2341-50x Series

Receiver-Controllers
General Instructions

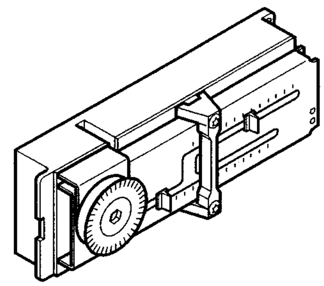
APPLICATION

2341-50x Series Receiver-Controllers are used — in pneumatic control systems — to provide proportional control of variables such as Temperature, Relative Humidity, Pressure, Differential Pressure (between water lines), Differential Static Pressure (of air), Air Velocity (in ducts), Enthalpy, etc., as sensed by remote pneumatic transmitters. Other pneumatic inputs may be used for special applications.

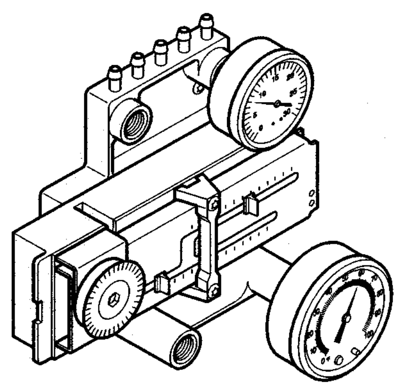
There are two models: 2341-501, Direct-Acting; and 2341-502, Reverse-Acting. Both can receive (but do not require) three inputs: Primary input signal (S) and Secondary (reset) signal input (R), normally received from pneumatic transmitters; and remote control-point adjustment input signal (C), usually received from a remotely-located manual pneumatic gradual switch or a transducer operated by a building automation system.

Both models are designed to be usable as limit-controllers without limit-setpoint drift: 2341-501 as low-limit controller; 2341-502 as high-limit controller (assuming the use of direct-acting transmitters). To prevent setpoint drift in limit applications, a built-in "limit valve", located on the rear of the controller, supplies constant main-air pressure (through port C) to the controller's pilot mechanism, even though the changing output pressure of another (primary) controller is connected to the limit-controller's main-air connection (M).

To provide sensitivity, repeatability, linearity and stability over their entire operating range, these controllers utilize a "nozzle and flapper" pilot mechanism, with pneumatic feedback, similar to that used in industrial instruments.



Receiver-Controller



Receiver-Controller and Two Gauges Mounted on P541-BASE

Features

- May be used either as:
  a. 1,2, or 3-input Receiver-Controller,
  b. Adjustable Ratio-Relay,
  c. High-Accuracy Reversing Relay (2341-502), or
  d. For other special applications.
- Provides Proportional plus Integral (PI) Control when used as Receiver-Controller along with an R500 (2351-001) Integral Relay.
- Compact Size.
- Wide Range of Throttling-Range & Authority Adjustments.
- High Sensitivity, Linearity and Stability.
- Requires no disassembly or parts rearrangement of any kind.
- May be mounted in either of the following ways:
  a. On **22-120**, to be used as part of a complete panel-mounted control system.
  b. **Individually on P541-BASE**, to be used as a stand-alone receiver-controller, along with up to two 2" receiver-gauges and two 1-1/2" pressure-gauges. (Both controllers are also available pre-mounted on P541-BASE; see ordering information below.)

Applicable Literature

- TAC Pneumatic Products Catalog, F-27383
- P541-BASE, Mounting Base General Instructions, F-26081

SPECIFICATIONS

Control Action:
2341-501; Direct-Acting. For ordering information see Table-1.
2341-502; Reverse-Acting. For ordering information see Table-1.
Construction: Glass filled nylon, steel, stainless-steel, brass, neoprene.
Environment:
Ambient Temperature Limits: 35 to 140°F (2 to 60°C).
Main Air Pressure:
Normal, 20-22 psig (138-152 kPa).
Maximum, 30 psig (207 kPa).
Air Consumption: 0.021 scfm, maximum (at constant output pressure).
Air Flow Capacity: 8 SCFH (230 scim) (0.063 L/s).
Connections: Barbed nipples for 1/4" O.D. polyethylene or 5/32" I.D. polyurethane tubing. See Table-2
Setpoint: Adjustable. Graduated dial with 0.25 psi divisions, receives (optional) adhesive Setpoint Dial Label, selected to match span of transmitter connected to Port S.
Throttling Range: Adjustable, 2 to 40% of Primary Transmitter's span.
Authority of Reset Input Signal: Adjustable, 10 to 300% of primary input transmitter signal.
Reset Action: Secondary transmitter, connected to Port R, provides reverse-reset of the primary input transmitter's setpoint; i.e., a pressure increase to Port R lowers the receiver controller's setpoint. The authority of input R - relative to that of Port S the primary transmitter - is adjustable from 10 to 300%. *Note:* direct reset may be obtained by using another controller, 2341-502, set at 40% T.R. and 60% Authority, to reverse the output signal of the secondary transmitter from 3-15 psig to 15-3 psig.
Control Point Adjustment (CPA): A 12 psig change - usually received from a remotely located manual pneumatic gradual switch - to the CPA Port (port C), directly and proportionately resets the controller's setpoint 20% (overall) of the primary transmitter's span.

