network to other nodes on the network. For example; An output network variable in one node can be bound to the 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; An Excel 15 or Excel 10 Controller is one node on the LONWORKS Bus network.

**NV**—Network Variable; An Excel 15 or Excel 10 parameter that can be viewed or modified over the LONWORKS Bus network.

**PC**—An Personal Computer with Pentium processor capable of running Microsoft® Windows™ 95.

**Plant Controller**—A device that can be used to monitor and control HVAC equipment and other miscellaneous loads in a distributed network.

**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.

**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 Management System, this is a piece of hardware that is functionally compatible to an SLTA 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 an Excel 15 W7760A or W7760C.

**RTC**—Real-time clock.

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

**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 EIA-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**—An Excel 10 Unitary heating/cooling Ventilation System Controller.

**VA**—Volt Amperes; A measure of electrical power output or consumption as 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).

**W7751**—The model number of the Excel 10 VAV Box Controllers (also see VAV).

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

**W7760**—The model number of the Excel 15 Building Manager Controller and the Plant Controller (also see Building Manager and Plant Controller).

**W7761**—The model number of the Excel 10 RIO Device.

**Wall Module**—The Excel 10 Space Temperature Sensor and other optional controller inputs are contained in the T7770 or the T7560A,B Wall Modules. See Application Step 5. Order Equipment for details on the various models of Wall Modules.

# CONSTRUCTION

## Controller

The W7760C 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).

NOTE: If terminals 13 and 14 on the LONWORKS Bus are used as inputs and 15 and 16 are used as outputs 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.

The cover/electronics assembly also includes a diagnostic LED that is visible from the front. See Fig. 3.

The W7760C 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 subbase 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, 1-3/8 x 5/16 in. (35 x 7.5 mm). Also for every W7760C using DIN rail, purchase locally two each DIN rail adapters part number TKAD from Thomas and Betts.

The W7760C includes a LONWORKS Bus communications 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.

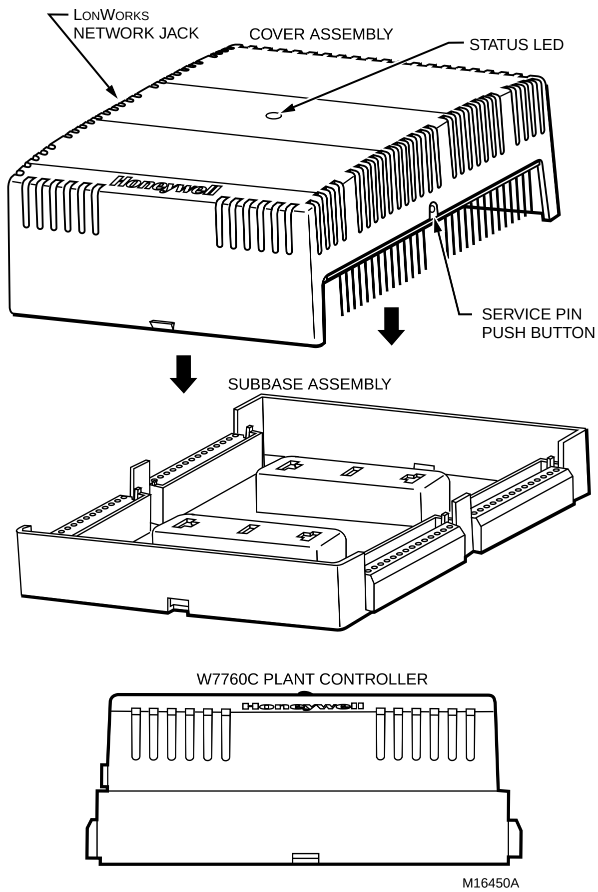


**Fig. 3. W7760C enclosure.**

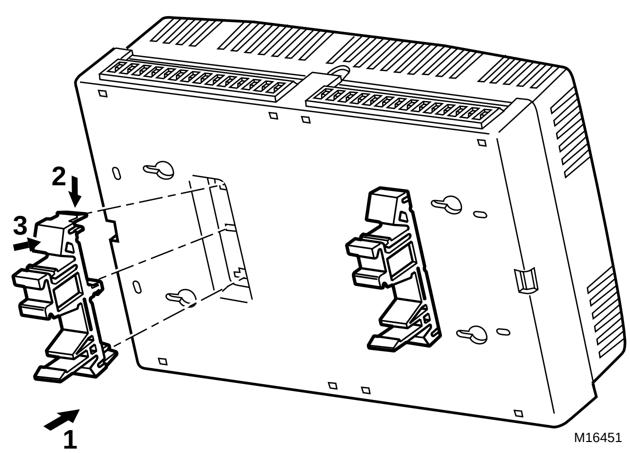


**Fig. 4. Using DIN rail adapters for mounting W7760C.**

Fig. 5 and 6 show the W7760C dimensions.

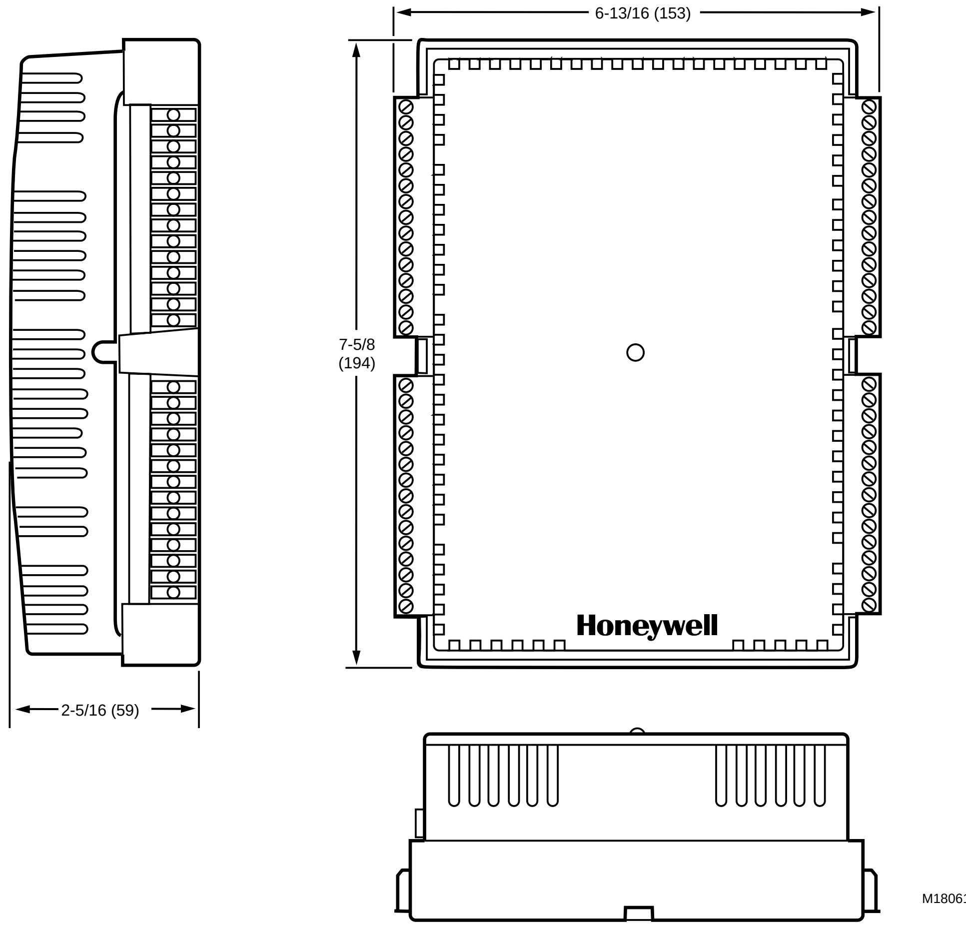


Fig. 5. W7760C assembly mounting dimensions in in. (mm).

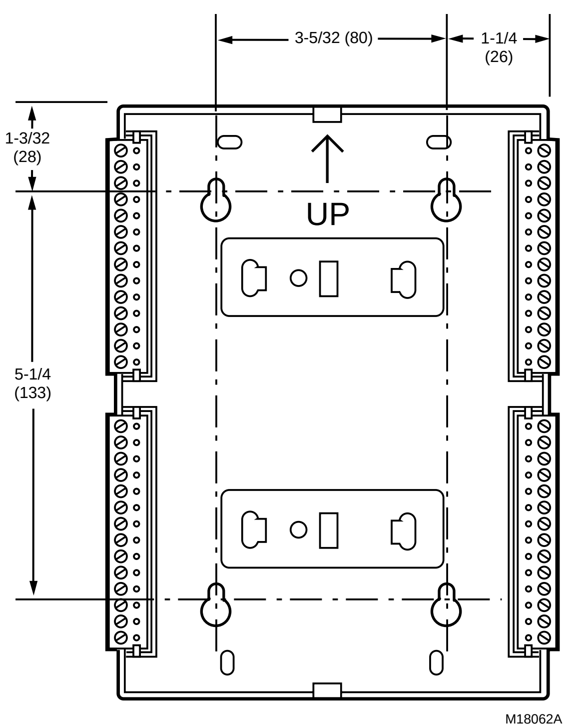


Fig. 6. W7760C subbase mounting dimensions in in. (mm).

## Performance Specifications

**CPU:**
DS80C310.

**Memory Capacity:**
128K EPROM for Operating System, 32K of flash for application programs, 32K of SRAM for runtime log (capacitor backed).

**Input Power:**
20 to 30 Vac, 50/60 Hz, 18 VA consumption (no load). Input power is from a 24 Vac transformer.

**Sensor Power Supply:**
The W7760C provides a 20 Vdc (65 mA maximum) regulated power supply for powering analog input and output devices.

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

**Dimensions:**
W7760C Cover Assembly: 7-1/2x5-1/4x1-15/16 in. (191x133x49 mm).
W7760C Subbase: 7-3/4x5-3/4x15/16 in. (197x146x24 mm).

**Environmental Limits:**
Operating Temperature: -40 to 150°F (-40 to 65.5°C).
Shipping/Storage Temperature: -4 to 122°F (-20 to 50°C).
Relative Humidity: 5 percent to 95 percent non-condensing.

## Communications

The W7760C Controller uses Echelon LONTALK protocol and complies with for the Free Topology Transceiver (FTT) transformer-coupled communications port that runs at 78 kilobits per second (kbps). Using the transformer-coupled communications interface offers a much higher degree of common-mode noise rejection while ensuring dc isolation.

## Cable Types

Approved cable types for LONWORKS Bus communications wiring is Level IV 22 AWG (0.34 $mm^2$) plenum or nonplenum rated unshielded, twisted pair, solid conductor wire. For nonplenum areas, use Level IV 22 AWG (0.34 $mm^2$) such as U.S. part AK3781 (one pair) or U.S. part AK3782 (two pair). In plenum areas, use plenum-rated Level IV, 22 AWG (0.34 $mm^2$) such as U.S. part AK3791 (one pair) or U.S. part AK3792 (two pair). See Tables 20 and 21 for part numbers. 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 frees the system installer from wiring using a specific bus topology. T-tap, star, loop, and mixed wiring topologies are all supported by this architecture. The maximum LONWORKS Bus length when using a combination of T-tap, star, loop, and bus wiring (singly terminated) is 1640 ft. (500m) with the maximum node-to-node length of 1312 ft. (400m). In the event that the total wire length is exceeded, then a Q7740A 2-Way Repeater or a Q7740B 4-Way Repeater can be used to allow the number of devices to be spread out as well as increasing the length of wire over which they communicate.

When utilizing 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 very flexible and convenient to install and maintain, but it is imperative to carefully plan the network layout and create and maintain accurate documentation. This aids in compliance verification and future expansion of the FTT network. This also keeps unknown or inaccurate wire run lengths, node-to-node (device-to-device) distances, node counts, total wire length, inaccurate repeater/router locations, and misplaced or missing terminations minimized. Refer to LONWORKS Bus Wiring Guidelines form, 74-2865 for complete description of network topology rules.

# OPERATION

## General Information

The W7760C Plant Controller is a LONMARK™ compliant general purpose controller intended for use in a wide range of applications such as control air handling units, large air handling plants, heating plants, cooling plants, pumping systems, and other HVAC mechanical room applications. The controller combines the ease of configuring an application specific controller with the flexibility in application of a fully programmable controller by providing control algorithm building blocks that can be combined to meet most HVAC application requirements.

Detailed descriptions Start-Stop Loops, Control Loops, Logic Loops, and Math Functions are provided later in this text.

In planning and configuring a W7760C, the following items should be considered.

## Network Point Data Operation

Refer to Input and Output Summary, Remote Points and Network points for more information on network points.

Network data points (network variables) are defined as being referred (also called bound points) or polled. The difference is in the network process used to communicate from one controller to another.

In general, most defined data points have two components, the network variable input (nvi) and the network variable output (nvo). The nvi is used to receive data from the network and the nvo is used to send data out to the network.

Referred points are best used when a point data such as an outside air is originated in one controller and is to be used in a number of other controllers on the network. Referred (or bound) points are configured such that the controller generating the nvo (the source controller) will transmit the point data whenever it changes or within a prescribed time period (55 seconds). Controllers that are to receive the data are configured with nvi's that match the data type (i.e. outside air temperature). The controller then monitors the network for the point data from the source controller and writes the data to the nvi for use in the controller. If the nvi is not updated within a prescribed time period called the fail detect time (300 seconds), an alarm message is generated and the input will be treated as a sensor fault.

NOTE: It is imperative that the default values of 55 seconds and 300 seconds are not changed. These values have been determined for optimum system performance. The failure detect time must be at least 5 times the update time.

Polled points are best used when a controller needs to read data from one or more controllers on the network. In polling, the controller requiring data from the network initiates a request (poll) for a specific point from a specific controller. The controller with the point data then responds returning the point data to the requesting controller. The W7760C polling algorithm polls each point every 2 seconds. If the response is not received within 10 seconds the poll is changed to one every 30 seconds. When the response is received the poll is returned to once every 2 seconds.

## User Name Assignment

Each W7760C controller and object (start-stop loop, control loop, logic loop, and math function) can be assigned a user name. The user name is 18 alpha numeric characters including spaces.

The user name is the address (user address) for each point in the system. A given point in the system is identified by controller name and point name. Each name within a controller must be unique, but point and object names can be repeated in different controllers. This process makes it very easy to share data between controllers using Refer Points. Operator interface devices display user names.

A consistent naming convention will make the configuration process easier. It is good practice that the name identify the associated function. For example, analog inputs might include the suffix.AI and control loops the suffix.CL. The suffix makes searching for and selecting the correct input or output much simpler.

Operator interface devices often display point data in alphabetical order based on the user name. To control the specific order in which point data is displayed, consider a naming strategy that will order the points in the sequence desired for display.

## LED Operation

The W7760C Plant Controller is equipped with an LED visible in the center of the front cover. The LED provides visual indication of the controller operating status as seen in Table 2.

**Table 2. Controller Operating Status.**

| Alarm Condition | Service LED Blink Rate[a] (cycles/second) |
|---|---|
| No alarms | 1 |
| Any alarm condition | Fast[b] or steady OFF |
| Initialization | Steady ON |

[a] The service LED blink rate is not affected by alarm reporting suppression.

[b] Fast is any blink rate quicker than 1/2 second on and 1/2 second off.

## Input/Output Summary

The W7760C Plant Controller algorithms can use inputs and outputs of multiple types. See Table 3 for the input and output types.

**Table 3. W7760C Input And Output Types.**

| Type | Description |
|---|---|
| Physical points | Inputs and outputs that are physically connected to the controller (local points). |
| Remote points | Point data from another controller on the network read or sent through the network. |
| Setpoints | A table that has up to 40 analog values. |
| Pseudo points | The outputs of start/stop loops, control loops, logic loops and math functions. |
| Network points | Standard points with data generated from a controller and read across the network. |

All inputs and outputs are either analog or digital. See Fig. 7. Analog refers to a signal that changes to represent a variable value such as temperature, humidity or pressure. Digital refers to a signal with two states on or off. Digital points are also referred to as binary or discreet points.

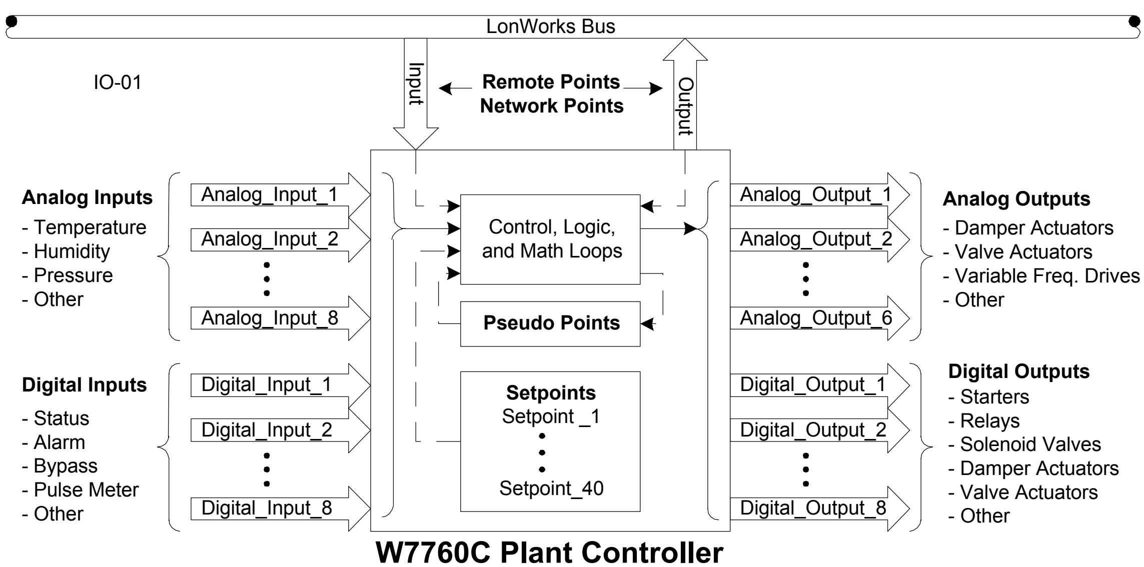


**Fig. 7. W7760C Plant Controller inputs and outputs.**

## Physical Inputs and Outputs

The W7760C Plant Controller has physical connections for eight analog inputs, eight digital inputs, six analog outputs and eight digital outputs.

## Analog Inputs

The W7760C has eight analog inputs (AI1 through AI8). These analog inputs are used to monitor external conditions such as temperature, humidity or pressure and other variables. These AIs are used for monitoring and as inputs to control loops, logic loops and math functions. The W7760C samples each of the eight AIs at least once per second. Each analog input can be assigned a unique native language name (refer to General Information, User Name Assignment). The name is stored in the controller and is used by other devices including the operator interfaces to identify the input.

The AIs can be individually configured as:
Resistive:
— With an input range of 100 to 6500 ohms.
— With an Accuracy of ± 10 ohms.
— An AI less than 100 ohms detects as a short and an AI that is greater than 10,000 ohms detects as an open.
— Has a linear scale of input range that matches assigned engineering units.
Voltage:
— With an input range of 0 to 10 Vdc

NOTE: 4 to 20 mA signals use an external 500 ohm precision resistor.

— With an Accuracy of ± 3 percent of the input range or ±10 millivolts, whichever is greater.
— An AI greater than 10 Vdc detects as an open.
— With a Sensor output impedance that is less than 2000 ohms.
— That has a linear scale that matches the input range.
20K NTC Resistive:
— That has a preconfigured RTD-the 20KOhm Negative Temperature Coefficient.
— With a temperature to resistance range of -40 to 239°F (-40 to 115°C) 839K ohms to approximately 695 ohms.
— That has open/short detection.
Digital:
— That senses dry contact closure.
— Functions as a digital input.

Engineering units can be customized for each AI.

Any configured analog input can be assigned as a network point. Network point types are OD Temp (outdoor temperature), OD Hum (outdoor humidity), and Discharge Temp (discharge air temperature). Only one input can be assigned as any given network variable type.

## Digital Inputs

The W7760C has eight digital inputs (DI1 through DI8). These digital inputs monitor status, alarm, bypass, pulse meters and other switched signals. DIs are used to monitor status, initiate alarms and as inputs to start/stop loops, control loops and logic loops for switching actions. The W7760C samples each of the eight DIs at least once a second.

Each DI can be assigned a unique native language name. The name is stored in the controller and is used by other devices including the operator interfaces to identify the input.

A DI requires a dry contact (no external power) to switch 10 mA at 5 Vdc. It is imperative that input devices are rated for switching electronic signals.

DIs can be individually configured as:
— Normally Open or Normally Closed; The physical DI state is inactive (false) when the input contact is in the normal position.
— Maintained; The logical input state tracks the physical input state (contact). This requires the contact to change state for a period greater than 50 milliseconds.
— Momentary; The logical input state toggles (inactive/active) each time the physical input state switches to *active*. This requires the contact to change to the active state for a period greater than 50 milliseconds.
— Counter Slow; This counts the number of pulses (the physical input state is transitioned to *active*) up to 65,535 pulses. The next pulse resets the counter to zero.
Maximum Frequency: 0.4 Hz.
Minimum Pulse Width: 1.25 seconds.
Maximum Chatter: 50 milliseconds.
— Counter Fast; This counts the number of pulses (the physical input state is transitioned to *active*) up to 65,535 pulses. The next pulse resets the counter to zero.
Maximum Frequency: 15 Hz.
Minimum Pulse Width: 20 milliseconds.
Maximum Chatter: 5 milliseconds.
— Pulse Meter; These are used with power meters that have pulsed dry contact outputs. Pulses are multiplied by the scale factor (kWh/Pulse). If two DIs are configured as a Pulse Meter, the values are added.

NOTES:
— Any two DIs can be configured as counters. The choices can be two counters that are slow or two counters that are fast or one slow and one fast counter.
— Two additional DIs can be configured for Pulse Meters.
— Any two DIs can be configured as the sources for network sensor occupancy points (Sensor Occupancy_[1,2] Out).
— Engineering units can be customized for each digital input. When selecting the engineering unit, the first unit in the pair is the inactive state and the second is the active state.

## Analog Outputs

The W7760C has six analog outputs (AO1 through AO6). These AOs are used to position valve and damper actuators, variable frequency drives, variable speed fans, step controllers and other devices that use a variable current or voltage output.

Each AO can be assigned a unique native language name. The name is stored in the controller and is used by other devices including the operator interfaces to identify the output.

The AOs are 0 to 20 mA (configurable) current outputs that have a maximum load of 500 ohms with a 7 + bit resolution.