Table-1 Ordering Information.

Model Number	Replaces	Action	Limit-Controller Application	Controller Mounted on P541-BASE
2341-501	P541	Direct	Low Limit	No
2341-521	P541-DA-B	Direct	Low Limit	Yes
2341-502	P541-RA	Reverse	High Limit	No
2341-522	P541-RA-B	Reverse	High Limit	Yes

Table-2 Connections.

Port	Function of Connection
B	Branch Output to Actuators, etc.
M	Main Air Supply
S	Signal (Primary Transmitter Input)
R	Reset (Secondary Transmitter Input, if used)
C	Control Point Adjustment (Remote gradual switch input, if used) Note: When receiver-controller is used as limit-controller, C port is used for Main Air Supply

ACCESSORIES

Part Number	Replaces Model	Description
20-881	N2-4	Calibration wrench.
21-038	N100-0010	Restrictor tee polyethylene tubing.
21-153	N100-2501	In-line restrictor.
900-012	N100-2597	Calibration kit.
2390-501	S510	Gradual switch.
2390-505	S511-5	Minimum switch position (5 psig span).
2390-510	S511-10	Minimum switch position (10 psig span).

TYPICAL APPLICATIONS (Piping diagrams)

Single-Input Receiver-Controller

When used as a single-input receiver-controller, the input signal (usually the output of a transmitter) is connected to the primary signal input, port S. unused ports are left open (not plugged). Refer to Figure-1**.**

A single input receiver-controller may be used with or without a remote setpoint device. When used, the device generating the remote setpoint signal, usually an S510 (2390-501) Gradual Switch is connected to the "Control Point Adjustment" (CPA) input, port C.

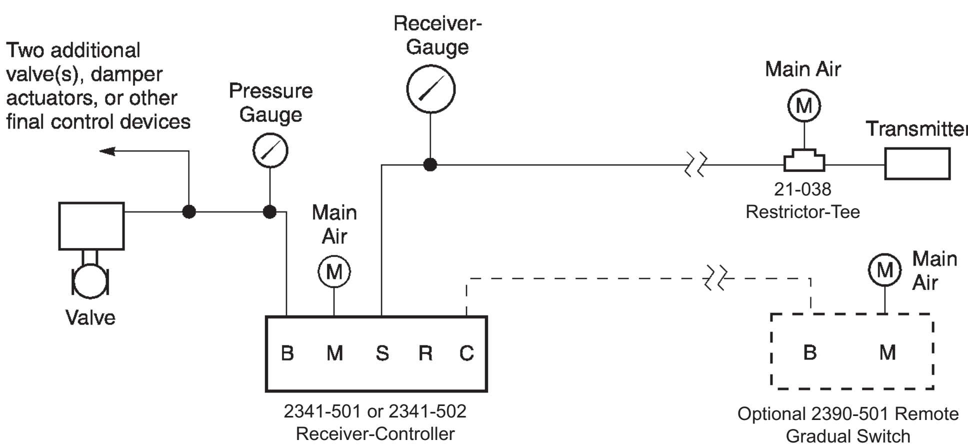


Figure-1 Typical Single-Input Receiver-Controller Piping Diagram (shown with optional Remote Gradual Switch.

Dual-Input Receiver-Controller

When used with dual inputs, the receiver-controller receives signals from two transmitters. The primary transmitter, connected to port S, normally senses the variable condition being controlled. The secondary transmitter, connected to (the "Reset" input) port R, resets the setpoint of the receiver-controller in response to an outside (secondary) condition. The most common example of this is a hot water supply temperature being reset by changes in outdoor air temperature, where the hot-water temperature transmitter is connected to input port S and the outdoor air transmitter is connected to port R (see Figure-2, below, and Figure-3, page 11).