Adding an external 500 ohm precision resistor allows the AO to be configured to match signals that range between 0 to 10 Vdc.

The AO signal can be configured to reverse the signal action. For example, the output could be configured so that an output of zero percent produces a 20 mA signal and an output of 100 percent produces 4 mA. This allows the output to match the controlled device without changing the operation of the control algorithm.

The AOs are also configurable as DOs, the output switches between the low and high configured output values. The digital load can not exceed 500 ohms.

## Digital Outputs

The W7760C has eight digital outputs (DO1 through DO8). These DOs are used to turn equipment and devices on and off, to position valve and damper actuators and other controlled devices that use floating control or PWM input signals. These DOs have 24 Vac Triacs that are isolated from controller power (25 mA minimum to 100 mA maximum loads). Each pair of Triacs shares a common terminal. See Fig. 8. Each DO is sequenced on and off at 50 ± 25 milliseconds. This prevents two or more Triacs from turning on or off at the same time.

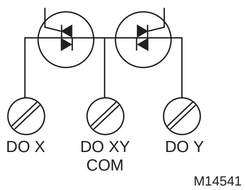


**Fig. 8. Digital output pair with common terminal.**

Each DO can be assigned a unique native language name (refer to General Information, User Name Assignment). The name is stored in the controller and is used by other devices including the operator interfaces to identify the output.

DOs can be configured to energize the physical output when the control output is on (de-energize when off) or to energize the physical output when the control output is off (de-energize when on). This enables the output to be configured to match the controlled device without changing the control algorithm. For example: lights are in fail-safe on, so a control contactor with normally closed contacts is selected. This requires the output to be configured for Energized Off. An off command energizes the contactor that turns off the lights.

Any DO can be configured for floating control operation. Floating control requires the configuration of two DOs, one to drive the controlled device open and one to drive it closed. Good engineering dictates a pair of Triacs that shares a common terminal be used. The configured pair can be used by a control loop as a modulating output. Accurate control of floating devices requires that the device speed (the time required to drive from fully closed to fully open) be entered. A maximum of two pair of DOs (four outputs) are configurable for floating operation.

The DOs are configurable as PWM outputs. See Fig. 9. The DO configured as a PWM output can be used by a control loop as a modulating output. Configuring a DO as PWM requires that the PWM period, 0 percent pulse width and 100 percent pulse width be defined to match the controlled device input requirements. The pulse width period is the time period for one pulse cycle and must be greater than or equal to the 100 percent pulse width value. The 0 percent pulse width is the time period of the pulse representing 0 percent output value from the controller (this must be greater than 0). One hundred percent pulse width is the time period of the pulse representing 100 percent output value from the controller. DOs that are connected to PWM devices are exempt from being sequencing on and off at 50 ± 25 milliseconds in order to maintain their timing.

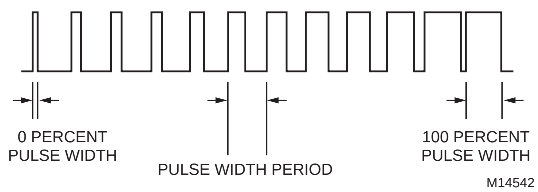


**Fig. 9. Pulse width modulation signal.**

## Remote Inputs and Outputs

Remote points are used by control algorithms in the same manner as physical points.

### REMOTE ANALOG INPUTS

The W7760C can use a maximum of 38* remote AOs. These consist of up to 18 AOs from W7761A Remote Input/Output devices (RIO) and 20* *polled* points. RIO AOs provide a maximum of six AIs from each of three RIO devices associated with the W7760C. RIO AIs are *bound*. See General Information, Refer Points for additional information on bound points.

### REMOTE DIGITAL INPUTS

The W7760C can use a maximum of 32* remote DIs. These consist of up to 12 DIs from W7761A RIO devices and 20* *polled* points. RIO DIs provide a maximum of four DIs from each of three RIO devices associated with the W7760C. RIO digital inputs are *bound*. See General Information, Refer Points for additional information on bound points.

* The W7760C can use a maximum of 20 *polled* inputs. Each polled input is either analog or digital. The 20 polled inputs can be any combination of analog or digital points. A polled AI can be any analog point accessible to the network. The points can be physical AIs or outputs connected to another controller, setpoints or pseudo points providing they are available to the network. Analog point data available to the network varies by controller type. See General Information, Polled Points for additional information on polled points.

### SETPOINTS

A W7760C Plant Controller can be configured with up to 40 setpoints for use as analog inputs to control loops, logic loops and math loops. Setpoints are analog constants that can be named and assigned engineering units. Setpoints are typically used as inputs to logic loops and math functions but can be used as an analog input to a control loop in some applications. These setpoints can not be read or modified by an operator interface.

### PSEUDO POINTS

Pseudo points are generated when a start/stop loop, control loop, logic loop or math function is configured. Pseudo points are analog or digital based on the output configuration. Start/stop loops have one DO. The pseudo point name is *LoopName*_Output. Control loops can be configured with as many as 17 outputs. Pseudo points are created only for configured outputs and are either analog or digital matching the configured output. See the pseudo point names in Table 4.

**Table 4. W7760C Pseudo Point Names.**

| Configured as Analog | Configured as Staged |
|---|---|
| *LoopName*_ EPID | *LoopName*_ EPID_STAGE [n] |
| *LoopName*_ SEQ[n] | *LoopName*_ SEQ[n]_STAGE [n] |
| | *LoopName*_ AUX |

[n] is the sequence output number or stage output number. A logic loops pseudo analog point is created if the DCAO statement is configured and the digital point is created if logical OR is configured. The pseudo point names are *LoopName*_ AO and *LoopName*_ DO respectively. Math functions are exclusively analog with the point name *LoopName*_ Output.

### NETWORK POINTS

Network points are a special case of remote points. Network points are points with defined functions shared across the network. Refer to General Information, Refer Points for further information on network points. See network points used with the W7760C in Table 5.

**Table 5. W7760C Network Points.**

| Analog Inputs | Digital Inputs | Analog Outputs | Digital Outputs |
|---|---|---|---|
| nviApplMode | nviEconEnable | nvoApplMode | nvoCoolUTML |
| nviBldgStatPress | | nvoOccupancy | nvoEconEnable |
| nviDuctStatPress | | | nvoHeatUTML |
| nviEmergOverride | | | |
| nviOccupancy | | | |
| nviRARH | | | |
| nviRATemp | | | |
| nviDATemp | | | |
| nviOdHum | | | |
| nviOdTemp | | | |

Analog and digital network inputs read their assigned values from the network if available. It is necessary to configure Network Refer Points to assign the source controller/point to the destination controller/points. Analog and digital network outputs are assigned to the physical inputs when the inputs are configured. It is necessary to make the physical point assignment for the network output point to make the data available on the network. It is necessary to configure Network Refer Points to assign the source controller/point to the destination controller/points.

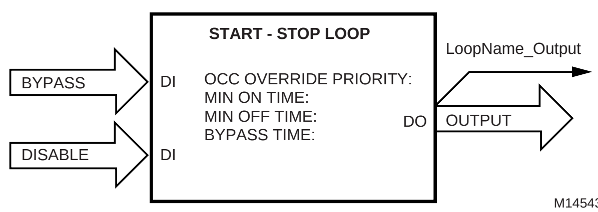


**Fig. 10. Start/Stop loop schematic**

# Configurations

## Start/Stop Loops

There are eight Start/Stop loops that can be configured to turn equipment on and off based on the Time Of Day (TOD) scheduling and/or Demand Limit Control (DLC) load shed and restore operation. Minimum on and off times can be assigned. Each start/stop loop is configured independently. See Fig. 10 for operation descriptions typical for all eight loops.

### TOD SCHEDULE

A W7760C Plant Controller start/stop loop receives the TOD status input from a W7760A Building Manager Controller TOD schedule. The TOD schedule is configured and assigned in the W7760A. See W7760A Building Manager System Engineering form 74-2969 and the ZL7760A Excel LONSPEC™ software Help for information on configuring and assigning TOD schedules.

The TOD schedule sets the start/stop loop to one of two possible conditions occupied or unoccupied. A Standby event from the TOD schedule is treated as occupied. If a TOD schedule is not assigned or fails the default setting is occupied.

#### BYPASS

When the start/stop loop is put into bypass operation during the unoccupied period, the output turns on for the configured bypass time. At the end of the time period the output turns off. If bypass is initiated during the occupied period and the bypass timer has not timed out, the start/stop loop will remain on for the time remaining on the bypass timer. If the unoccupied period ends during the bypass period, the bypass operation terminates. The bypass time can be set from 0 to 1080 minutes in one minute increments.

Bypass operation can be initiated by the DI configured for bypass or from a network command. The Occupancy Override Priority for the start/stop loop can be configured for *Network Wins* or *Last One Wins*. If set for Network Wins and the loop is placed in bypass by a network command, the DI is ignored until the bypass period has expired or is canceled by a network command. If set for Last One Wins the last command from either the network or the DI controls the bypass operation. The default Occupancy Override Priority for the start/stop loop configuration is Network Wins.

Once initiated by the bypass digital input, the bypass operation can not be terminated by the bypass input. If bypass is initiated during bypass operation, the bypass timer resets to the full bypass time.

#### MINIMUM ON AND MINIMUM OFF TIME

A minimum on time and a minimum off time can be configured individually for the output. The minimum times can be set from 0 to 254 minutes. The default value for each is 0. When the output is turned on, it remains on for the Minimum On Time setting and when it is turned off, it remains off for the Minimum Off Time.

#### DEMAND LIMIT CONTROL

The start/stop loop can be assigned as a load in the Excel 15 W7760A Building Manager DLC program. See W7760A Building Manager System Engineering form 74-2969 and the ZL7760A Excel LONSPEC™ software Help for information on configuring and assigning loads to a DLC program.

When there is no shed command from the DLC, all other functions operate as described above. When the start/stop loop receives a shed command from the DLC, it turns off the output regardless of the TOD schedule or the bypass status. It insures that the configured Minimum On Time requirement has expired before turning the output off. The output remains off until the DLC sends the loop a restore command. It remains off until the Minimum Off Time has been met. The output then returns to the control of the TOD schedule and bypass command in effect.

#### LOOP DISABLE

A DI can be selected to disable the start/stop loop. When disabled the loop TOD schedules, bypass or DLC and the output are off. The loop is enabled if the disable loop is not configured.

NOTE: The loop is enabled when the disable input is off (false) and disabled when the input is on (true). Be sure the input logic meets the design requirements.

#### MANUAL MODE

The start/stop loop can be placed in the manual mode from a network command. In the manual mode the output can be commanded on or off regardless of the loop operation. When commanded to manual on or off, a network command is required to return the loop to automatic operation.

#### CONFIGURATION DATA

Start/Stop loops have the following configuration data:
— Loop Name: Should change to describe the function of the Start/Stop loop. Default–StartStop_Loop_# where # is the loop number.
— Bypass: (DI, optional)–Select from drop down list.
— Disable Loop: (DI, optional)–Select from drop down list.
— Start/Stop Output: (DO, required)–Select from drop down list.
— Occupancy Override Priority
Network Wins or Last One Wins–Select radio button.
— Minimum On Time: 0 to 254 minutes. Default is 0.
— Minimum Off Time: 0 to 254 minutes. Default is 0.
— Bypass Time: 0 to 1080 minutes. Default is 180.

*Display Data*:
— Enable/Disable/Manual mode.
— Effective Occupancy (occupied, unoccupied, standby or bypass.
— Scheduled Occupancy (occupied, unoccupied and standby.
— Occupancy Sensor state (on/off).
— System Mode (Auto/Off are the only system modes used. (Off indicates the start/stop loop is disabled by the Disable DI).
— DLC Shed status mode.
— Digital Output Status (on/off).
— Minutes remaining in Bypass state.
— Other status data from other sources in the Plant Controller such as: Loop Name.

## Control Loops

The W7760C Plant Controller can be configured with up to ten control loops that are used to command outputs based on an input variable. A control loop is configurable to use either the Enhanced Proportional + Integral + Derivative (EPID) algorithm or plus (+) the Honeywell proprietary nonlinear algorithm. Control loops have many built in features enabling them to command a wide variety of applications. Control loops can be cascaded with logic, math and control loops to create complex control strategies. See Fig. 11.

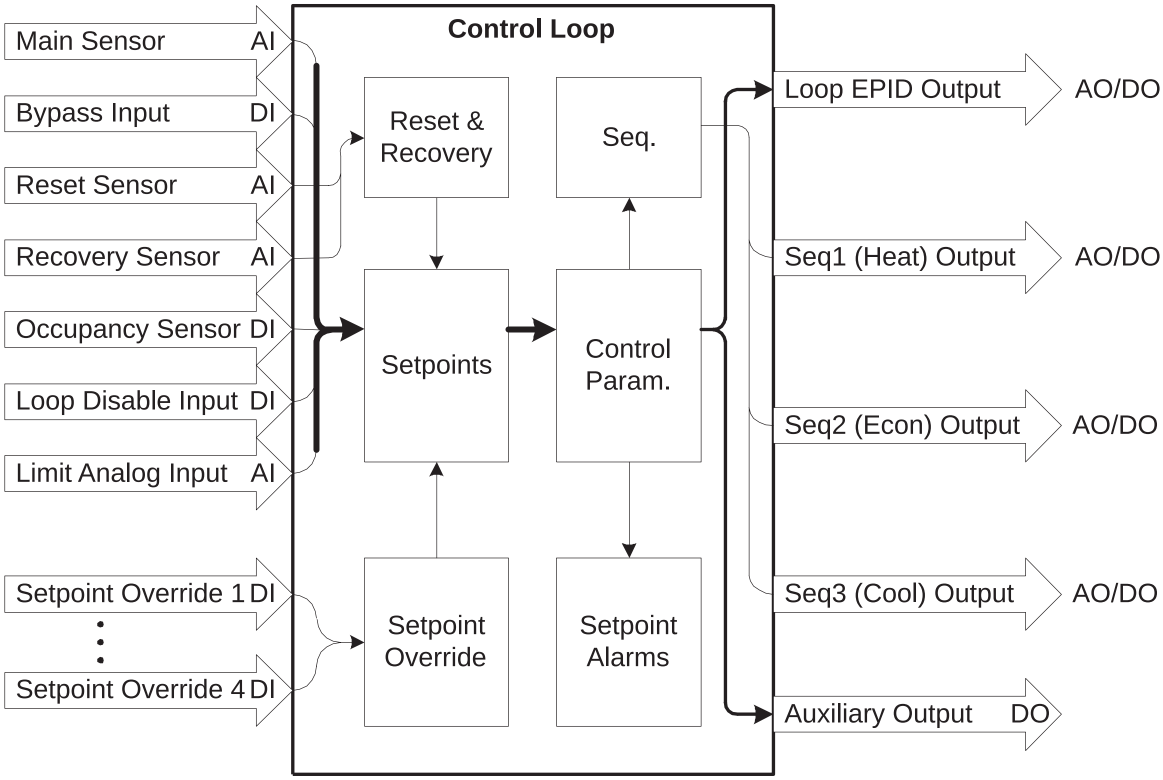


**Fig. 11. Control loop schematic.**

The fundamental operation of a control loop compares the value of the input sensor (measured variable) to the setpoint and calculates the output using the PID or nonlinear parameters. The complexity and flexibility of the W7760C control loop is due to the ability to modify the effective setpoint based on a number of the following control conditions:

— Scheduled setpoints: occupied, unoccupied and standby.
— Startup ramp time.
— Adaptive Intelligent Recovery™.
— Intelligent setback.
— Unoccupied bypass.
— Setpoint reset.
— Setpoint override.
— Demand Limit Control.

Additional flexibility is included in the control loop by configuring the outputs. Each control loop can configure the primary output as analog or staged (1 to 4 stages). The integrated sequencer outputs can scale the primary output into three additional outputs that can be configured as analog or staged (1 to 4 stages) outputs for use in sequenced applications (heating, economizer, and cooling). Each control loop has an auxiliary DO for controlling a fan or a pump. Configured control loops run once per second.

## PID CONTROL

The actual PID control algorithm is more complex, but can be explained as follows where:
O = Control signal output.
V = Calculated output.
M = Output Bias.
$E_p$ = Proportional Error.
$E_{p-1}$ = $E_p$ from the previous iteration.
$E_i$ = Integral Error.
$E_d$ = Derivative Error.
Sen = Input sensor value.
SP = Setpoint.
TR = Throttling Range.
$T_i$ = Integral Time.
$T_d$ = Derivative Time.

O = If (V x 100% + M) < 0%
Then 0%
Else if (V x 100% + M) > 100%
Then 100%
Else (V x 100% + M)

$$V = E_p + E_i + E_d$$

Direct Acting or Reverse Acting

$$E_p = \frac{Sen - SP}{TR} \qquad E_p = \frac{SP - Sen}{TR}$$

$$E_i = \Sigma \frac{E_p}{T_i}$$

$$E_d = (E_{p-1} - E_p) \times T_d$$

NOTE: The control loop signal output values are bound at 0 to 100 percent. However, the internal calculations are not bound and calculate positive and negative values to the limit of the floating point decimal range.

## PROPORTIONAL CONTROL

Proportional control is the function that determines the output setting required to meet the load conditions. See Fig. 12 and 133.

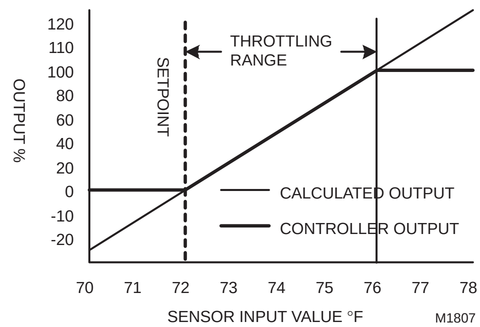


**Fig. 12. Proportional direct acting (cooling).**

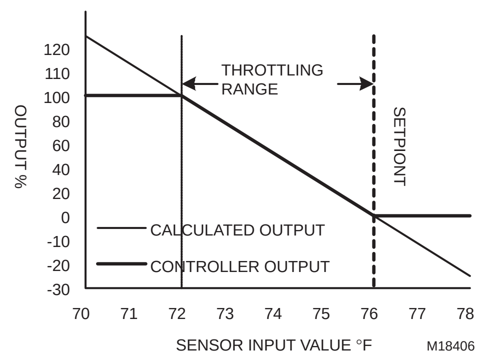


**Fig. 13. Proportional reverse acting (heating).**

In a direct acting control loop the output increases as the input sensor value rises above the setpoint. In a reverse acting control loop the output increases as the input falls below the setpoint. Direct and reverse acting are selected based on application requirements associated with the consideration that the setpoint is the *no load* value of a measured variable because it has 0 percent output when the energy input is closed or off. The physical outputs are configured to match the controlled devices (for example, normally open, normally closed, energized on, energized off). See the following application examples.

| *Direct Acting* | *Reverse Acting* |
|---|---|
| Cooling | Heating |
| Dehumidification | Humidification |
| Mixed Air | Hot Water Pump |
| Static Pressure | Lighting |
| Chilled Water Pump | |
| Condenser Water Pump | |

The proportional calculation determines the proportional error ($E_p$). $E_p$ is the deviation from the setpoint of the sensed medium (input sensor) divided by the throttling range in the units of the input sensor. The setpoint is the value of the input sensor that satisfies the control loop. When the input sensor value is at the setpoint, there is no proportional error and the output is 0 percent. The throttling range is the amount of change in the sensed medium that is required to drive the output from 0 to 100 percent. In proportional control the input value must deviate from the setpoint to initiate a change in the output.

The throttling range must be narrow enough to provide good control without becoming unstable. The throttling range is determined by a number of factors such as the control application, the response time to the equipment being controlled and the control algorithm in use. The narrower (smaller) the throttling range, the more precise the control operation. The wider (larger) the throttling range, the more stable the control action. The objective is to set the throttling range to achieve the optimum balance between precision and stability.

## INTEGRAL CONTROL

The purpose of the integral function is to eliminate the offset inherent in proportional control. Integral control functions to hold the input sensor value at setpoint. See Fig. 14.

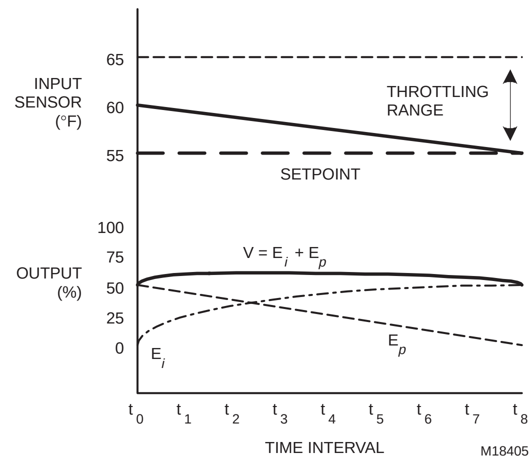


**Fig. 14. Proportional Integral control.**

The integral function is a result of proportional error and time. When the proportional error is greater than 0, the integral error is calculated and added to the proportional error to determine the control loop output. The integral error is cumulative and continues to increase as long as the proportional error is greater than 0. The increase in the output signal drives the controlled device further open and the controlled medium is brought closer to the setpoint. While the proportional error is reduced, the integral error continues to increase until the proportional error is eliminated. When the proportional error equals 0, the calculated integral error is no longer increasing or decreasing and no change is made to the output. When the proportional error is less than 0, the integral error decreases in value.

The integral time value is set in seconds based on the lag time of the controlled process. A slow process such as space temperature control requires a long integral time (600 seconds or more), while a fast process such as static pressure control requires a short integral time. An integral time of 0 (default) eliminates the integral function for the control loop.

Stability of the PI control loop is a balance of the throttling range and the integral time. If a PI control loop is unstable, increase the throttling range and/or increase the integral time. Generally the throttling range required for PI control is greater than what is used for proportional control only. PI control should only be used in closed loop applications. Without feedback from the controlled medium, integral windup occurs. Integral windup is a run away condition in which the integral error continues to increase due to the lack of proportional corrections. Plan the control strategy to insure integral windup does not occur or cause problems in the system performance.

NOTE: The output value read by all operator interface devices is the controller output value (0 to 100 percent) not the calculated output value. The user can not read the various components of a PI output to determine the respective contribution to the output value.

### DERIVATIVE CONTROL

The purpose of derivative control is to reduce *ringing* or severe overshoot and undershoot when there is a significant load change in a short period of time. See Fig. 15 through 17.

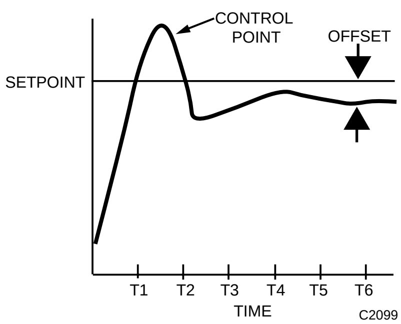


**Fig. 15. Proportional control.**

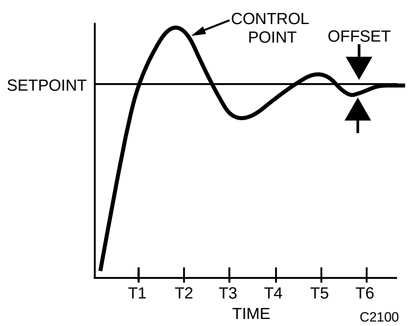


**Fig. 16. Proportional integral control.**

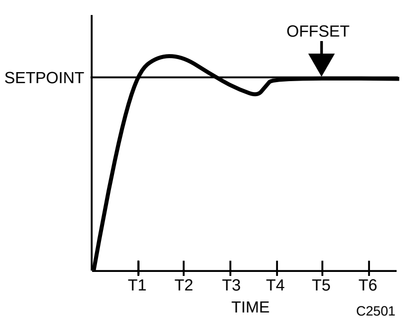


**Fig. 17. Proportional integral derivative control.**

NOTE: Few applications in HVAC require the use of derivative control. This is especially true with the W7760C EPID control loop. EPID features such as start ramp eliminate many of the traditional control issues requiring derivative control. The loop stability and time associated with tuning derivative loops dictates that derivative not be used unless absolutely necessary.

Applications that are candidates for derivative control are very fast responding and subject to sudden large changes in external load conditions. These include static pressure control of fan systems, direct fired gas units, oversized controlled equipment and in some chilled water temperature control cases. Each application should be carefully examined before applying derivative control.

The derivative control function opposes change. The greater the proportional error the greater the braking effect of derivative control. The derivative function is calculated by subtracting the current proportional error value from the proportional error value of the previous loop execution and multiplying the result by the derivative time in seconds. The derivative error is summed with the proportional and integral errors to determine the loop output value.

In selecting the derivative time setting, the smaller the time setting, the smaller the derivative effect and the greater the time setting, the greater the derivative effect. A derivative time of 0 (default) eliminates the derivative error. If using the derivative time, it must be set to match the system response time of the controlled equipment and significantly impacts the throttling range and integral time settings. There are no application specific settings for the derivative time as the settings are unique to the equipment and load conditions.

### DEADBAND OPERATION

Deadband control enhances the performance of conventional PID controllers. It improves the controller stability and further extends actuator life. Deadband is expressed as a percentage of the throttling range. The range is (0 to 100) percent with a resolution of (1) percent. Deadband requirements are related to problems with actuator resolution and hysteresis. If the actuator resolution or hysteresis is unsuitable (too large), frequent control output oscillation results. Output oscillation is undesirable because it results in excess energy consumption and accelerated deterioration of the mechanical system (actuators, valves and dampers).

Deadband control detects when the control loop is operating in an acceptable deadband region. For example, the absolute value of error less than the deadband threshold, and waits for somewhat steady state conditions. After these two conditions are confirmed, the control loop is opened, then the proportional error is set to zero and the controller output is held constant at the value of the previous time step. Deadband control is recommended when the primary control objective is to minimize actuator movement, tolerating small error offsets. If the error drifts out of the acceptable deadband region, the control loop closes and conventional control resumes. Deadband control continues to search for acceptable deadband error and somewhat steady state conditions. Deadband applies to PID control loops. It is ignored on nonlinear loops. To detect when the control loop operates in an acceptable deadband region, it is necessary to establish a delay time (time period in seconds). The delay time is the time that the proportional error must be less than the deadband before the loop will hold a constant output value. See Table 6.

**Table 6. Initial Settings For Single Loop Applications Using Modulating Motors.**

| Parameter | HVAC Application | | | | |
|---|---|---|---|---|---|
| | Heating Coil | Cooling Coil | Mixed Air Cold Climate | Mixed Air Warm Climate | Static Pressure |
| Deadband | | | | | |
| Electric actuator | 1.5°F | 1.0°F | 1.0°F | 0.75°F | 0.2 in. WC |
| Pneumatic actuator with positioner | 1.5°F | 1.0°F | 1.5°F | 1.0°F | 0.2 in. WC |
| Pneumatic actuator without positioner | 1.5°F | 1.0°F | 4.0°F | 3.0°F | NA |
| Variable speed fan motor drive | NA | NA | NA | NA | 0.1 in. WC |
| Deadband Delay | 300 seconds | 300 seconds | 300 seconds | 300 seconds | 60 seconds |

#### NONLINEAR CONTROL

The nonlinear algorithm is offered as an alternative to the PID algorithm. The nonlinear characteristics provide an output that is more stable than PID in some cases. PID is the primary choice, but if there is a problem achieving a stable loop, then the nonlinear algorithm could be the solution.

The W7760C has a control loop execution speed of once every second and is considered fast acting for HVAC applications. Standard PID control loops can be used in most HVAC applications. The nonlinear algorithm is more successful for loops with output instability or where overshoot is not desirable. The nonlinear algorithm develops an error signal and makes relative corrections to reach and maintain zero offset. The main advantage of the nonlinear algorithm compared to the PID algorithm is that the nonlinear algorithm can not make large changes in the output. One parameter for the nonlinear algorithm is *Max. Drive Percent*. This value limits the amount that the output can change in one control interval. If there is a large change in the control point that causes a large offset, PID control makes 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 causing the PID control to 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 tends to cause the PID control to overshoot and become unstable. With the nonlinear algorithm limited to *Max. Drive Percent* per cycle, the commanded output follows closer to the actual motor position. This results in a more stable control and very little overshoot. The nonlinear algorithm can work better than PID for systems that have a very slow response or long sensor time constants.

For this algorithm the parameters are used to set a predefined control surface profile. The three parameters used to describe the control surface are:

1. Max. Drive Band – The absolute error (in delta units of the setpoint and sensor) at which the output changes by the amount equal to the Max. Drive Percent.
2. Max. Drive Percent – The maximum motor travel percentage per controller cycle (1 second). The amount the output changes in percent when the absolute value of the loop error is equal to the Max. Drive Band. The range is 0 to 100 percent with one tenth percent resolution.
3. Deadband – The error at which the algorithm does not take any action (the output remains unchanged). This is a percentage of the Max. Drive Band. The range is 0 to 100 percent with one tenth percent resolution

Guidelines for choosing these parameters follow:

1. The Max. Drive Band is selected close to the PID throttling range. However, it should be at least five times the deadband.
2. Max. Drive Percent should not be greater than the amount that the actual controlled actuator can change in one control interval.

   Example:
   In the W7760C a nonlinear algorithm is controlling an analog output that is driving a 90 second motor (takes 90 seconds to travel one full stroke of its output range), the amount the actuator can change in one second (execution cycle for a control loop) is 1/90 = 1.1 percent. 1.1 percent is a good starting value for the Max. Drive Percent in this application. This value should be made smaller if the process delays or long sensor time constants make the control overshoot excessively or become unstable.
3. Deadband – the deadband is chosen based on the resolution of the inputs and outputs plus the stability of the input sensor signal.

   Example:
   To control a valve with an actuator that has only 50 possible effective positions on a heating coil with a 50°F coil pickup, the output can only control to a 1°F resolution (50°F/50 positions). The output is not capable of resolving the output finer than 1°F. 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 eliminate problems with noisy sensor inputs. It is necessary to set the deadband to command the control to stop since the output is as close as it can be positioned or as close as needed. If the deadband is set at 0 or too narrow, the control loop continuously cycles the output back and forth by trying to get the error to zero which it can not do.

## Output Bias

In some applications it may be desirable to have control above and below the setpoint. By changing the output bias to 50 percent it is possible to achieve an effective equivalent of a center setpoint. 50 percent output bias operates the same for direct and reverse acting control loops. No other change is made to the control loop operation. Direct acting and reverse acting setpoint relationships are still enforced. See Fig. 18 for output bias information.

The PID algorithm calculates the control loop PID output above and below the setpoint to values limited only by the floating point decimal capacity of the controller. The final output is limited to a positive percentage (0 to 100) that represents the output change for the full throttling range with 0 percent or less PID error equaling 0 percent final output. This also means that 100 percent or more PID error equals 100 percent final output. In a proportional only loop, the final output with 0 percent bias is 0 percent when the input equals setpoint (0 proportional error). Adding 50 percent bias to the PID output results in an output of 50 percent when the total calculated PID error is 0 percent. The PID loop calculates a negative 50 percent to change the final output to 0 percent. Also when the PID error is 50 percent the final output is 100 percent. The default parameter setting is 0 percent bias. This means no bias is being added to the PID output calculation to set the output value. Selecting 50 percent bias adds 50 percent to the calculated output.

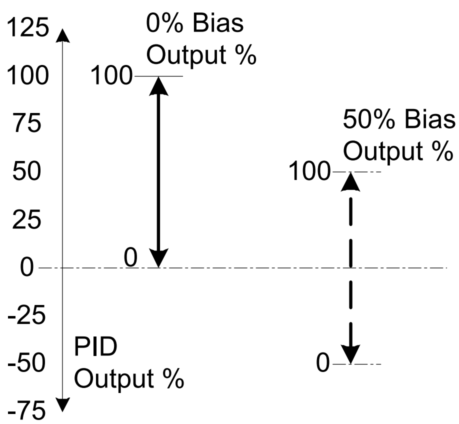


**Fig. 18. Output bias percentages.**

## Setpoint Control

### EFFECTIVE SETPOINT

When working with control loops there is a distinction between the program setpoints and the effective setpoint. The program setpoints are the values entered into the controller program for the occupied, standby and unoccupied setpoints for each control loop that is configured. These values can be changed at any time from an operator interface. These setpoints are the initial values used in calculating the effective setpoint. The effective setpoint is the actual setpoint value used in a control loop to perform the PID and nonlinear calculations. It is the result of programmed and calculated setpoint values that are controlled by time and events. All setpoint values are in units of the main input sensor. Control loop occupied, standby and unoccupied setpoint values are required even if no schedule is assigned to a control loop. If a Setpoint Override digital input is active, the effective setpoint value is equal to the override setpoint value regardless of any other setpoints settings or calculations. If no Setpoint Override digital input is active, the effective setpoint value is equal to the setpoint determined by the current occupancy mode, setpoint reset, DLC, occupancy sensor and unoccupied bypass.

The following relationship rules apply to setpoint values:
Direct Acting – Occupied must be ≤ Standby ≤ Unoccupied.
Reverse Acting – Occupied must be ≥ Standby ≥ Unoccupied.

The following relationship rules are rules are enforced in the W7760C controller:

Direct Acting – The effective setpoint must be ≤ the unoccupied setpoint.
IF Occupied > Unoccupied THEN the effective setpoint equals unoccupied.
IF Standby > Unoccupied THEN the effective setpoint equals unoccupied.

Reverse Acting – The effective setpoint must be ≥ the unoccupied setpoint.
IF Occupied < Unoccupied THEN the effective setpoint equals unoccupied.
IF Standby < Unoccupied THEN the effective setpoint equals unoccupied.

Occupied setpoint reset can not be reset beyond the value of the unoccupied setpoint. This means the unoccupied setpoint must be set to accommodate the reset amount if it is used. (See Setpoint Reset for more information.)

NOTE: LONSPEC does not check or enforce the setpoint relationship rules.

Effective setpoints are determined by the effective occupancy state, setpoint reset, DLC setpoint bump, Adaptive Intelligent Recovery, Intelligent Setback and setpoint override. See the occupancy states in Table 7.

**Table 7. Occupancy States.**

| Occupancy State | Meaning |
|---|---|
| OCCUPIED | The space is considered occupied and the control loop uses the occupied effective setpoint. |
| STANDBY | The space is considered to be in standby, a state between occupied and unoccupied, with the control loop using the standby effective setpoint. |
| UNOCCUPIED | The space is considered unoccupied and uses unoccupied setpoint. |
| BYPASS | The space is considered occupied but is not scheduled to be occupied and the control loop uses the occupied effective setpoint. |

Refer to Fig. 19 for more information on how the effective setpoint is determined. Refer to Fig. 20 for more information on how the effective occupancy state is determined.

### OCCUPIED STATE OPERATION

Occupied is the default effective occupancy state for a control loop. A control loop is initialized in the occupied mode and remains in the occupied mode unless a network command changes the mode to standby or unoccupied.

*Effective Setpoint Calculation*

Where:
SP = Occupied Setpoint.
Rst = Max Reset Amount.
Reset = Reset Calculation.
DLC = DLC Setpoint Bump.

Effective setpoint is equal to:
```
(For Direct Acting)
IF Rst is positive
   THEN
    IF (SP + Reset) > (SP + DLC)
          THEN (SP + Reset)
          ELSE SP + DLC
   ELSE (SP + Reset + DLC)*

(For Reverse Acting)
IF Rst is positive
   THEN
    IF (SP - Reset) < (SP - DLC)
          THEN (SP - Reset)
          ELSE SP - DLC
   ELSE (SP - Reset - DLC)*
```

* Reset is a negative value.

When a direct acting control loop is in the effective occupied state and the Reset Amount is 0 or a positive value, the effective setpoint is a value greater than the occupied setpoint plus the calculated reset or the occupied setpoint plus the DLC bump value. If reset and/or DLC is not configured, the respective values are 0. If reset is configured with a negative reset amount, the effective setpoint is the occupied setpoint minus the calculated reset plus the DLC bump value.

When a reverse acting control loop is in the effective occupied state and the Reset Amount is 0 or a positive value, the effective setpoint is a value less than the occupied setpoint minus the calculated reset or the occupied setpoint minus the DLC bump value. If reset and/or DLC is not configured, the respective values are 0. If reset is configured with a negative reset amount, the effective setpoint is the occupied setpoint plus the calculated reset minus the DLC bump value.

If the control loop is configured with an occupancy sensor and the scheduled occupancy is occupied, the occupancy sensor switches the effective occupancy state between occupied when the sensor is active and standby when the sensor is inactive. See Bypass Operation for more information.

### STANDBY STATE OPERATION

When a control loop is in the standby state, the effective setpoint is the standby setpoint plus the value calculated by the Adaptive Intelligent Recovery algorithm. The default settings for Adaptive Intelligent Recovery are 0. See Adaptive Intelligent Recovery for more information. Setpoint Reset, DLC setpoint bump and occupancy sensor functions do not operate in the scheduled standby mode.

### UNOCCUPIED STATE OPERATION

When a control loop is in the unoccupied state, the effective setpoint is the unoccupied setpoint plus the value calculated by the Adaptive Intelligent Recovery algorithm. The default setting for the Adaptive Intelligent Recovery algorithm is 0. See Adaptive Intelligent Recovery for more information. A control loop can be configured for no control action during the unoccupied state. In this case, PID or nonlinear calculation outputs are set to the startup value, usually 0 percent (off) during the unoccupied period.

### BYPASS OPERATION

Bypass operation can be initiated in three ways:

1. A bypass command from an operator interface (use LONSTATION or a command display device). The control loop bypass timer is started and the bypass remains active until the timer times out or the bypass is terminated by a command.
2. The bypass operation of another loop or controller on the network is shared with the control loop. The control loop bypass timer is not used and the loop will remain in bypass for as long as the associated controller(s) remain in bypass.
3. A bypass input is configured for the control loop. A digital input that can be either a local physical point or a remote point from another controller on the network. The control loop bypass timer starts and the bypass remains active until the timer times out.

See Table 8 for the scheduled state and bypass result.

**Table 8. Scheduled State And Bypass Result.**

| Scheduled State | Bypass Result[a] |
|---|---|
| Occupied[b] Effective Occupied | The effective occupancy state remains occupied (no change). |
| Occupied[c] Effective Standby | The effective occupancy state is occupied (changes from standby). |
| Standby | The effective occupancy state is occupied. |
| Unoccupied | The effective occupancy state is bypass. |

[a] If the control loop bypass timer is active at the end of the scheduled occupancy the bypass operation for the new scheduled state is active for the bypass time remaining.
[b] No occupancy sensor configured or occupancy sensor active.
[c] Occupancy sensor configured and not active.

See Fig. 19 for a flow chart that explains how the effective setpoint is determined.

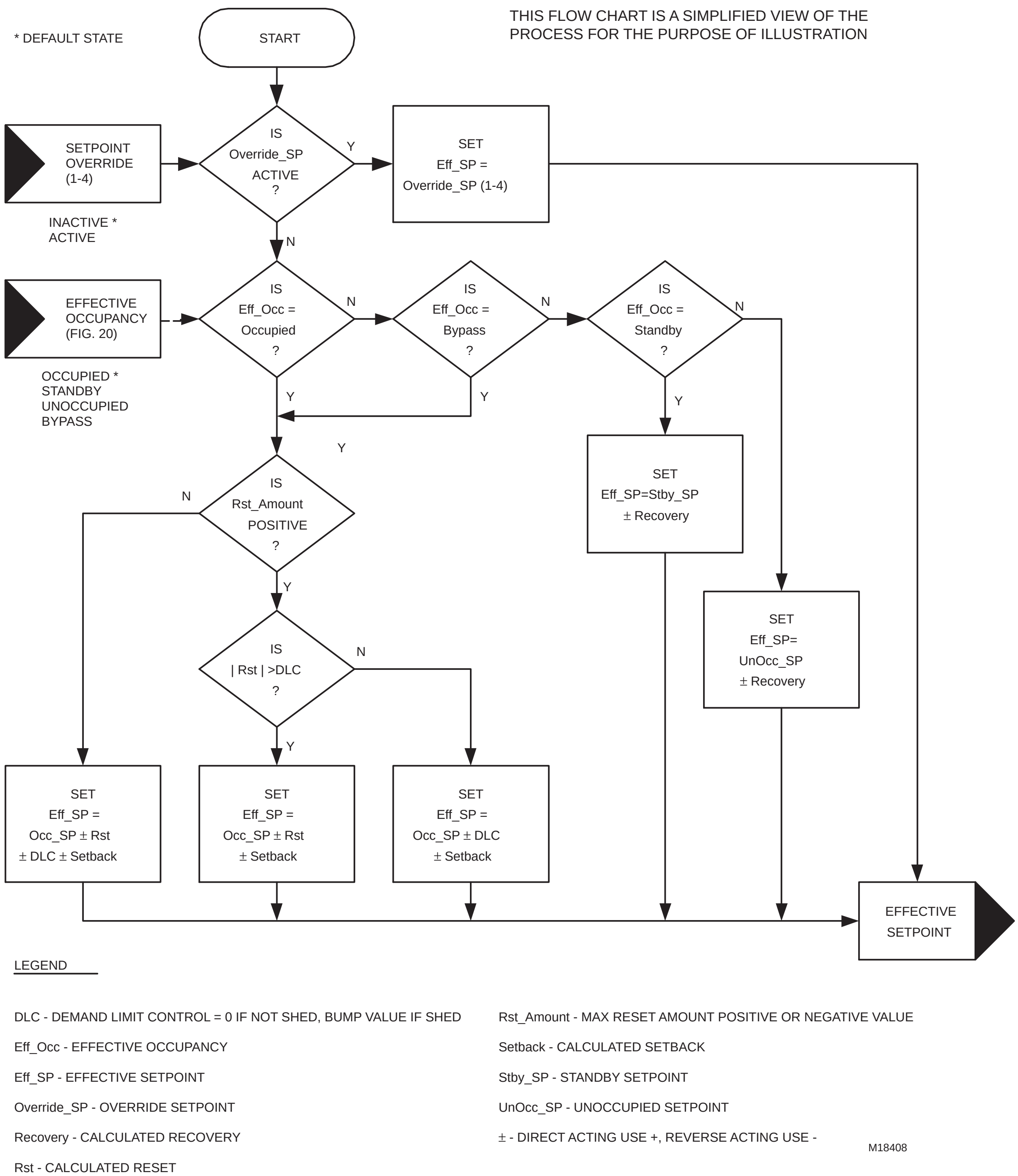


**Fig. 19. Effective setpoint flow chart.**

See Fig. 20 for a flow chart that explains how effective occupancy is determined.

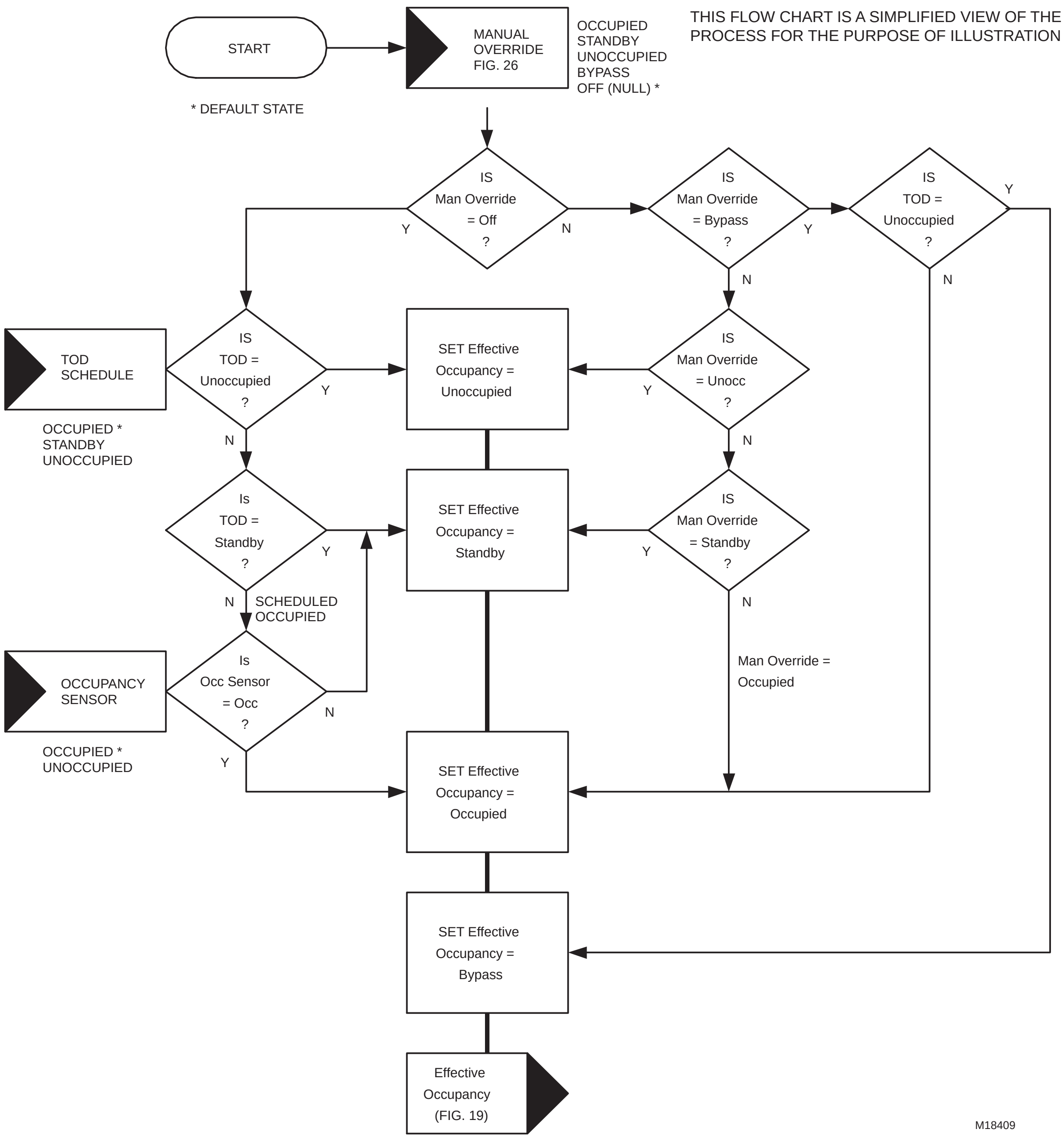


**Fig. 20. Effective occupancy flow chart.**

## SCHEDULING

TOD schedules are not part of the Excel 15 W7760C Plant Controller configuration. TOD schedules are configured and operate in time keeping controllers (W7760A or Q7300H) located on the network.

NOTE: When a Q7300 uses Schedule Assign, it can not receive a schedule from another source. In this case the Q7300 ignores its own schedule so the outputs are null at that point. If there is no schedule bound to that Q7300, then the outputs go according to its own schedule.

Control loops are assigned to a schedule as part of the time keeping controllers configuration. Occupancy data is transmitted from the time keeping controllers to the W7760C control loop.

NOTE: T7300F/Q7300H schedules support four events, two occupied and two unoccupied plus TUNCOS. T7300F/Q7300H schedules do not support standby, special or exception schedules.

Scheduled occupied, standby and unoccupied setpoint values are required even if no schedule is assigned to a control loop. The relationship rules apply to setpoint values as follows:

Direct Acting – Occupied must be ≤ Standby ≤ Unoccupied.
Reverse Acting – Occupied must be ≥ Standby ≥ Unoccupied.

If a schedule in another network device is assigned to a control loop, a network signal from the schedule sets the occupancy mode and the setpoint is selected accordingly.

The scheduled occupancy state of a Start/Stop or Control Loop can be different than the effective occupancy state. The scheduled occupancy is determined by the Time of Day Schedule to which the loop is assigned. The effective occupancy is determined by a combination of the Time of Day Schedule, bypass (override) operation, and manual override from a supervisory device. See Fig. 20.

For information on scheduling, refer to System Engineering for the W7760A Building Manager, form 74-2969. Also refer to System Engineering for the T7300F/Q7300H Series 2000 Commercial Thermostats and Communicating Subbases, form 63-4365.

### OCCUPANCY SENSOR OPERATION

The occupancy sensor function is only applicable when a control loop is configured with a digital input assigned as the occupancy sensor and the control loop is in the occupied state. If the occupancy sensor input for the control loop is not configured the loop operates in the occupied state. If the occupancy sensor input for the control loop is configured and the loop is scheduled for unoccupied or standby state the loop operates in the scheduled state and the occupancy sensor function has no effect. If the occupancy sensor input for the control loop is configured and the loop is scheduled for occupied, the loop checks the status of the occupancy sensor. If the occupancy sensor is active indicating an occupied space, the loop operates in the occupied state. If occupancy sensor is inactive indicating the space is not occupied, the loop operates in the standby state.

### SETPOINT RESET

Setpoint reset uses the reset input to reset (raise or lower) the control loop occupied setpoint. Setpoint reset is only applicable to the occupied mode. The amount of the reset and the range of the reset input used to reset the setpoint are configurable. The reset input is an AI and can be a physical or remote sensor, an output from another control loop (pseudo point) or a setpoint. See Fig. 21 and 22. If the input is not configured, setpoint reset is not applicable to the control loop operation.

Setpoint reset requires program entry of three reset setpoints. They are the Zero Reset Sensor Value, Max Reset Sensor Value and Max Reset Amount. See Fig. 21 and 22.

Zero Reset Sensor Value is the reset input value where no reset occurs. (Effective Setpoint equals Occupied Setpoint.) Max Reset Sensor Value is the reset input value where the maximum reset is achieved. (Effective Setpoint equals Occupied Setpoint plus Max Reset Sensor Amount.) Max Reset Amount is the maximum amount the Effective Setpoint can change from the occupied setpoint as the reset input value varies from the Zero Reset Sensor Value to the Max Reset Sensor Value.

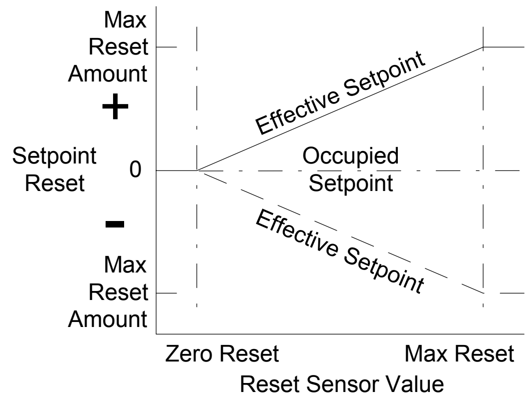


**Fig. 21. Direct acting setpoint reset.**

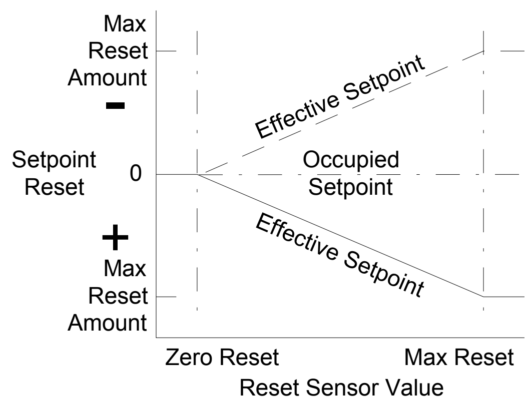


**Fig. 22. Reverse acting setpoint reset.**

Setpoint reset is designed to operate in the energy saving direction, direct acting control loops are reset up from the occupied setpoint. See Fig. 21. Reverse acting control loops are reset down from the occupied setpoint. See Fig. 22. However, entering a negative (-) value for the Max Reset Amount reverses the direction of reset if an application requires. Reset is limited to the Max Reset Amount from the setpoint. The only constraint on the Zero Reset and Max Reset Sensor values is that they must be within the range of the input. Positive and negative numbers are acceptable if they are in the reset sensor range. The Zero Reset Sensor value can be greater than or less than the Max Reset Sensor value.

*Setpoint Reset Calculation*

Where:
SP = Occupied Setpoint.
Rst = Max Reset Amount.
$Sen_r$ = Reset Sensor Input Value.
$Z_r$ = Zero Reset Sensor Value.
$Max_r$ = Max Reset Sensor Value.

Effective setpoint is equal to:

Direct Acting or Reverse Acting

$$SP + Rst \times \frac{Sen_r - Z_r}{Max_r - Z_r} \qquad SP - Rst \times \frac{Sen_r - Z_r}{Max_r - Z_r}$$

NOTE: Formulas are only valid for $Z_r \le SEN_r \le Max_r$. The reset amount, Rst, is limited by the unoccupied setpoint value. This means the setpoint will not reset beyond the unoccupied setpoint regardless of the value of Rst, Max Reset Amount. It is necessary to set the unoccupied setpoint to a value that accommodates to the Max Reset Amount, Rst.

### DEMAND LIMIT CONTROL

The following information covers only the operation of a W7760C Plant Controller control loop as a load in a DLC program. Refer to the W7760A Building Manager System Engineering, form 74-2969 for more information about DLC strategy and configuration. The W7760C Plant Controller control loops uses network commands from other controllers on the network to initiate a DLC setpoint bump. See Fig. 23.

All demand program parameters are part of the demand program and the DLC setpoint bump remains active for the duration of the DLC shed command from the network. DLC setpoint bump is only applicable in the occupied mode. When a control loop receives a shed command the DLC setpoint bump is added to the occupied effective setpoint. Direct acting control loop setpoints are raised and reverse acting control loop setpoints are lowered by the DLC setpoint bump value. If the control loop has an output greater than 0 percent or on and the main sensor value satisfies the DLC effective setpoint, the outputs are either 0 percent or turned off observing minimum on time and interstage off time requirements for the control loop.

For the single DLC parameter being configured as the DLC Setpoint *Bump*.

*DLC Setpoint Calculation*

Where:
SP = Occupied Setpoint.
Rst = Max Reset Amount.
Reset = Reset Calculation.
DLC = DLC Setpoint Bump.

```
(For Direct Acting)
IF Rst is positive
   THEN
    IF (SP + Reset) > (SP + DLC)
          THEN (SP + Reset)
          ELSE SP + DLC
   ELSE (SP + Reset + DLC)*

(For Reverse Acting)
IF Rst is positive
   THEN
    IF (SP - Reset) < (SP - DLC)
          THEN (SP - Reset)
          ELSE SP - DLC
   ELSE (SP - Reset - DLC)*
```

* Reset is a negative value.

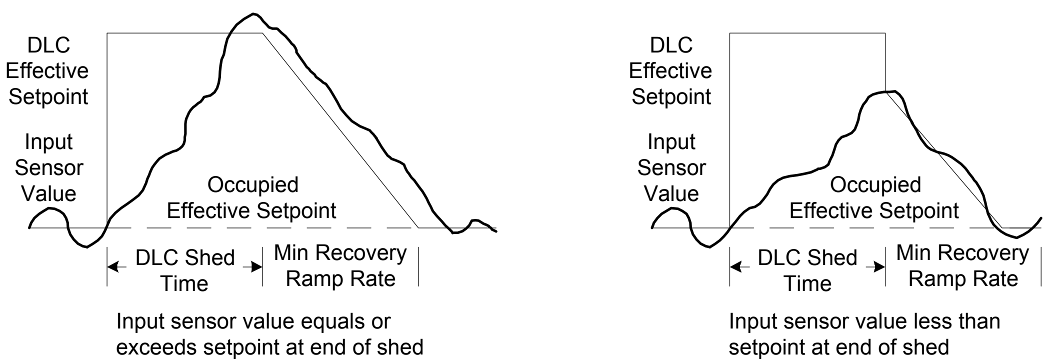


**Fig. 23. DLC effective setpoint (direct acting control loop).**

When the DLC restores the load (removes the DLC setpoint bump) the effective setpoint is ramped to the occupied setpoint plus reset. The ramp time is minimum recovery ramp rate (refer to Adaptive Intelligent Recovery). If Minimum recovery ramp rate is 0, the ramp rate is the DLC bump value per hour. If the input sensor value is greater than the DLC setpoint, the recovery ramp calculates from the DLC setpoint. If the input sensor value is less than the DLC setpoint, the setpoint ramp calculates from the input sensor value at the end of the DLC shed. Fig. 24 applies to a direct acting control loop. For a reverse acting control loop the effective setpoint is bumped down and the recovery ramps up. DLC recovery observes the minimum off time and the interstage on time requirements

### ADAPTIVE INTELLIGENT RECOVERY

Adaptive Intelligent Recovery is a Honeywell proprietary algorithm to minimize energy consumption and assure that comfort conditions are achieved at the beginning of the scheduled occupancy period. See Fig. 24. The W7760C Plant Controller control loops use Adaptive Intelligent Recovery for scheduled transitions from unoccupied to occupied, standby to occupied, unoccupied to standby and DLC setpoint bump to occupied operation. The concept of Adaptive Intelligent Recovery is to ramp the setpoint from the unoccupied or standby setpoint, to the standby or occupied setpoint over a period of time that is based on the recovery capability of the mechanical system. The minimum ramp rate assures that if the mechanical equipment is correctly sized, the occupied temperature will be met at the scheduled occupied time. If the equipment is oversized or the conditions are at partial load, the equipment is cycled off to prevent meeting the occupied setpoint before the scheduled time. By adjusting the ramp rate based on the recovery sensor value, the setpoint ramps to the occupied setpoint at a rate that matches the recovery capability of the mechanical system minimizing energy consumption and reducing equipment cycling. Adaptive Intelligent Recovery requires four data points to be configured for the control loop. See Table 9.

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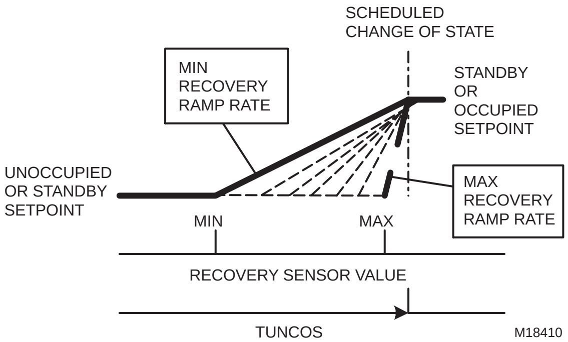


**Fig. 24. Adaptive Intelligent Recovery (reverse acting).**

**Table 9. Adaptive Intelligent Recovery Setpoint Name.**

| Setpoint Name | Description |
|---|---|
| Minimum Recovery Sensor Value | The value of the recovery sensor (typically outside air at local design temperature) at which the minimum recovery ramp occurs. |
| Maximum Recovery Sensor Value | The value of the recovery sensor (typically outside air at no load temperature) at which the maximum recovery ramp occurs. |
| Minimum Recovery Rate | The recovery rate for the mechanical system (typically heating or cooling) at design conditions (usually the outside air temperature). This minimum *rate* of recovery takes the maximum time to get to the new occupied or standby setpoint. |
| Maximum Recovery Rate | The recovery rate for the mechanical system (typically heating or cooling) at no load conditions (usually the outside air temperature at which heating or cooling is no longer needed). This maximum *rate* of recovery takes the minimum time to get to the new occupied or standby setpoint. |

NOTE: When used with Adaptive Intelligent Recovery, minimum and maximum apply to the rate of recovery expressed in degrees per hour. The smallest amount of recovery in one hour is minimum recovery. The most recovery in one hour is maximum recovery. For example, a heating plant can be sized for a recovery of 3°F per hour, at 0°F outside air temperature and a recovery of 8°F per hour at 55°F. The minimum recovery rate is 3°F per hour and the maximum recovery rate is 8°F per hour.

The W7760C Plant Controller has no time keeping capability. When another device on the network has a schedule assigned to a control loop, the device sends network data to the control loop with the current occupancy status, TUNCOS and the next state. The Adaptive Intelligent Recovery routine calculates the setpoint ramp between the minimum and maximum ramp times based on the value of the recovery sensor and executes the recovery process when TUNCOS is equal to or less than the ramp time. Adaptive Intelligent Recovery can be configured to provide a setpoint step change instead of a ramp. This results in the setpoint changing from the unoccupied or standby value, to the standby or occupied value at the time calculated to start the ramp. The stepped recovery provides the functional equivalent of the optimum start operation. If the Adaptive Intelligent Recovery is not configured, the setpoint transitions from unoccupied to standby or occupied in a single step at the scheduled standby or occupied time

### INTELLIGENT SETBACK

The W7760C Plant Controller control loop provides for the intelligent setback of the occupied setpoint. This capability is used for energy savings by ramping the effective setpoint from the occupied setting to the standby setting over a fixed period of time at the end of the occupied period. See Fig. 25. Intelligent Setback is only applicable if the loops assigned schedule has standby assigned for the end of the occupancy period. The setpoint change for occupied to unoccupied and from standby to unoccupied is a step change that occurs at the scheduled time.

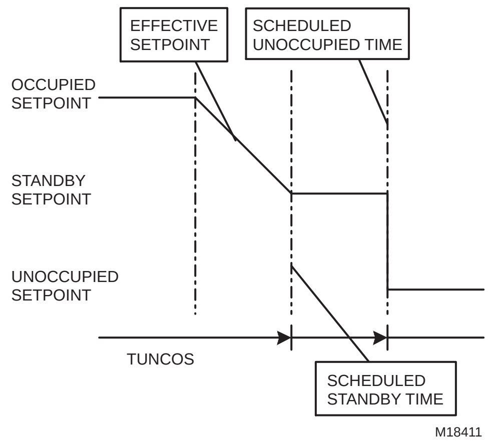


**Fig. 25. Setback ramp (reverse acting).**

If the intelligent setback ramp is a value greater than 0, the intelligent setback is applied. If the value is 0, the transition from occupied to standby is a step change. The transition to unoccupied is always a step change. The ramp time is calculated by dividing the difference between occupied and standby setpoints by the ramp rate.

### OCCUPANCY OVERRIDE OPERATION

Manual override can be used to place the control loop effective occupancy state in something other than the scheduled occupancy state. An operator interface (ZL7761A LONSTATION or the S7760A Command Display), a digital input or the bypass operation of another controller on the network can initiate manual override. See Fig. 26.

The W7760C Plant Controller supports manual override commands for occupied, standby, unoccupied and bypass. When the control loop is placed in manual occupied, standby or unoccupied operation it operates in the occupancy state selected until manual operation is terminated. When the control loop is placed in bypass operation, a bypass timer is initiated. At the end of the preset bypass time, bypass operation terminates. See Bypass Operation for more information.

NOTE: LONSTATION only supports the manual bypass command. The Command Display supports occupied, unoccupied and bypass commands but not standby.

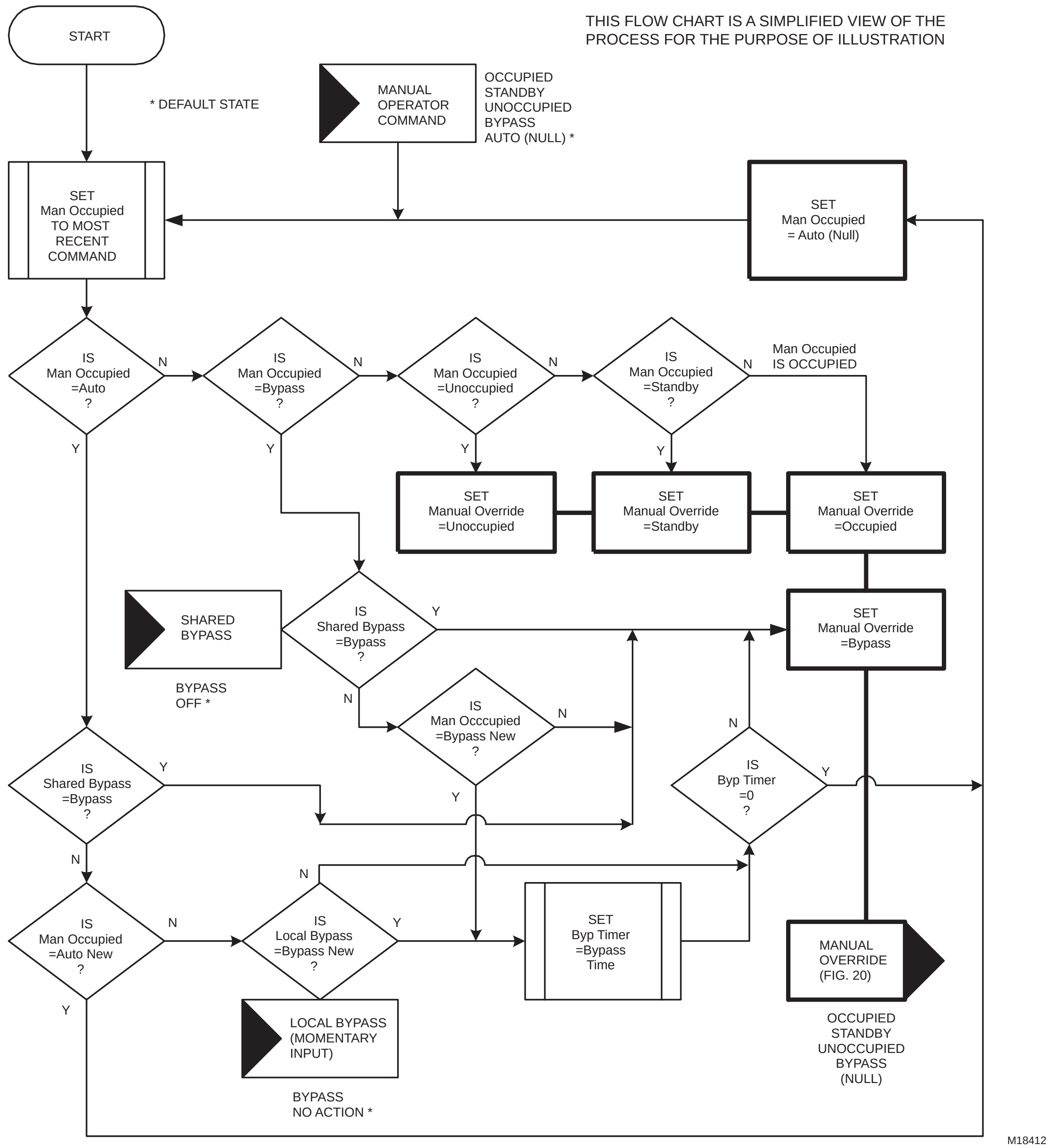


**Fig. 26. Manual override state flow chart (net wins).**

## SETPOINT OVERRIDE OPERATION

Four setpoint overrides can be programmed to override the calculated effective setpoint. If a setpoint override digital input is active, the effective setpoint value is equal to the override setpoint value regardless of any other setpoint settings, calculations or manual occupancy override. If multiple setpoint override inputs are active, the one assigned the highest number is active (setpoint override four has the highest priority). If no setpoint override digital input is active, the effective setpoint is equal to the setpoint determined by the current occupancy mode, setpoint reset, DLC, occupancy sensor and unoccupied bypass.

NOTE: There is no occupancy state indication on operator interface devices that indicates the setpoint override is active. The effective setpoint displays the occupancy state that would be used if no override was in effect.

## CONTROL LOOP INPUTS

The control loop has seven control inputs plus four setpoint override inputs, each has a specific purpose. See Table 10.

**Table 10. Control Loop Inputs.**

| Input Name | Type | Description |
|---|---|---|
| Main Sensor | Analog | The input sensor is used in the PID loop to calculate the required output positions. This is also referred to as the primary sensor. This input must be configured to have a control loop that is configured. If a fault (for example: open, short or loss of data) occurs on the main sensor, the control loop stops and all outputs are set to start value (usually 0) percent or off. In LONSPEC, changing the main sensor to *unconfigured* causes all configured data to be set to the unconfigured default values. |
| Bypass Input | Digital | The bypass input is used to restore occupied operation during an unoccupied or standby period when a schedule is applied to the control loop. Bypass input is not required for schedule operation. Refer to Unoccupied State Operation and Standby State Operation for more information. |
| Reset Sensor | Analog | This sensor resets the occupied setpoint when the reset schedule is configured. Refer to Setpoint Reset for more information. |
| Recovery Sensor | Analog | This sensor is used to reset the Adaptive Intelligent Recovery setpoint ramp. Refer to Adaptive Intelligent Recovery for more information. |
| Occupancy Sensor | Digital | The occupancy sensor is used to change the setpoint from Standby to Occupied and back. Refer to Standby mode for more information. |
| Loop Disable Input | Digital | This input disables the loop when the input is active (on, true). When the Loop Disable Input is active, minimum on times are observed for any outputs that are on.<br>*CAUTION*: The loop is disabled when the input is active. The loop is enabled when the input is inactive (off, false). Use care when designing the control strategy so that the input logic is correct. |
| Limit Analog Input | Analog | An input from a control loop that is configured to act as a high or low limit. Refer to High/Low Limit Application for more information. |
| Setpoint Overrides<br>Digital Input 1<br>Digital Input 2<br>Digital Input 3<br>Digital Input 4 | Digital | Overrides the control loop calculated setpoint value when the input is active (on, true). Refer to Setpoint Override for more information. |

Only the Main Sensor is required for control loop operation. All other sensors are optional depending on the application that the control loop is configured for.

All input points are selected using the drop down combo list box. An input can be used by multiple loops. See Table 11 for input point source information.

**Table 11. Input Point Source Information.**

| Point Source | Description |
|---|---|
| Physical Inputs | These are input devices that are physically connected to the W7760C controller. The input selection lists all physical input points of the appropriate type (analog or digital) that are configured for the controller. The control loop treats an analog input that is configured as digital as a digital input. |
| New Digital Input<br>or<br>New Analog Input | Opens the appropriate input configuration screen to configure a new physical input that is used for the control loop input. Closing the physical input configuration screen returns the user to the Control Loop Input Selection screen. |
| Digital Pseudo Point<br>or<br>Analog Pseudo Point | Pseudo Points are the outputs of Start/Stop Loops, Control Loops, Logic Loops and Math Loops within the controller. These loops are created when a loop output is configured. Pseudo Points are automatically named using the loop name with a suffix of the output function. The pseudo point names can not be changed. |
| Remote | Remote points are physical input points and pseudo points created in another controller. Selecting *Remote* opens the Remote selection window. The user must select the source controller for the input and then select the input point from the list provided. Only Remote points of the appropriate type (analog or digital) are displayed. |
| Setpoints (analog only) | Setpoints are preset values that can be used as inputs when a fixed value is desired. Setpoints are analog only. |
| UNCONFIGURED | This is the default value and disables the input function. It can also be used to unconfigure a previously configured input. |

### STARTUP RAMP

The startup ramp function is used to limit a control loop output during a defined startup period. The startup ramp acts as both a high and low limit on the loop output to prevent overdriving the output during the startup process. The startup ramp is defined by the Ramp Time and Startup Value Percentage. See Fig. 28. Startup occurs when the loop is enabled after power up, controller reset, loop disable input changing to inactive or the end of an unoccupied period when the loop is configured *Disable in Unoccupied*.

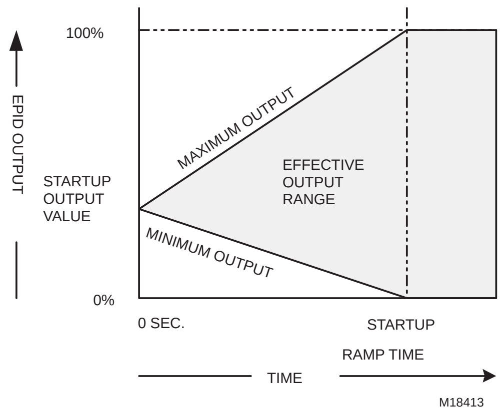


**Fig. 27. Startup ramp.**

The Startup Value Percentage is the value at which the control loop output is set when the controller is powered up, when the controller is reset, when the loop disable input is active or when the loop configured for *Disable in Unoccupied* is in the unoccupied state. At the beginning of the startup ramp period the controller output is at the Startup Value Percentage. The Ramp Time is the minimum time in seconds required for the output to change from the Startup Value output to 100 percent or 0 percent. The ramp time is selected to limit the output over time to prevent overshoot in the controlled precess. The time must match the process lag. When the control loop acquires control during the ramp time, it controls the output between the minimum and maximum output defining the effective output range.

### CONTROL LOOP OUTPUTS

A control loop has five outputs, four of which can be configured as analog or staged. See Table 12 for the control loop outputs.

**Table 12. Control Loop Outputs.**

| Output Name | Description |
|---|---|
| Loop EPID output | This is the primary output signal for the control loop. The output represents the full throttling range of the control loop. The output can be configured as analog, staged, or pseudo. Refer to PID Control for more information. |
| Sequence 1 (Heat) Output | The first sequencer output can be used for any application requiring sequenced operation. When used in sequenced space temperature or discharge air applications it is typically the heating output. The output can be configured as analog, staged or pseudo. Refer to Sequencer Operation for more information. |
| Sequence 2 (Econ) Output | The second sequencer output can be used for any application requiring sequenced operation. When used in sequenced space temperature or discharge air applications it is typically the economizer output. The output can be configured as analog, staged or pseudo. Refer to Sequencer Operation for more information. |
| Sequence 3 (Cool) Output | The third sequencer output can be used for any application requiring sequenced operation. When used in sequenced space temperature or discharge air applications it is typically the cooling output. The output can be configured as analog, staged or pseudo. Refer to Sequencer Operation for more information. |
| Auxiliary Out | Functions like the *Fan* output on commercial thermostats. See Aux Output Operation for more information. |

### OUTPUT OPERATION

A control loop calculates an output value of 0 to 100 percent for each configured control loop output. *Analog outputs* will be positioned proportionally to the output value based on the output configuration. *Staged outputs* are configured with one to four digital outputs. The staging selections made for the EPID and sequenced outputs are configured for each output used. Staged output operation is shown in Fig. 28.

Minimum off and on times can be assigned from 0 to 254 minutes. The minimum times apply to all stages configured for the control loop output.

NOTE: The loop disable and manual mode commands do not use the minimum off and on times. On power up and controller reset the minimum off times are initialized to provide an orderly and controlled start up of equipment.

Interstage off and on times can be assigned from 0 to 254 minutes. The interstage times apply to all stages configured for the control loop output. Interstage time is the time lapse required before the next stage can be switched on or off. The time should be set to match the mechanical system response time.

Lead/Lag operation can be set for the stages assigned to a control loop output. Lead/lag operation applies only to the digital outputs assigned to the control loop staged output. If multiple control loop outputs are configured as staged, the lead/lag function operates independently for each. See Table 13 for Lead/Lag Selection.

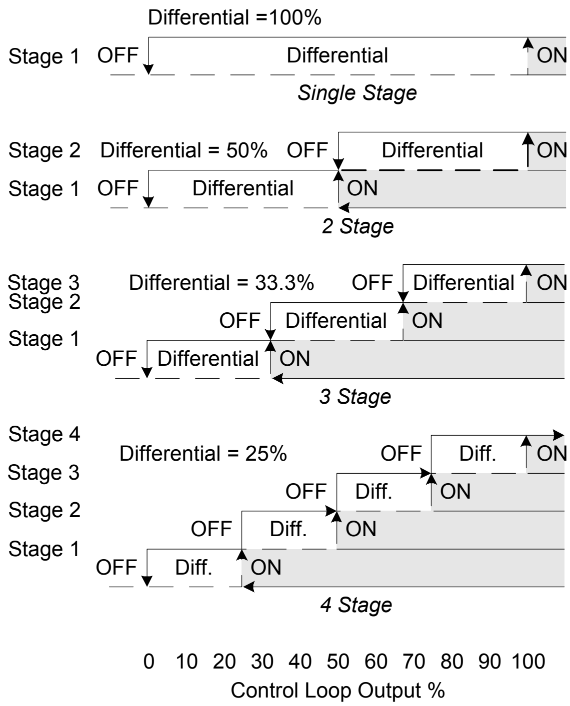


**Fig. 28. Staged output operation.**

**Table 13. Lead/Lag Selection And Operation.**

| Lead/Lag Selection | Operation |
|---|---|
| No Lead/Lag | Lead/Lag is not used (this is the default setting). The stages will always be cycled in the same sequence with Stage 1 on first, then Stage 2, then Stage 3 and then Stage 4. Off occurs in the reverse order. |
| First On First Off | This is a rotating scheme. The first stage on is the first stage that turns off. If all stages are off the first stage on will be the stage following the last stage that was turned off. |
| Equal Runtime | The stage with the lowest amount of runtime is turned on first. In the event two or more stages have equal amounts of runtime, the lowest numbered stage is selected first. The stage with the most runtime is turned off first. |

NOTE: If the Lead/Lag Selection is changed while the W7760C control loop is operating, it continues to use the old selection until all stages are off. The new selection takes effect when the next on cycle occurs.

The W7760C keeps track of runtime on each digital output stage of each control loop to the nearest hour in the runtime file. Internally, runtime is incremented every minute. When an hour has elapsed the runtime value is incremented. If the control loop is configured for equal runtime lead/lag, it makes the decision on what stage to run based on the runtime values. The maximum runtime value that can be stored is 65535 hours with a resolution of one hour. When a runtime value reaches 65535 hours, it stops incrementing. The user needs to clear the file before this time. The runtime file is kept in capacitor backed RAM (CRAM) and mirrored in FLASH memory. Once a day, the file is transferred from CRAM to FLASH. This saves the runtime file in case of an extended power outage. If the CRAM copy is bad, the runtime file is restored from FLASH memory. If the FLASH copy also is bad, then the runtime file is zeroed. No alarm is reported.

*Pseudo output* is created for each configured output point. If an output is being used only as the input to another loop within the W7760C, it can be configured as a pseudo point by assigning the pseudo point name as the output point. The pseudo point name is the loop name_Output and is available in the Output drop down list box for the output being configured.

*Aux Output Operation*; the Aux (auxiliary) Output is a digital output that works like the fan output on a commercial thermostat. The Aux output can be configured for either continuous or intermittent operation. This selection applies to occupied, bypass and standby operation. Unoccupied is always intermittent. In continuous operation the output is on continuously, regardless of the operation of the other control loop outputs. In intermittent operation the output is on only when an analog output value is greater than 0 or at least one staged output is on. The Aux output can be configured with minimum off and on times.

### CONTROL LOOP PARAMETERS

See Table 14 for control loop parameters.

**Table 14. Control Loop Parameters.**

| Parameter | Description |
|---|---|
| Throttling Range | The proportional change in the measured variable required to change the control output from 0 to 100 percent. This is expressed in the engineering units of the main input sensor. See Proportional Control for more information. |
| Integral Time (Seconds) | Determines the integral gain in a PI or PID loop. The greater the time in seconds, the less the integral change per second. A setting of 0 eliminates the integral function. See Integral Control for more information. |
| Derivative Time (Seconds) | Determines the derivative gain in a PID loop. The greater the time in seconds, the greater the derivative effect per second. See Derivative Control for more information. |
| DLC Setpoint *Bump* | The amount the effective setpoint is bumped (changed) if the loop is given a DLC shed command. A direct acting loop setpoint increases by the *Bump* value. A reverse acting loop setpoint decreases by the *Bump* value. See Setpoints for more information. |
| Control Action | Direct Acting or Reverse Acting selection. A direct acting loop output increases as the input increases. A reverse acting loop output decreases as the input increases. See Proportional Control for more information. |
| Bias | Output bias. The default value of 0 for output bias has no effect. Selecting 50 percent adds 50 percent to the loop output calculation, effectively moving the setpoint to the middle of the throttling range. See Proportional Control for more information. |
| Analog Limit Select | Sets the function of the Analog Limit input. See High/Low Limit Applications for more information. |

#### SEQUENCER

The sequencer is used to scale the EPID Output into three additional outputs. The outputs can be analog or staged. This function is used when multiple outputs are being controlled in sequence from a single control loop. Up to three outputs can be sequenced. Each output can be analog or staged with one to four digital outputs. See Fig. 29.

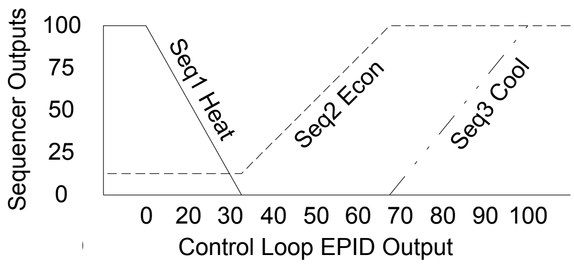


**Fig. 29. Sequencer output operation.**

A sequencer output is scaled to the selected range as the EPID output changes by the configured amount. An application example is discharge air or space control of a single zone air handling unit. One output is required for heating control and one output is required for cooling control. In this application output Seq1(Heat) is generally used for heating control, output Seq2 (Econ) is generally used for economizer control. and Seq3(Cool) is generally used for cooling control. See Fig. 30. It should be noted that better control performance is obtained using separate control loops for each function.

To configure the sequencer, it is necessary to know what the control loop EPID output represents. In the previous example, if the control loop is configured as direct acting an EPID output of 0 percent would represent a call for full heat and 100 percent world represent a call for full cooling. The individual sequenced output operation is defined by entering the following four values.

Seq Start X Percent:
  The value of the EPID output when the sequenced output is starting operation. No sequenced output operation occurs beyond the range defined by the Seq Start X Percentage and the Seq End X Percentage.

Seq End X Percent:
  The value of the EPID output when the sequenced output is stopping operation. No sequenced output operation occurs beyond the range defined by the Seq Start X Percentage and the Seq End X Percentage.

Seq Start Y Percent:
  The value of the sequenced output at the Seq Start X value. Sequenced output is limited to the range defined by the Seq Start Y Percentage and the Seq End Y Percentage.

Seq End Y Percent:
  The value of the sequenced output at the Seq End X value. Sequenced output is limited to the range defined by the Seq Start Y Percentage and the Seq End Y Percentage.

Definition of the X and Y Percentage values can be used to sequence outputs that are directly or inversely proportional to the change of the EPID output, and to limit the range of the sequenced output.

#### HIGH/LOW LIMIT APPLICATIONS

Control loops can be configured for high or low limit applications. High and low limit applications require two control loops, one configured for limit and one configured for control. See Fig. 30.

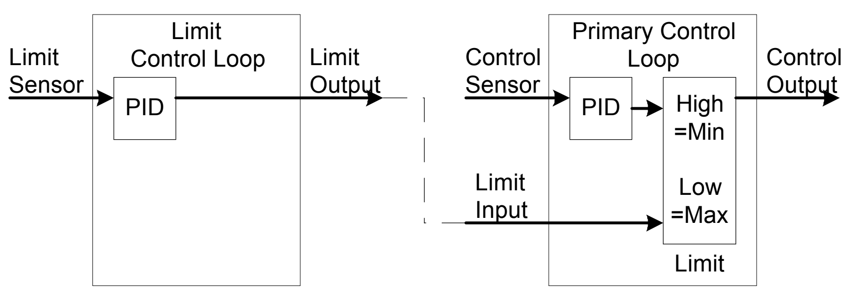


**Fig. 30. High/Low limit control.**

The limit loop is configured as a standard control loop with the setpoint at the limit value. The primary control loop is configured with either the high or low limit selected. The limit control loop output is configured as the primary control loop Limit Input. If the primary control loop is configured as the low limit, the loop output will be the larger of the PID output or the Limit Input. If configured as the high limit, the loop output will be the smaller of the PID output or the Limit Input. Care must be taken to select direct or reverse acting to insure the limit control loop output is correct. Both the limit control loop and the primary control loop should be set for the same action. Direct or reverse acting should be selected based on the control application. For more information about direct and reverse acting control, see Proportional Control.

#### SETPOINT ALARMS

Setpoint alarms can be configured for each control loop. Setpoint alarms can be configured for high and low alarm conditions. The alarms occur when the primary input sensor value exceeds the programmed (Delta) from the effective setpoint. The alarm thresholds track changes in the setpoint values. Pre and post times can be assigned to the alarms to filter out nuisance alarms.

#### CONTROL LOOP DISABLE

Each control loop can be disabled with the Loop Disable Input or by manual command from an operator interface. When the loop is disabled the EPID output is set to the Startup Ramp Start Value. Disable does not observe the minimum off and on times. The control loop is disabled when the Disable Loop input is active (true). The loop is enabled when the input is inactive (off, false). Care must be taken in designing the control strategy to insure that the input logic is correct. A control loop can be commanded to the Disable, Auto or Manual mode from an operator interface. The last mode command received is the mode in effect. When a loop is disabled using an operator interface it remains disabled until it is enabled by an operator interface. Loop disable mode remains in effect if there is a power outage for the duration of the backup capacitor. When power is restored, the EPID output restores the Startup Ramp Start Value.

#### OUTPUT MANUAL MODE OPERATION

Outputs assigned to control loops can be manually commanded from an operator interface. When a control loop is in manual mode, all outputs associated with the loop are in manual control. Individual analog outputs can be manually positioned from 0 to 100 percent and individual digital outputs can be turned on and off.

***IMPORTANT***

> *Be extremely careful when commanding loop outputs manually. All control safeties, software interlocks and minimum off and on times are ignored. There is a potential for damage to the equipment being controlled.*

When a control loop is placed in manual mode, the control loop is turned off and all outputs are positioned as commanded. When the loop is returned to Auto operation, it is reinitialized. Manual mode remains in effect until the output is commanded to automatic mode. Manual mode remains in effect if there is a power outage for the duration of the backup capacitor. When power is restored the output immediately resumes the manually commanded state without delay.

#### CONTROL LOOP OUTPUT CONFIGURATION DATA

Control loops have output configuration data. Two methods of controlling equipment that affects the controlled sensor are modulating and stages. Modulating controls a valve or damper that varies the output capacity based on a analog signal. Stages control equipment that has two states, on and off. The primary analog output of the control loop can be used as is or be sent to a sequencer to control multiple analog outputs or stages.

The output configuration data is:
— Analog primary output of the EPID (onboard or remote).
— Analog Sequence 1 output (onboard or remote).
— Analog Sequence 2 (onboard or remote).
— Analog Sequence 3 (onboard or remote).
— Digital Outputs: for controlling stages (onboard or remote).
— Up to four digital outputs can be assigned to each of the four analog outputs (16) total.
— Typically the user either assigns up to four digital outputs to the primary analog output or up to 12 digital outputs to the three sequenced analog outputs.
— Staging intervals are equally fixed across the 0 to 100 percent output band, with fixed hystersis.
— Digital Auxiliary output (onboard or remote).

## Logic Loops

The W7760C Plant Controller supports 32 independent logic loops. Logic loops can be used for on/off control, control interlocks, analog switching and other uses. Logic loops can be used independently or cascaded with control loops, math loops or other logic loops. Logic loops are run once per second starting with logic loop 1, then logic loop 2 and sequentially until all active loops are run.

Each logic loop consists of three logical AND functions, three Analog Compare Digital Output (ACDO) functions, one logical OR function and one Digital Compare Analog Output (DCAO) function. Each logic loop can use up to eight AIs and 16 DIs to determine the output state for one AO and one DO. See Fig. 31.

Analog inputs configured as digital are used by logic loops as digital inputs. Digital inputs are read as active equals true and inactive equals false. Analog inputs are floating point decimal. Inputs for the ACDO, AND, OR and DCAO functions can be physical inputs, remote inputs, setpoints, pseudo points or outputs from logic functions in the same logic loop in which they are configured.

#### ANALOG COMPARE DIGITAL OUTPUT (ACDO)

Each logic loop can be configured with up to three logical ACDO functions. See Fig. 32. ACDO compares one analog input against another analog input. The result is a digital output.

The analog inputs for an ACDO can be selected from analog physical points, remote points, setpoints, pseudo points or outputs from control loops, logic loops or math loops. The digital output can be used only by other logic functions within the same logic loop.

ACDO can be programmed with a deadband that is subtracted from the analog input AI2 value before making the comparison when the output is true. The deadband is expressed in the units of AI2. ACDO can be programmed with pre-delay and post-delay in seconds. Pre-delay requires the compare statement to be true for the programmed time before the output is set true. Post-delay requires the compare statement to be false for the programmed time before the output is set false. ACDO logic can be expressed for each of the following type comparisons:

*Greater Than (>)*
IF AI1 > AI2 for time > pre-delay
    THEN output = TRUE.
    ELSE IF AI1 < (AI2 - deadband) for time > post-delay
        THEN output = FALSE
        ELSE output = previous state.

*Less Than* (<)
IF AI1 < AI2 for time > pre-delay
    THEN output = TRUE.
    ELSE IF AI1 > (AI2 - deadband) for time > post-delay
        THEN output = FALSE
        ELSE output = previous state.

*Equal To* (=)
IF AI1 ≤ AI2 AND AI1 ≥ (AI2 - deadband) for time > pre-delay
    THEN output = TRUE.
    ELSE IF AI1 > AI2 OR AI1 < (AI2 - deadband) for time > post-delay
        THEN output = FALSE
        ELSE output = previous state.

NOTE: The *equal to* (=) is fuzzy equal. The deadband is used to make the equal comparison. If the value of AI1 is within the deadband of AI2 the comparison is considered to be equal (TRUE).

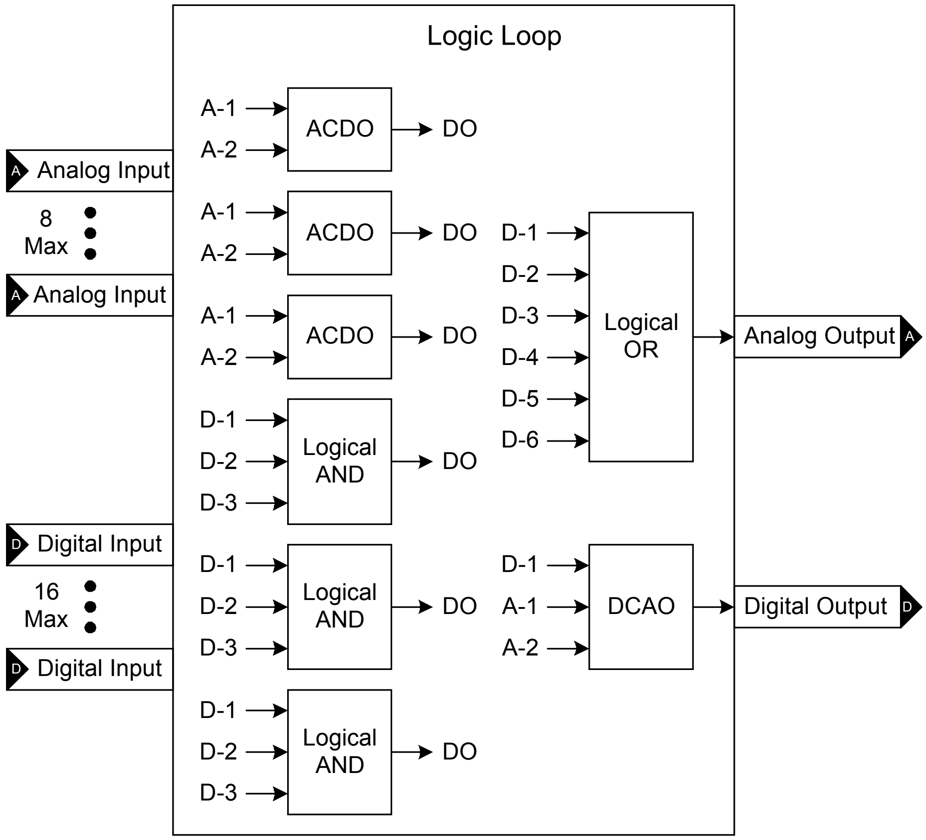


**Fig. 31. Logic loop schematic**

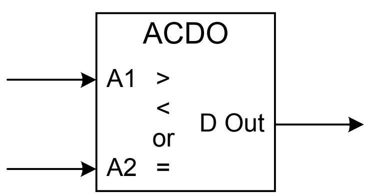


**Fig. 32. ACDO.**

### LOGICAL AND

Each logic loop can be configured with up to three logical AND functions. The AND function compares three digital inputs to determine the logic state of the digital output. The output is true if and only if all input states are true. See Fig. 33.

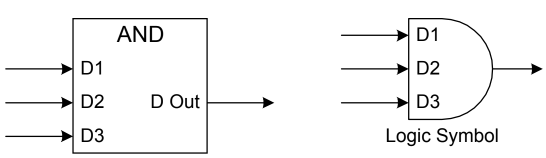


**Fig. 33. Logical AND function.**

The digital inputs to an AND function can be any combination of digital physical points, remote points, pseudo points or outputs from logic functions within the same logic loop. The output from an AND function can only be used by another logic function within the same logic loop. An unconfigured input to an AND function is set to TRUE. Each digital input of an AND function can be assigned as NOT, this means the AND function reads an input state of TRUE as FALSE and an input state of FALSE as TRUE. The AND function can be programmed with pre-delay and post-delay in seconds.

Pre-delay requires the AND statement to be true for the programmed time before the output is set TRUE. Post-delay requires the AND statement to be false for the programmed time before the output is set FALSE.

AND logic can be stated as follows:
IF (DI1 AND DI2 AND DI3) =TRUE for time > pre-delay
    THEN output = TRUE.
    ELSE IF (DI1 OR DI2 OR DI3) =FALSE for time>post-delay
        THEN output = FALSE
        ELSE output = previous state.

See Table 15 for an AND function logic table.

**Table 15. AND Function Logic Table.**

| Input State | | | Output |
|---|---|---|---|
| **DI1** | **DI2** | **DI3** | |
| T | T | T | T |
| F | T | T | F |
| T | F | T | F |
| T | T | F | F |
| T | F | F | F |
| F | T | F | F |
| F | F | T | F |
| F | F | F | F |

NOTE: A NOT function on an input reverses the input logic state.

**LOGICAL OR**

There is one logical OR function in each logic loop. The output of the OR function is the digital output for the logic loop. The OR function compares six digital inputs to determine the logic state of the digital output. The output is true if one or any combination of inputs is true. See Fig. 34 for Logical OR function.

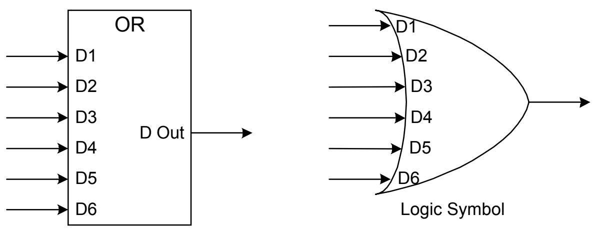


**Fig. 34. Logical OR function.**

The digital inputs to an OR function can be any combination of digital physical points, remote points, pseudo points or outputs from logic functions within the same logic loop. The output from an OR is the digital output from the logic loop and can be assigned to a physical or remote digital output and/or used as an input to one or more control loops and/or logic loops. An unconfigured input to an OR function is set to FALSE. Each digital input of an OR function can be assigned as NOT, this means the OR statement reads the input state of FALSE as TRUE and an input state of TRUE as FALSE. The OR function can be programmed with pre-delay and post-delay in seconds. Pre-delay requires the OR statement to be true for the programmed time before the output is set TRUE. Post-delay requires the OR statement to be false for the programmed time before the output is set FALSE.

OR logic can be stated as follows:
IF (DI1 OR DI2 OR DI3 OR DI4 OR DI5 OR DI6) =TRUE for time > pre-delay
THEN output = TRUE.
ELSE IF (DI1 AND DI2 AND DI3 AND DI4 AND DI5 AND DI6) =FALSE for time>post-delay
THEN output = FALSE
ELSE output = previous state.

See Table 16 for an OR function logic table (partial for illustration).

**Table 16. OR Function Logic Table.**

| Digital Input State | | | | | | OR Output |
|---|---|---|---|---|---|---|
| DI1 | DI2 | DI3 | DI4 | DI5 | DI6 | |
| T | F | F | F | F | F | T |
| F | T | F | F | F | F | T |
| F | F | T | F | F | F | T |
| F | F | F | T | F | F | T |
| F | F | F | F | T | F | T |
| F | F | F | F | F | T | T |
| F | F | F | F | F | F | F |
| T | T | T | T | T | T | T |
| T | F | T | F | F | F | T |

NOTE: A NOT function on an input reverses the input logic state.

**DIGITAL COMPARE ANALOG OUTPUT (DCAO)**

There is one logical DCAO function in each logic loop. The output of the DCAO function is the analog output for the logic loop. The DCAO selects one of two analog input values to be the analog output value. See Fig. 35.

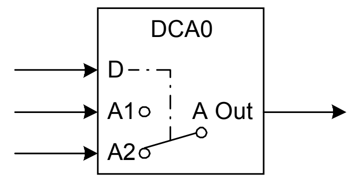


**Fig. 35. DCAO function.**

All inputs for a DCAO function must be configured or the function will not operate. The digital input to a DCAO function can be a digital physical point, remote point, pseudo point or an output from a logic function within the same logic loop. The analog inputs can be selected from analog physical points, remote points, setpoints or pseudo points. The output from a DCAO is the analog output from the logic loop and can be assigned to a physical or remote analog output and/or used as an input to one or more control loops, logic loops, and/or math loops.

The DCAO function can be programmed with pre-delay and post-delay times in seconds. Pre-delay is the time the digital input must be TRUE before the output switches to AI1. Post-delay is the time the digital input must be FALSE before the output switches to AI2.

The operation of the DCAO can be expressed as:
IF DI1 = TRUE for time > pre-delay
THEN A Out = AI1
ELSE IF DI1 = FALSE for time > post-delay
THEN A Out = AI2
ELSE A Out = previous output.

## Math Functions

The Plant Controller supports 30 general math functions. Math functions are used to make special computations that can be required in a control strategy. Math functions are used as inputs to control loops, logic loops and to other math functions. An input to a math function can be a physical or remote point value, a pseudo point, a setpoint, a output of a control or logic loop, or an output of a math function.

Math functions are executed once every second starting with math function 1, then 2 and sequentially for all configured math functions. Each math function except square root and enthalpy can be configured to operate using inputs A1 through A6. Each math function consists of one of eight math operands. AIs can be any floating point value available from physical inputs, remote points, setpoints or pseudo points. The math function result is an analog pseudo point that can be used with control loops, logic loops and math loops in the same W7760C controller. Math functions can not be directly assigned to a physical or remote output. Network Special is a unique case of math functions that is used with network points. See Fig. 36 for a math function loop schematic.

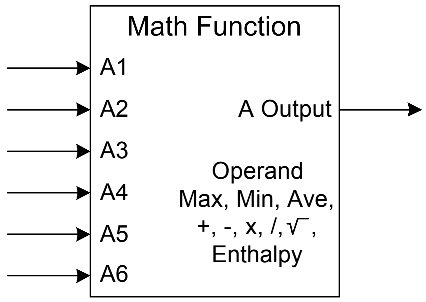


**Fig. 36. Math loop schematic.**

#### MATH FUNCTION OPERATORS

See Table 17 for a description of the math function operators.

**Table 17. Math Function Operators.**

| Operand | Description | Comments |
|---|---|---|
| Minimum | Output equals Minimum value of AI1, AI2, AI3, AI4, AI5, AI6. | An input is skipped if it is not configured or is invalid. |
| Maximum | Output equals Maximum value of AI1, AI2, AI3, AI4, AI5, AI6. | An input is skipped if it is not configured or is invalid. |
| Average | Output equals Average value of configured inputs AI1, AI2, AI3, AI4, AI5, AI6. | An input is skipped if it is not configured or is invalid. |
| Square Root | Output equals Square Root of the absolute value of AI1. | If AI1 is negative, it is converted to positive and then the square root of the value is taken. Result is Float_Invalid if AI1 is invalid. |
| Add | Output equals the Sum of AI1, AI2, AI3, AI4, AI5, AI6. | It makes no difference which inputs are configured, typically AI1 is configured then AI2 and the rest in sequence. Result is Float_Invalid if a configured input is invalid. |
| Subtract | Output equals AI1 - AI2 - AI3 - AI4 - AI5 - AI6. The ordinal position must be observed. | AI1 must be configured. If AI1 is configured, it makes no difference which other AIs are configured. Typically they are in sequence AI2 through AI6. Result is Float_Invalid if a configured input is invalid. |
| Multiply | Output equals AI1 x AI2 x AI3 x AI4 x AI5 x AI6. | It makes no difference which inputs are configured, typically AI1 is configured then AI2 and the rest in sequence. Result is Float_Invalid if a configured input is invalid. |
| Divide | Output equals AI1 ÷ AI2 ÷ AI3 ÷ AI4 ÷ AI5 ÷ AI6. The ordinal position must be observed. | AI1 must be configured. If AI1 is configured, it makes no difference which other AIs are configured. Typically they are in sequence AI2 through AI6. Divide by zero sets the result to Float_Invalid. Result is Float_Invalid if a configured input is invalid. |
| Enthalpy | Output (kJ/kg) equals Enthalpy in SI units.<br>AI1 equals the temperature in °C.<br>AI2 equals the percentage of Relative Humidity. | Result is Float_Invalid if either of the two inputs are invalid.<br>NOTE: This calculation is SI (metric). |

***IMPORTANT***

*Use care when observing the operation of the engineering units for the input point. Actual values used in the math functions are in SI. SI to Imperial unit conversion can yield unexpected results especially when working with temperature, enthalpy and airflow.*

For example:

1. °F + Delta °F = °F.
2. °F - °F = Delta °F.
3. °F - Delta °F = °F
4. A case that does not work is °F +°F.
   For imperial units, 68°F +68°F = 136°F.
   Note that the SI equivalent is not the same:
   20°C + 20°C = 40°C which is 104°F.
   A math function adding 68°F to 68°F has a result of 104°F.

#### MATH FUNCTION NETWORK SPECIAL

Six network special math functions are provided to work with network points. Three math functions are available for temperature points (space or room temperatures from any Excel 10 controllers) and three for terminal load points (terminal loads from W7751 VAV box controllers). Each math function is limited to six source points and the operators are limited to Minimum, Maximum and Average. The network special math function is then configured by selecting the W7760C network input point (it can be renamed if desired) and selecting the math operator (Minimum, Maximum or Average), and then selecting up to six inputs.

## I/O Configuration

The Plant Controller can support both its onboard I/O and its remote I/O. The remote I/O capability, from up to three RIOs, is 24 DOs, 12 DIs and 18 AIs. All inputs can be used by multiple control loops. Outputs can only be commanded by one control loop.

**REMOTE POLL POINTS**

Use remote poll points for control loop inputs, start/stop loop inputs, math or logic functions. The Plant Controller supports a maximum of 20 remote inputs.

# APPLICATION STEPS

## Overview

The application steps shown in Table 18 are planning considerations for engineering an Excel 15 W7760C Plant 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 W7760C Plant Controller in the overall EXCEL 5000® OPEN™ SYSTEM architecture.

**Table 18. Application Steps.**

| Step No. | Description |
|---|---|
| 1 | Plan the System. |
| 2 | Determine Other Bus Devices Required. |
| 3 | Lay Out Communications 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 W7760C 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 will know where they can plug in to the LONWORKS Bus network with a portable PC.

Refer to Step 4. Prepare Wiring Diagrams for details.

The FTT communication wiring, (LONWORKS Bus) between controllers is a free topology scheme that supports T-tap, star, loop, and/or bus wiring. Refer to the LONWORKS 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 W7760C Controllers, and for the system as a whole. Usually there are variables that must be passed between the W7760C 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 ZL7760A software Help for configuring information on the W7760C, W7751B,D,F,H, 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 controller nodes can communicate on a single LONWORKS Bus segment. Each LONWORKS Bus device constitutes one node.

Each LONWORKS Bus segment is set up with seven unused nodes to allow portable PCs and software tools to be connected to the LONWORKS Bus at the same time. Table 19 summarizes the LONWORKS Bus segment configuration rules.

**Table 19. LONWORKS Bus Configuration Rules And Device Node Numbers.**

| One LONWORKS Bus Segment | Maximum Number of Nodes Equals 127 |
|---|---|
| Ports for tools and portable PC access | 7 nodes |
| Maximum number or Excel 15s/10s and Q7300Hs | (For configured controllers and devices with a network schedule:)<br>Up to 4 Excel 15 Building Managers (each W7760A can use up to 3 RIO Devices).<br>A total of up to 116 W7760Cs, Excel 10 VAV IIs, CVAHUs UV Controllers, RIO Devices, Command Displays or Q7300H Communicating Subbases.<br>If there are over 60 controllers or devices on a bus, use a Repeater (up to 60 nodes on each side. |
| Total | 127 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 toPin 2
Pin 3 toPin 3
Pin 4 toPin 8
Pin 5 toPin 7
Pin 6 toPin 20 and 4

Refer to the LONWORKS 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 LONWORKS 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 W7760C 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. 37. For these applications,* only one W7760C *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 mm$^2$) 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 120 (see Table 18) Excel 15/10 Controllers, T7300F/Q7300Hs, Command Displays requires 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 LONWORKS 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.

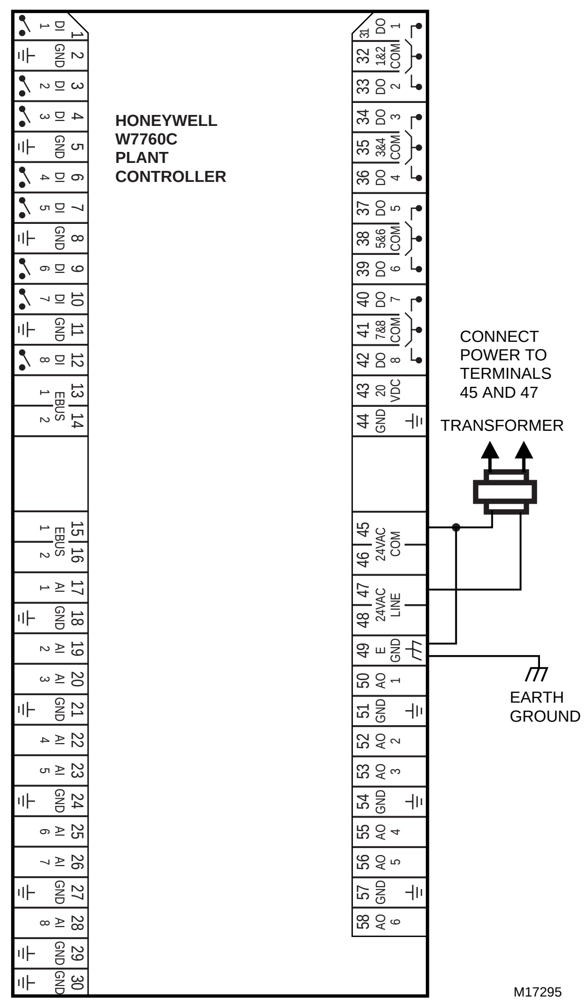


**Fig. 37. Transformer power wiring details for one W7760C used in UL 1995 equipment (U.S. only).**

NOTE: If a 209541B Termination Module is required at a W7760C, 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 LonWorks 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 a LonWorks Bus wire run, mount the termination module on the appropriate terminals as shown in Fig. 38.

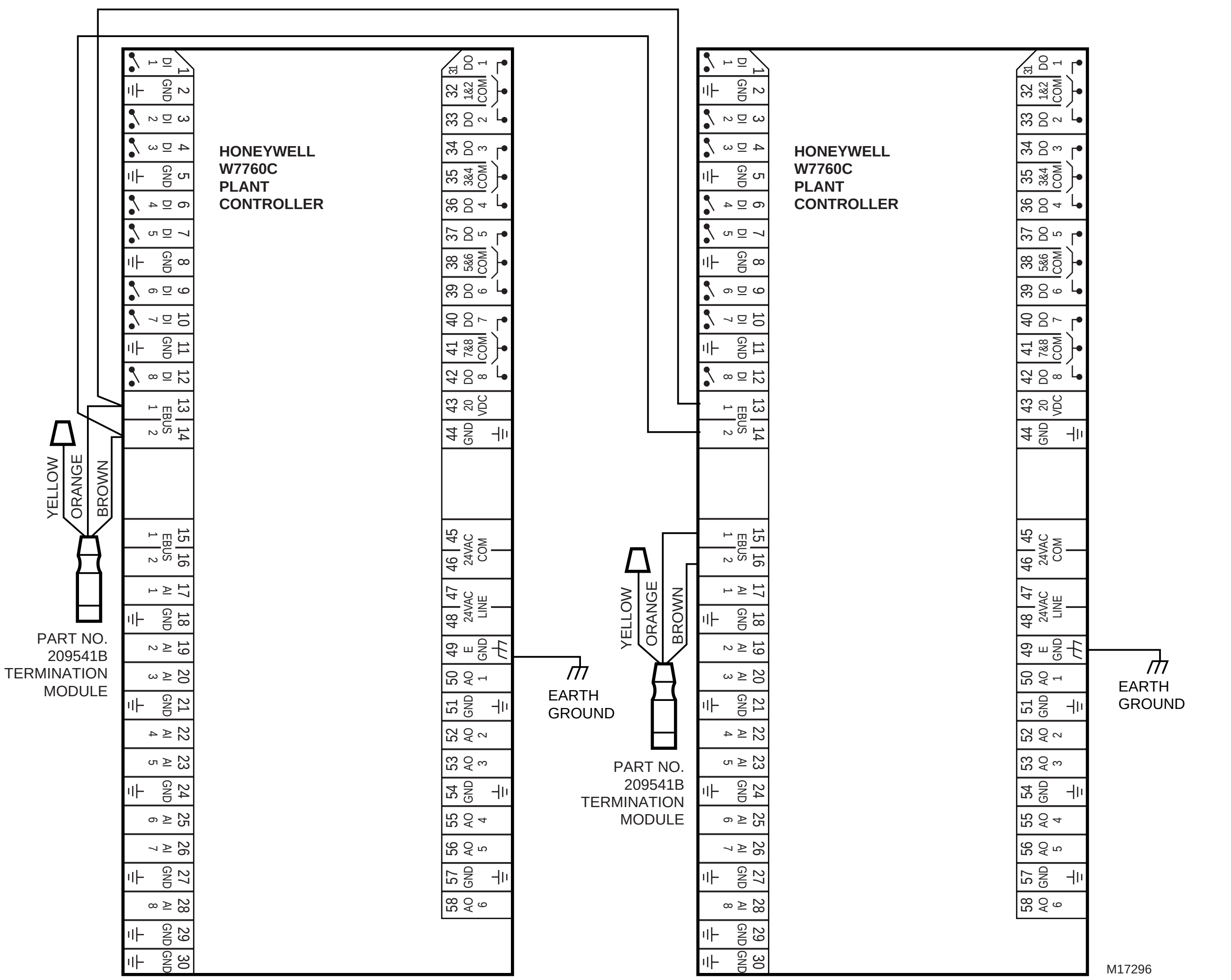


**Fig. 38. Termination modules (doubly terminated LonWorks Bus).**

Connect the LonWorks Bus cable to the W7760C communication terminals 13 and 14 or 15 and 16. For daisy-chain wiring, see form 74-2865.

NOTE: If terminals 13 and 14 on the LonWorks Bus are used as inputs and 15 and 16 are used as outputs 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.

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. 39. Deviation from this rule can result in improper electrical contact.

1. Strip 1/2 in. (13 mm) insulation from the conductor.
2. If using a single wire in the required terminal location, cut the wire to 3/16 in. (5 mm) insert 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.

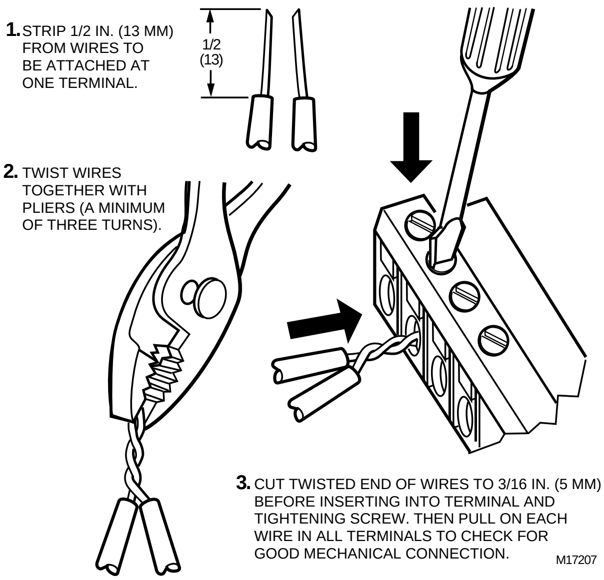


**Fig. 39. Attaching two or more wires at terminal blocks.**

Fig. 40 and 41 show two typical LONWORKS Bus segment network topologies.

Fig. 40 shows a typical LONWORKS Bus segment network topology with one doubly terminated LONWORKS Bus segment that has 120 nodes or less. Fig. 41 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.

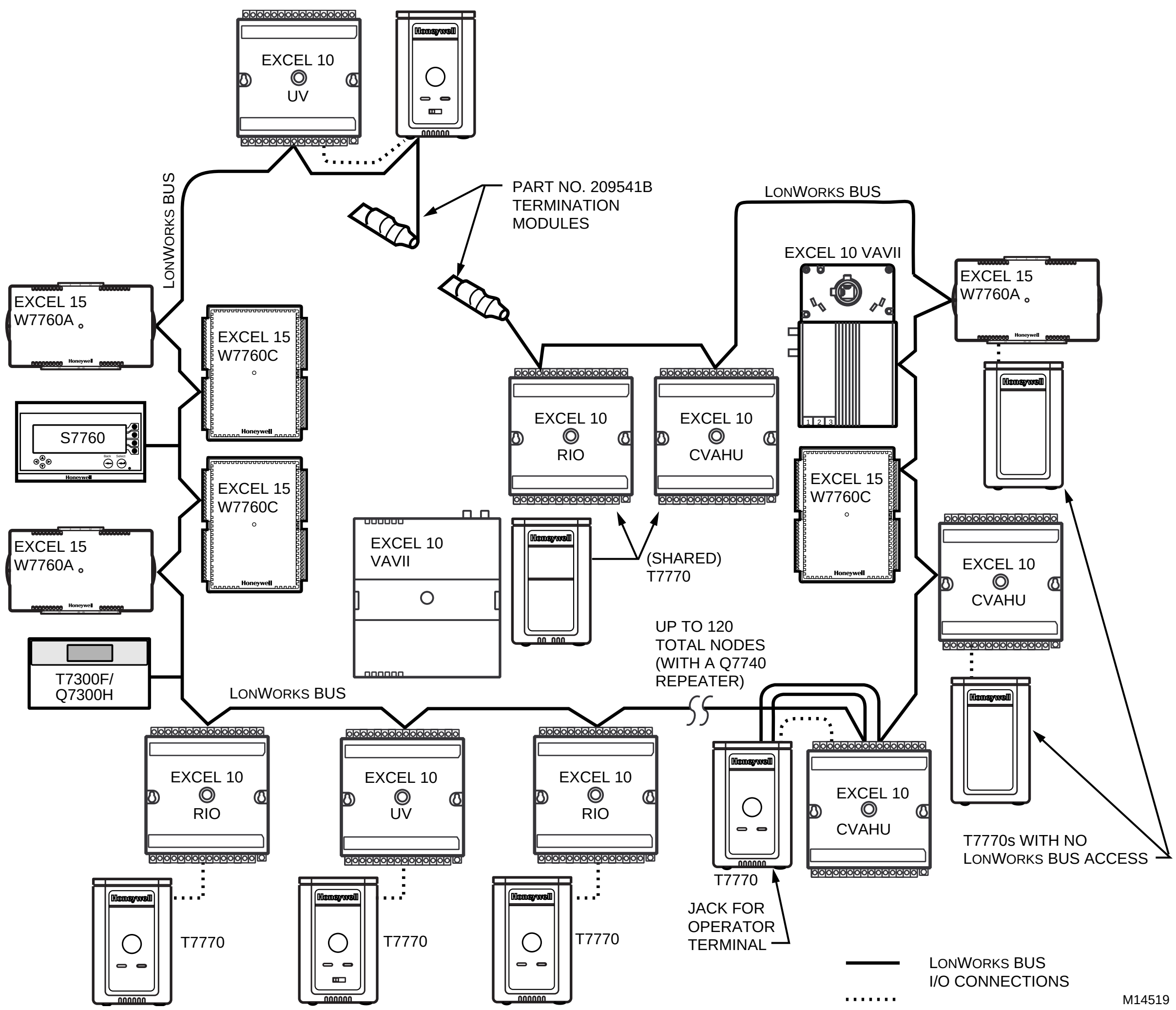


**Fig. 40. Wiring layout for one doubly terminated daisy-chain LONWORKS Bus segment.**

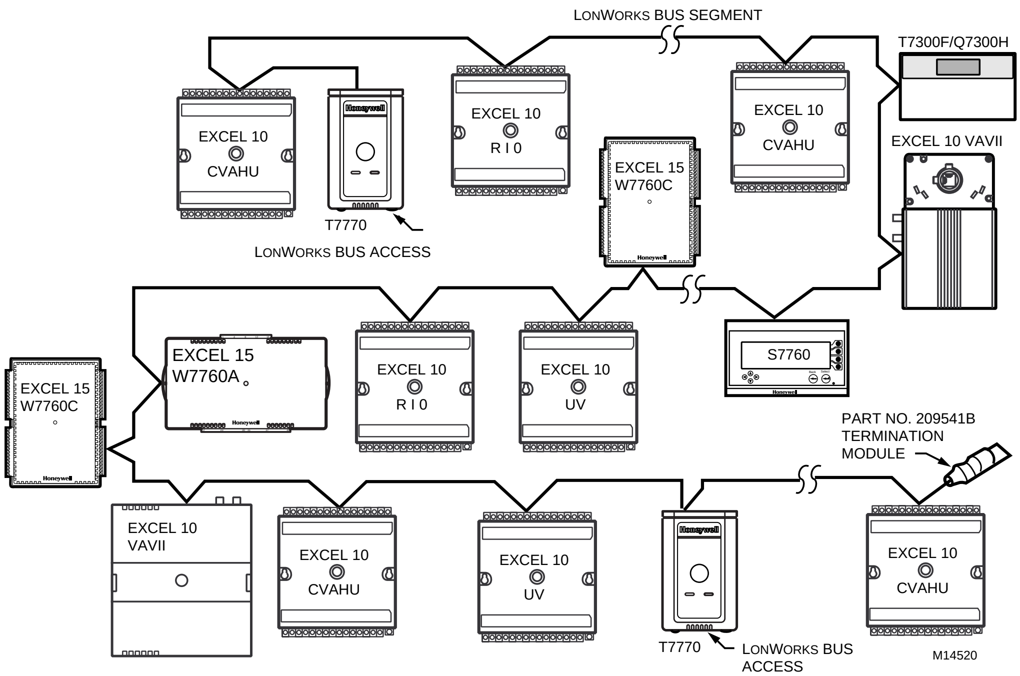


**Fig. 41. Wiring layout for one singly terminated LONWORKS Bus segment**

## Power

A power budget must be calculated for a W7760C 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 W7760C. This includes the W7760C 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 W7760C Excel 15 Plant Controller.

Assume a W7760C 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 W7760C Plant Controller | 18.0 | W7760C Specification Data |
| ML6161 Damper Actuator | 2.2 | TRADELINE® Catalog |
| R8242A Contactor fan rating | 21.0 | TRADELINE® Catalog inrush rating |
| D/X Stages | 0.0 | NOTE: For example, assume the cooling stage outputs are wired into a compressor control circuit and has no impact on the budget. |
| M6410A Steam Heating Coil Valve | 0.7 | TRADELINE® Catalog, 0.32A at 24 Vac |
| TOTAL | 41.9 | |

The Excel 15 System example requires 41.9 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 Plant Controllers and meet NEC Class 2 restrictions (no greater than 100 VA). See Fig. 44 and 45 for illustrations of power wiring details. See Table 20 for VA ratings of various devices.

**Table 20. VA Ratings For Transformer Sizing.**

| Device | Description | VA |
|---|---|---|
| W7760C | Excel 15 W7760C Plant Controller | 18.0 |
| 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 W7760C 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 W7760C Controller. Fig. 42 shows power wiring details for a single device and Fig. 43 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.*

NOTES: 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 (W7760C Terminal 49) must be connected to a verified earth ground for each controller in the group. See Fig. 42 and 43. 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 W7760C must be powered by the same transformer that powers the W7760C.

— Keep the earth ground connection (W7760C Terminal 49) wire run as short as possible. Refer to Fig. 42 and 43.

— Do *not* connect earth ground to the W7760C digital or analog ground terminals (2, 5, 8, 11, 18, 21, 24, 27, 29, 30, 44, 51, 54 and 57). Refer to Fig. 42 and 43.

— 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.

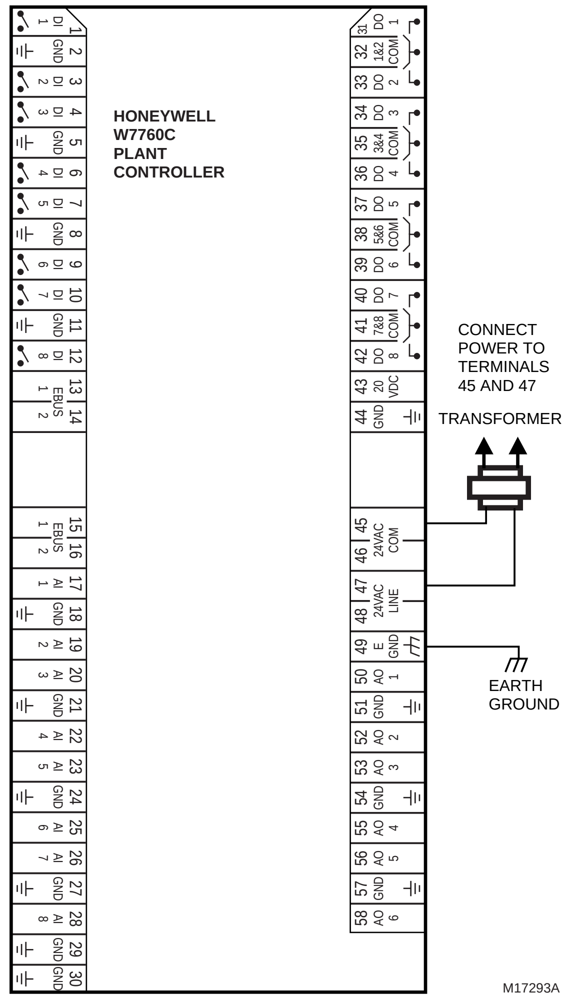


**Fig. 42. Power wiring details for one W7760C per transformer.**

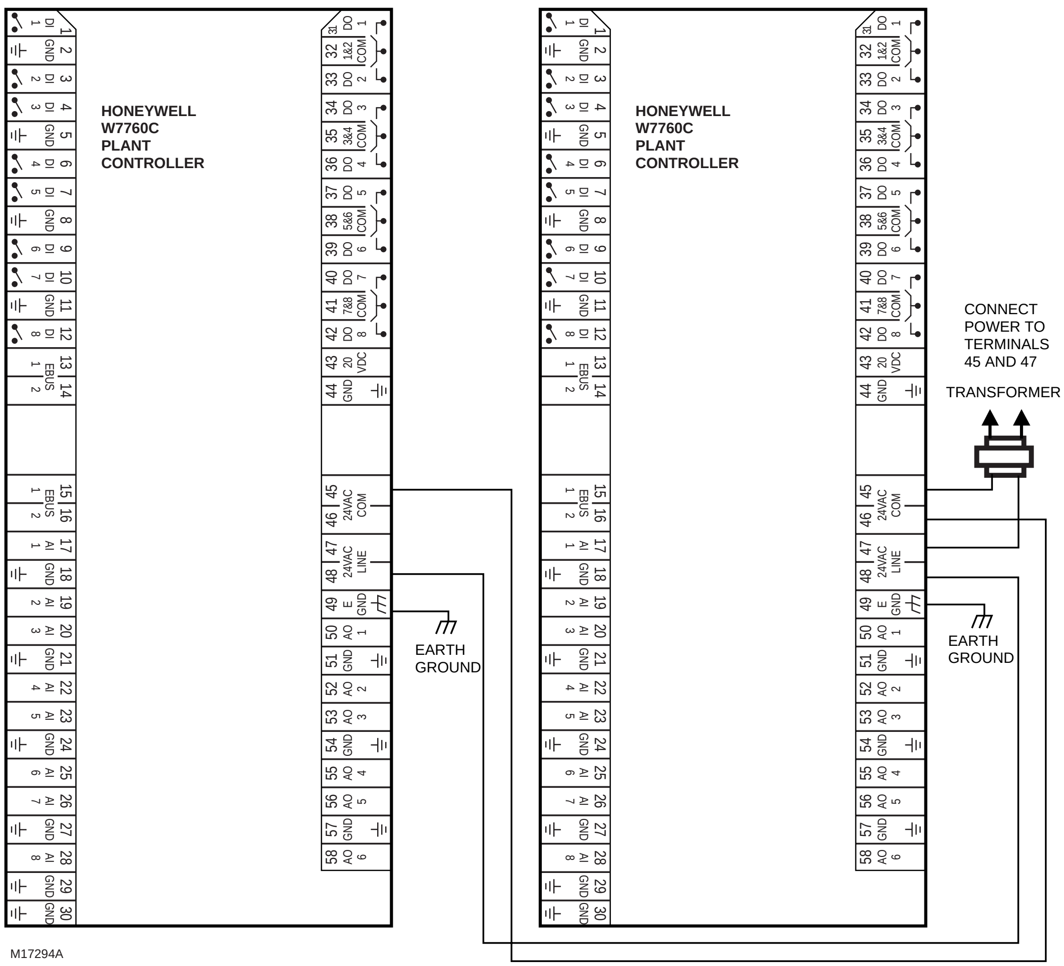


**Fig. 43. Power wiring details for two W7760Cs per transformer.**

## 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 W7760C 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 twisted pair wire has 6.52 ohms per 1000 feet.

Loss = [(400 ft.) 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. 44 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. 44, 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. 44 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 an output of 24.4 volts minus the four volt line loss supplies 20.4V to the controller. See Fig. 44. 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. 44 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.

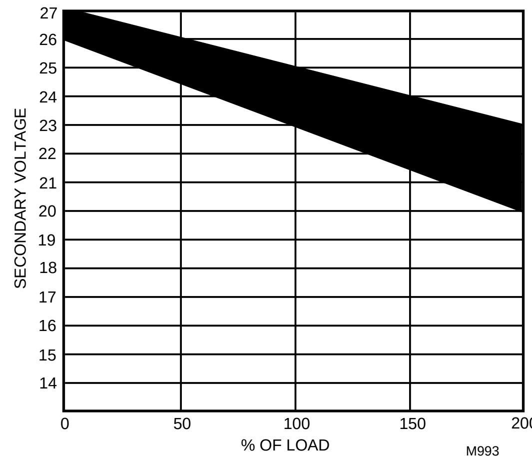


**Fig. 44. NEMA class 2 transformer voltage output limits.**

The following Honeywell transformers meet this NEMA standard:

| Transformer Type | VA Rating |
|---|---|
| AT20A | 20 |
| AT40A | 40 |
| AT72D | 40 |
| AT87A | 50 |
| AK3310 Assembly | 100 |

# Step 4. Prepare Wiring Diagrams

## Wiring Details

Fig. 45 through 50 show W7760C terminal arrangement and provide detailed wiring diagrams. Reference these diagrams to prepare site-specific job drawings.

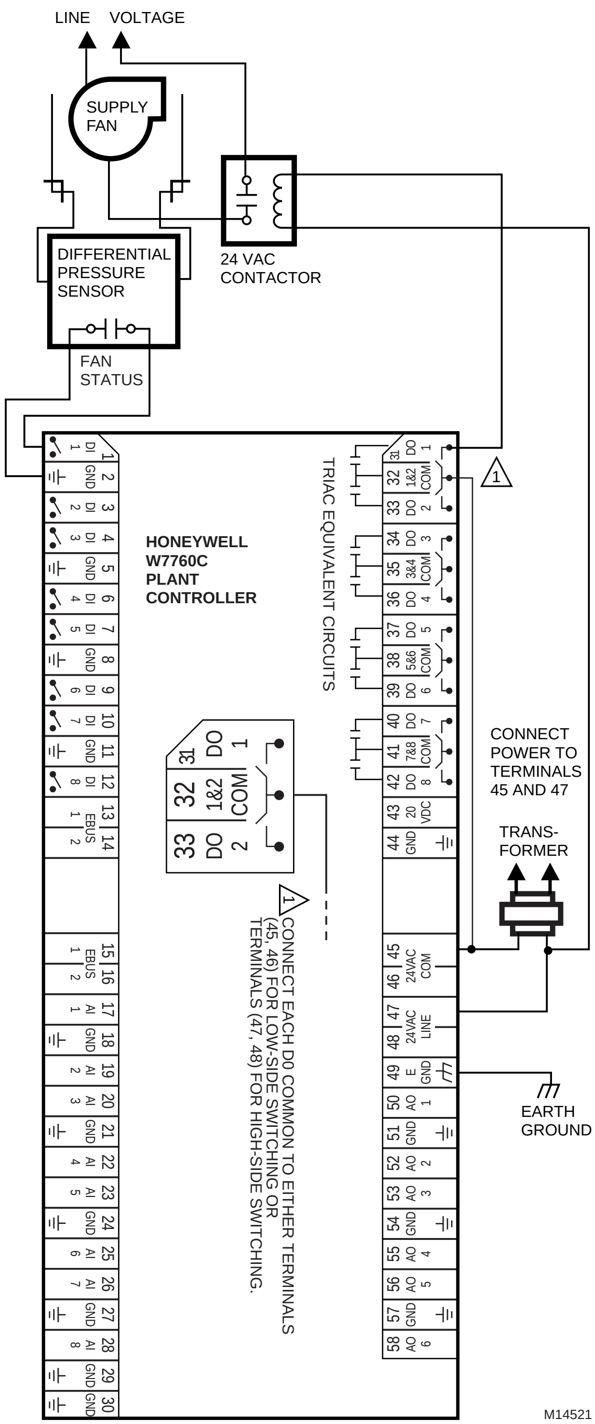


Fig. 45. Typical W7760C wiring diagram.

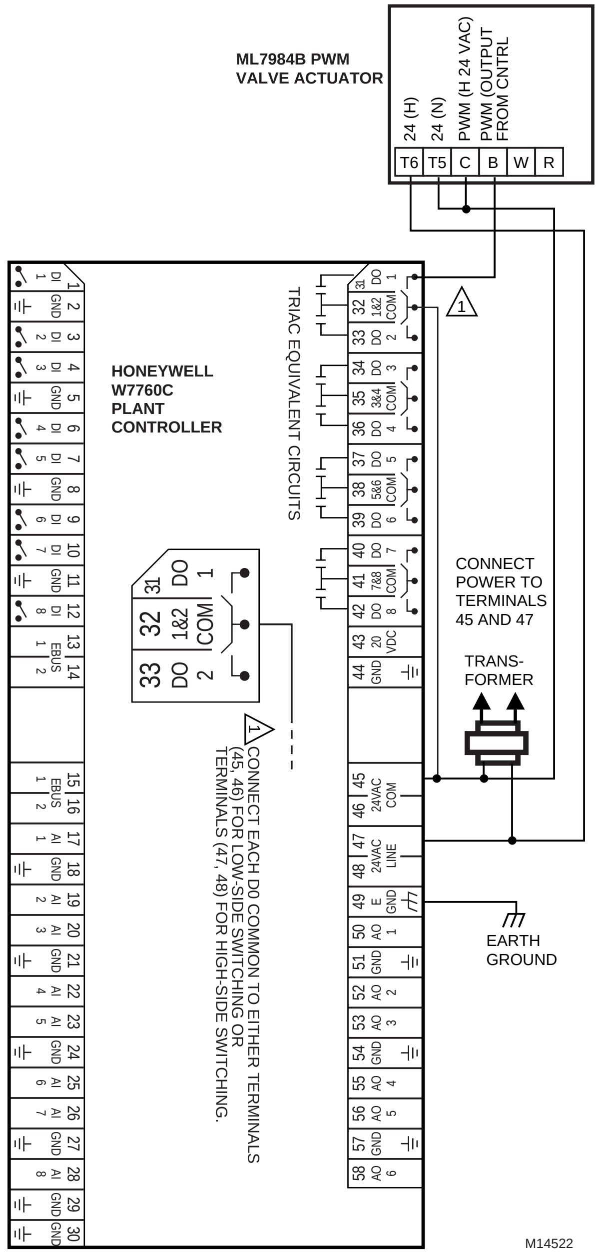


Fig. 46. Typical PWM Valve Actuator to W7760C.

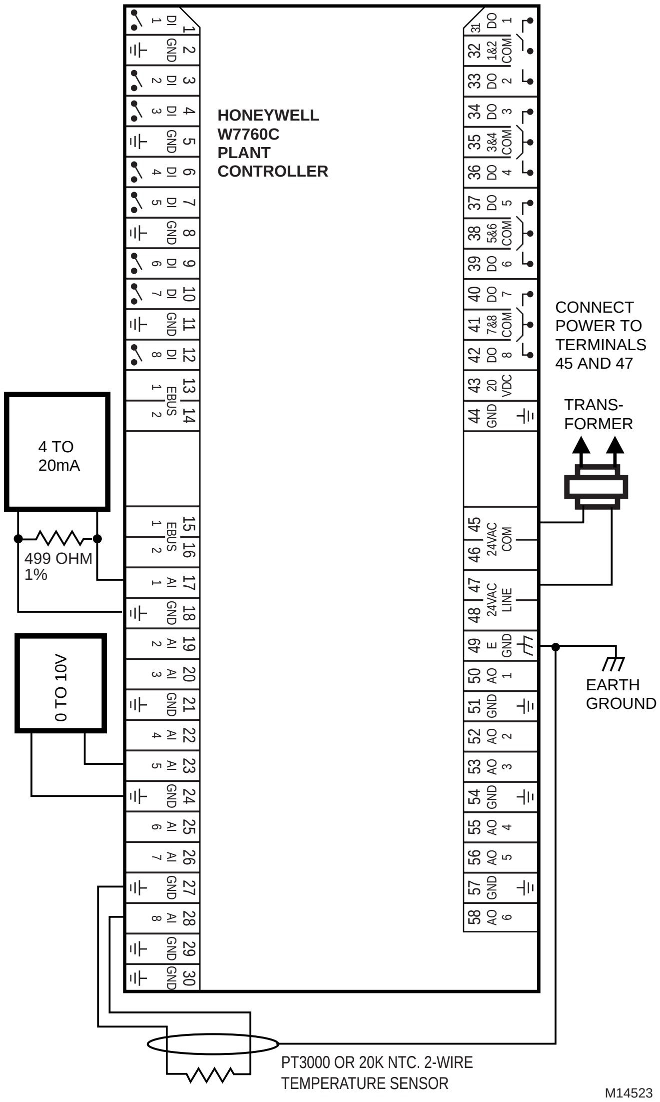


**Fig. 47. Typical Analog Inputs to W7760C**

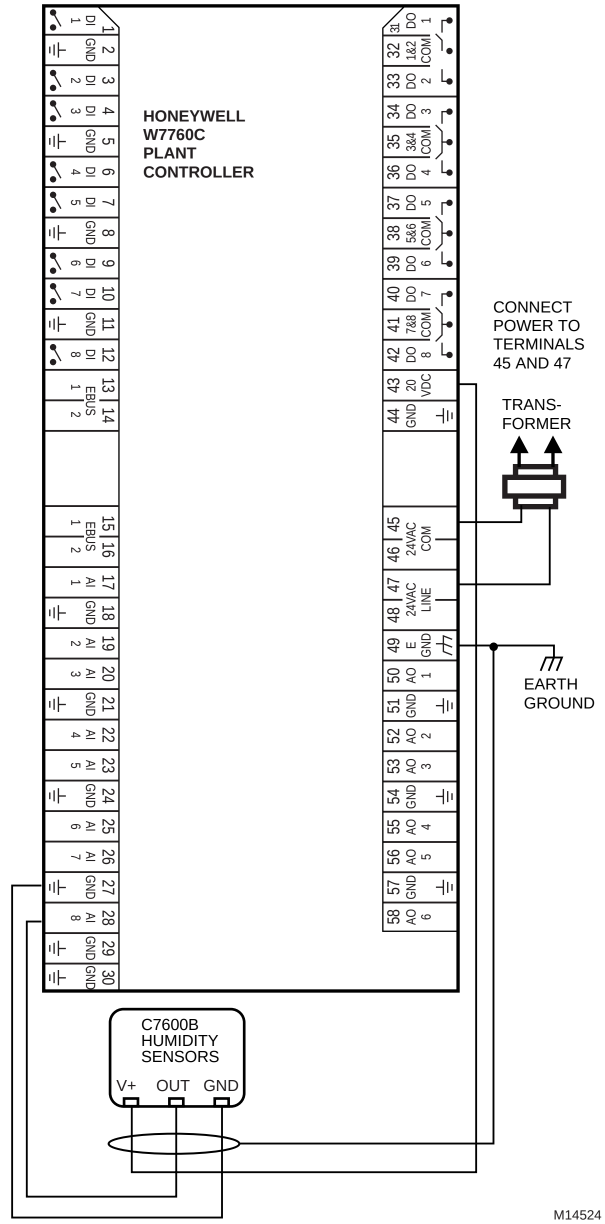


**Fig. 48. Typical 2 to 10 Volt Humidity Sensor to W7760C (C7600B is 3 wire device).**

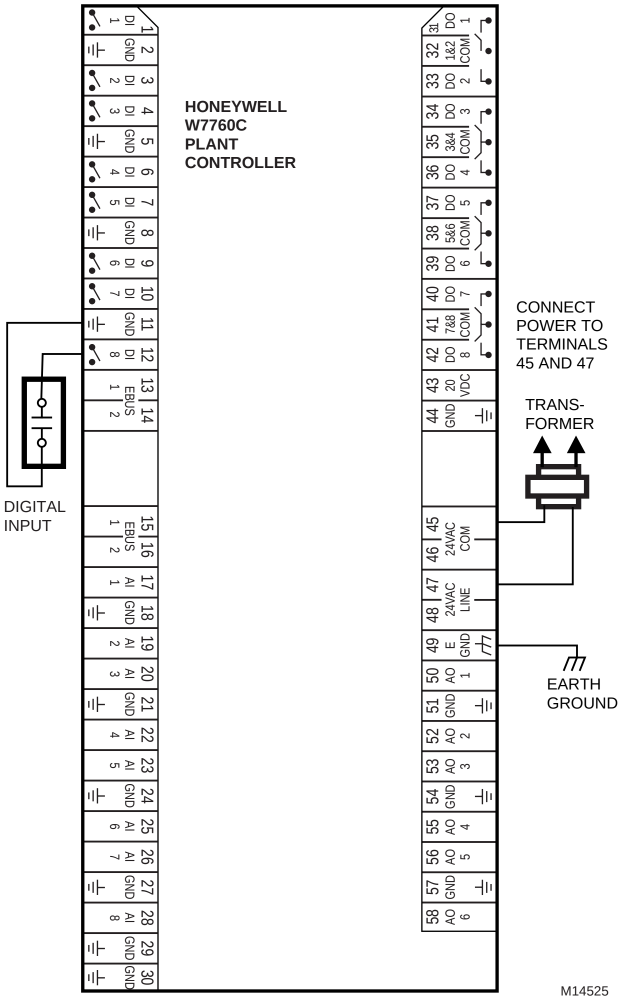


**Fig. 49. Typical Digital Input to W7760C.**

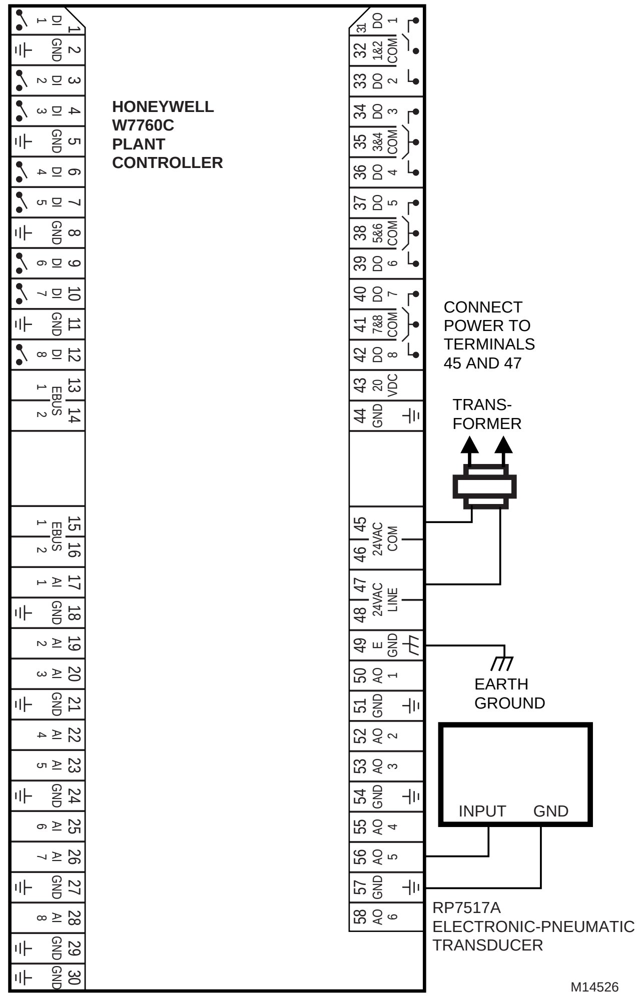


**Fig. 50. Typical RP7517A Electronic Pneumatic Transducer to W7760C.**

## General Considerations

NOTE: For field wiring, when two or more wires attach to the same terminal twist them together per Fig. 39. Deviation from this rule can result in improper electrical contact.

Table 21 lists wiring types, sizes, and distances for Excel 15 products. The terminals on the W7760C, W7751, 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 21. Field Wiring Reference Table (Honeywell listed as AK#### or equivalent).**

| Wire Function | Recommended Minimum Wire Size AWG ($mm^2$) | Construction | Specification or Requirement | Vendor Wire Type | Maximum Length 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 LONWORKS Bus Wiring Guidelines 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 LONWORKS Bus Wiring Guidelines 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 2 140°F (60°C) rating | Honeywell AK3702 (18 AWG) AK3712 (16 AWG) AK3754 (14 AWG) | Limited by line-loss effects on power consumption. (See Line Loss subsection.) |
| **Power Wiring** | 14 AWG (2.0 $mm^2$) | Any pair nonshielded (use heavier wire for longer runs). | NEC Class 2 140°F (60°C) rating | Honeywell AK3754 (14 AWG) twisted pair AK3909 (14 AWG) single conductor | Limited by line-loss effects on power consumption. (See Line Loss subsection.) |

## Step 5. Order Equipment

After compiling a bill of materials through completion of the previous application steps, refer to Table 22 for ordering information. Contact Honeywell for information about Controllers and Wall Modules with no logo.

**Table 22. Excel 15 W7760C Ordering Information.**

| Part Number | Product Description | Comments |
|---|---|---|
| W7760C2009 | **Excel 15 W7760C Plant Controller** | Excel 15 Controller |
| | **Excel 10 W7750 Controllers:** | |
| W7750A2005 | Constant Volume AHU Controller (W7750A) | Three Analog Inputs, Three Digital Inputs and Six 24 Vac Relay Outputs |
| W7750B2011 | Constant Volume AHU Controller (W7750B) | Six Analog Inputs, Five Digital Inputs and Eight (High-side Low-side switchable)Triac Outputs |
| W7750C2001 | Constant Volume AHU Controller (W7750C) | Six Analog Inputs, Five Digital Inputs, Five Triac Outputs and Three Analog Outputs |
| | **Excel 10 W7751 Controllers:** | |
| W7751B2002 | OEM Base Board (Only in bulk pack of 10) | Order 207912 Snaptrack (See Accessories) |
| W7751D2008 | Base Board, Mounting Enclosure | With External Wiring |
| W7751F2003 | Base Board, Mounting Enclosure | With External Wiring |
| W7751H2009 | Smart VAV II Actuator is a factory-combined VAV Box Controller and a ML6161B1000 Actuator | Plenum Rated |

**Table 22. Excel 15 W7760C Ordering Information. (Continued)**

| Part Number | Product Description | Comments |
|---|---|---|
| Y7751D2006 | W7751D2008 Base Board, Mounting Enclosure packed with ML6161B1000 Actuator | With External Wiring |
| Y7751F2001 | W7751F2003 Base Board, Mounting Enclosure packed with ML6161B1000 Actuator | With External Wiring |
| | **W7751D,F Subbases and Electronics Assy.** | |
| 206166A | Subbase for W7751D with Internal Wiring | Available in bulk pack of 10 each (for use with 206168B VAV Controller Assembly). |
| 206167A | Subbase for W7751F with External Wiring | Available in bulk pack of 10 each (for use with 206168B VAV Controller Assembly). |
| 206168B | Cover and Electronics for W7751D,F | Contains Circuit Board for use with 206166A or 206167A Subbases (available only in bulk pack of 10). |
| | **Excel 10 W7753A Controller** | |
| W7753A2002 | Unit Ventilator Controller (W7753A) | Six Analog Inputs, Five Digital Inputs and Eight Triac Outputs |
| | **Excel 10 W7761A** | |
| W7761A2002 | Remote Input/Output Device | RIO |
| | **T7770 or T7560 Wall Modules for Excel 10s:** | |
| T7770A1006 | Sensor with Honeywell Logo | Used with Excel 10 Controllers |
| T7770A1014 | Sensor with No Logo | Used with Excel 10 Controllers |
| T7770A2004 | Sensor, LONWORKS Jack and Honeywell Logo | Used with Excel 10 Controllers |
| T7770A2012 | Sensor with LONWORKS Jack and No Logo | Used with Excel 10 Controllers |
| T7770B1004 | Sensor with Setpoint and LONWORKS Jack, Honeywell Logo | Degrees F Absolute |
| T7770B1046 | Sensor with Setpoint and LONWORKS Jack, Honeywell Logo | Relative Setpoint |
| T7770B1012 | Sensor with Setpoint and LONWORKS Jack, No Logo | Degrees F Absolute |
| T7770B1020 | Sensor with Setpoint and LONWORKS Jack, Honeywell Logo | Degrees C Absolute |
| T7770B1053 | Sensor with Setpoint and LONWORKS Jack, No Logo | Relative Setpoint |
| T7770B1038 | Sensor with Setpoint and LONWORKS Jack, No Logo | Degrees C Absolute |
| T7770C1002 | Sensor with Setpoint, Bypass/LED and LONWORKS Jack, Honeywell Logo | Degrees F Absolute |
| T7770C1044 | Sensor with Setpoint, Bypass/LED and LONWORKS Jack, Honeywell Logo | Relative Setpoint |
| T7770C1010 | Sensor with Setpoint, Bypass/LED and LONWORKS Jack, No Logo | Degrees F Absolute |
| T7770C1028 | Sensor with Setpoint, Bypass/LED and LONWORKS Jack, Honeywell Logo | Degrees C Absolute |
| T7770C1051 | Sensor with Setpoint, Bypass/LED and LONWORKS Jack, No Logo | Relative Setpoint |
| T7770C1036 | Sensor with Setpoint, Bypass/LED and LONWORKS Jack, No Logo | Degrees C Absolute |
| T7770D1000 | Sensor with Bypass/LED and LONWORKS Jack, Honeywell Logo | Degrees F Absolute |
| T7770D1018 | Sensor with Bypass/LED and LONWORKS Jack, No Logo | Degrees C Absolute |
| T7560A1018 | Digital Wall Module with Sensor, Setpoint and Bypass/LCD, Honeywell Logo | |

**Table 22. Excel 15 W7760C Ordering Information. (Continued)**

| Part Number | Product Description | Comments |
|---|---|---|
| T7560A1016 | Digital Wall Module with Sensor, Setpoint, Bypass/LCD and Humidity, Honeywell Logo | |
| | **Sensors:** | |
| C7770A1006 | Air Temperature Sensor. 20 Kohm NTC nonlinearized | Duct-mounted sensor that functions as a primary and/or secondary sensor. |
| C7031J1050 | Averaging Discharge/Return Air Temperature Sensor. 20 Kohm NTC | Duct element cord length 12 ft. (3.7m). |
| C7031B1033 | Discharge Air or Hot Water Temperature Sensor. 20 Kohm NTC | Use 112622AA Immersion Well. |
| C7031C1031 | Duct Discharge/Return Air Sensor. 20 Kohm | 18 in. (457mm) insertion length. |
| C7031D1062 | Hot or chilled Water Temperature Sensor. 20 Kohm NTC | — |
| C7031F1018 | Outside Air Temperature Sensor. 20 Kohm NTC | W7750B,C only |
| C7031K1017 | Hot or chilled Water Temperature Sensor. 20 Kohm NTC | Strap-on |
| C7100A1015 | Averaging Discharge/Return Air Temperature Sensor. PT3000 | 13 in. (330mm) insertion length. |
| C7170A1002 | Outdoor Air Temperature Sensor. PT3000 | — |
| | **Echelon Based Components and Parts:** | |
| Q7760A2001 | Serial Interface | (FTT) |
| Q7752A2009 | Serial Interface (PCMCIA card) | (FTT) |
| 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/two required per LONWORKS Bus segment |
| 205979 | Operator Terminal Cable for LONWORKS Bus | Serial interface to wall module or controller |
| | **Accessories (Sensors):** | |
| EL7680A1008 | Wall Mounted Wide View Infrared Occupancy Sensor | — |
| EL7628A1007 | Ceiling Mounted Infrared Occupancy Sensor | — |
| EL7611A1003, EL7612A1001 | Ultrasonic Occupancy Sensors | — |
| EL7630A1003, EL7621A1002, EL7621A1010 | Power Supply/Control Units for Occupancy sensors | — |
| C7242A1006 | $CO_2$ Sensor/Monitor | Use to measure the levels of carbon dioxide |
| C7400A1004 | Solid State Enthalpy Sensor (4 to 20 mA) | For outdoor and return air enthalpy |
| C7600B1000 | Solid State Humidity Sensor (2 to 10 V) | For outdoor and return air humidity |
| C7600C1008 | Solid State Humidity Sensor (4 to 20 mA) | For outdoor and return air humidity |
| C7600C1018 | Solid State Humidity Sensor (2 to 10 V) | For outdoor and return air humidity |
| | **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 |
| ML6161B1000 | Damper Actuator Series 60 | — |
| M6410A | Valve Actuator Series 60 | Use with V5852/V5853/V5862/V5863 Valves |

**Table 22. Excel 15 W7760C Ordering Information. (Continued)**

| Part Number | Product Description | Comments |
|---|---|---|
| ML684A1025 | Versadrive Valve Actuator with linkage, Series 60 | Use with V5011 and V5013 Valves |
| ML6464A1009 | Direct Coupled Actuator, 66 lb-in. torque, Series 60 | — |
| ML6474A1008 | Direct Coupled Actuator, 132 lb-in. torque, Series 60 | — |
| ML6185A1000 | Direct Coupled Actuator, 50 lb-in. spring return | Series 60 |
| V5852A/V5862A | 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. Close-off 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.) |
| V5853A/V5863A | 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. Close-off 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. |
| — | Two DIN rail adapters | Obtain locally: Part number TKAD, from Thomas and Betts, two for each controller. |
| 207912 | Snaptrack, 3.25 in. (82 mm) by 9 in. (228 mm) for use with W7751B Controller | (pack of 10) |
| Fair-Rite® 044316451 or equivalent Honeywell part 229997CB | Split ferrite cores | Split ferrite cores must also be in a metal enclosure when used with W7751B VAV Controller. |
| — | 5-micron Air Filters for Microbridge Sensor. | |
| | **Cabling:** | |
| — | Serial Interface Cable, male DB-9 to female DB-9 or female 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 2 140°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 W7760C Controllers to match their intended application. The LONSPEC ZL7760A has Help that provides details for operating the PC software.

# Step 7. Troubleshooting

## Check Installation and Wiring:

Inspect all wiring connections at the W7760C 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 W7760C. See Fig. 43. 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 49) on the W7760C 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. 42.

— Verify Triac wiring to external devices uses the proper load power/24 Vac hot terminals (terminals 31 through 42 on the W7760C). 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 LONWORKS 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 operation.

## Startup

## W7760C Controller Status LED

The LED on the front and center of a W7760C Controller provides a visual indication of the status of the device. See Fig. 51. When the W7760C 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 W7760C has an alarm condition.

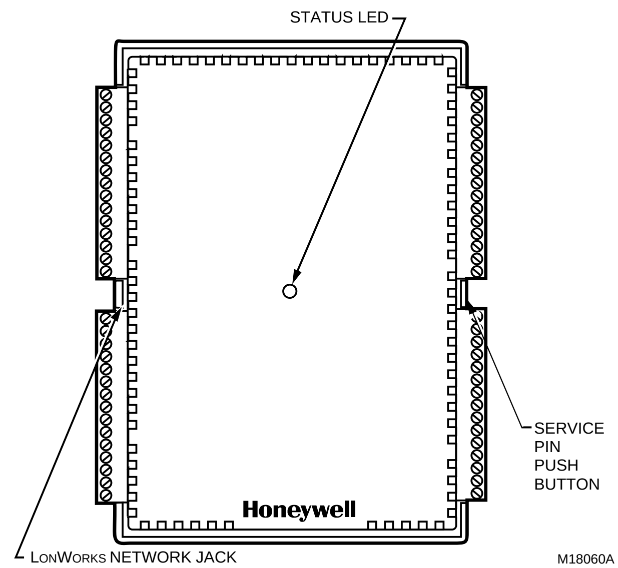


**Fig. 51. LED location on W7760C.**

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.

## Alarms

When an Excel 15 W7760C has an alarm condition, it reports it to the central node on the LONWORKS Bus (typically, a W7760A). See Table 23. 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 15C can provide the alarms listed in Table 23.

**Table 23. Excel W7760C Enumerated Alarms.**

| W7760C Alarm | Alarm Definition |
|---|---|
| RETURN_TO_NORMAL | Returns to normal after being in an alarm condition. The sum of this alarm code and another alarm code indicates that the alarm condition has returned to normal. |
| NO_ALARM | No alarms are currently being detected. |
| SET_POINT_LOOP1_ALARM | Setpoint loop alarms occur when the control sensor exceeds the configured high or low delta for the pre delay time. These alarms are reset when the control sensor value goes back inside of the deltas for the post delay time. |
| SET_POINT_LOOP2_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| SET_POINT_LOOP3_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| SET_POINT_LOOP4_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| SET_POINT_LOOP5_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |

**Table 23. Excel W7760C Enumerated Alarms.**

| W7760C Alarm | Alarm Definition |
|---|---|
| SET_POINT_LOOP6_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| SET_POINT_LOOP7_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| SET_POINT_LOOP8_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| SET_POINT_LOOP9_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| SET_POINT_LOOP10_ALARM | See the meaning for SET_POINT_LOOP1_ALARM type. |
| INPUT_NV_ALARM | One or more network variable (NV) inputs have failed in receiving an update within their specified FAILURE_DETECT_TIME. This is valid only on those NVs with fail detect. |
| SENSOR_ALARM | This indicates an open or short on an Analog Input or a problem with one of the calibration channels. |
| FLASH_CHECKSUM_ALARM | The FLASH checksum alarm indicates at least one of the configuration (internal to controller) sections or the NV configuration table has a bad checksum and needs a download. The W7760C reinitializes all of the sections and the NV configuration table in FLASH to the default values. These make the W7760C *unconfigured*. This alarm goes away on the next powerup/ reset. The W7760C never issues a *Return to Normal* because a download of all files causes a reset and erases any RTN that could have been issued on a download. This alarm should never occur on a properly working W7760C. Controller lost configuration and needs download. |
| INPUT_REM_POLL_ALARM | The input remote poll alarm is set when the W7760C has not been able to get a new value for a general poll point for 300 seconds. |
| FILE_ALARM | When received as a *file window out of sequence*, *window didn't complete* or *received more bytes than were supposed to*. Controller lost configuration and needs download. Redownload the file and reset the W7760C to make the error/alarm go away. |
| RAM_CHECKSUM_ALARM | This alarm and its return to normal tells the user the W7760C had a problem and fixed it. |
| ALARM_NOTIFY_DISABLE | Alarms have been disabled. |

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 23 for information contained in an alarm message.

There are two methods of assigning a Neuron ID from an Excel 15 W7760C 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 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. See Fig. 51. 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 ZL7760A software Help for more information on the ID assignment process.

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