A dual input receiver-controller may be used either with or without a remote setpoint device. When used, the device generating the remote setpoint signal, usually a 2390-501 Gradual Switch, is connected to the "Control Point Adjustment" input, port C.

Note:

- Leave all unused input ports (S,R or C) open; do not block.
- Using (recommended) 1/4" OD tubing, 200 ft. (61 m) is the maximum recommended distance between the restrictor and transmitter. 1000 ft. (305 m) is the maximum recommended distance between the transmitter and receiver-controller.
- For best accuracy, place restrictor at transmitter's location; this prevents air movement, and the associated slight pressure drop, through tubing.

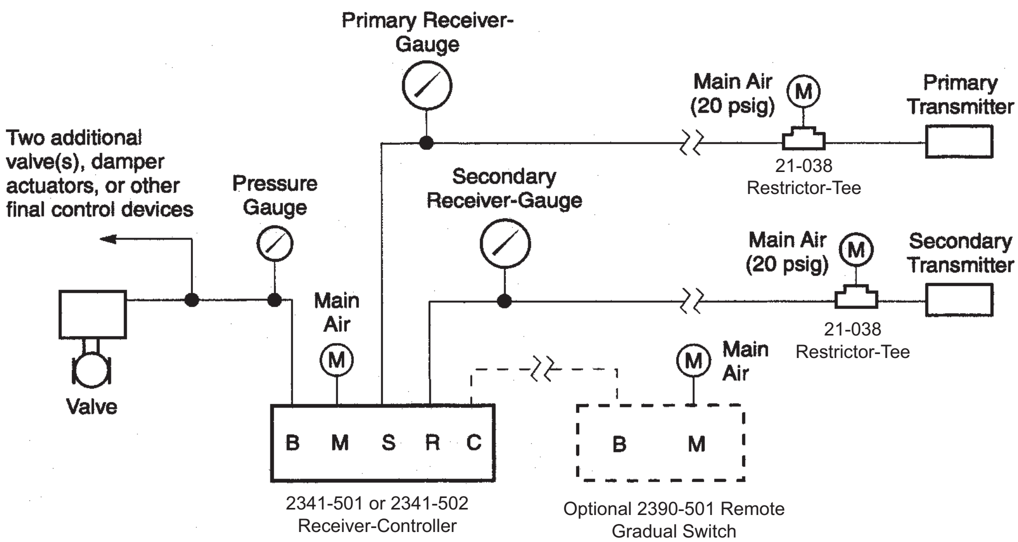


Figure-2 Typical Dual-Input Receiver-Controller Piping Diagram shown with optional Remote Gradual Switch.

INSTALLATION

Inspection

Inspect the package for damage. If damaged, notify the appropriate carrier immediately. If undamaged, open the package and inspect the device for obvious damage. Return damaged products.

Requirements

- Piping Diagrams.
- Tools (not provided):
  - No. 1 point phillips screwdriver for mounting screws.
  - Drill and drill bit for mounting screws.
- Appropriate accessories.
- Training: Installer must be a qualified, experienced technician.

Precautions

Caution:

- Use a refrigerated air-dryer, particulate filter, and coalescing filter to provide clean, dry, oil-free air (refer to EN-123).
- The compressor oil must be non-paraffin, mineral base or naphtha base. The use of synthetic or paraffin base oils will destroy pneumatic controls and void the warranty.
- Avoid locations where excessive oil, dust, moisture, corrosive fumes or vibration is present.

Mounting

The P541 or 2341-502 Receiver-Controller may be mounted in either of two ways:

- **On P541-BASE**, for use as a stand-alone Receiver-Controller, with four Phillips-head double-helix screws (22-134) and one sealing gasket (22-133), included with P541-BASE. P541-BASE also mounts up to two 2422-003 Series (2" nominal diameter) Receiver-Gauges and two 2420-001 Series (1-1/2" nominal diameter) Pressure-Gauges. P541-BASE has five barbed connections for use with 1/4" OD polyethylene tubing.

Note: Both controllers are available pre-mounted on the P541-BASE as 2341-521 (direct-acting), or 2341-522 (reverse-acting). See "Ordering Information."

Note: Connections to the nipples of the 22-120 must be made with MCS-TUBE (TAC Pneumodular Tubing).

Mounting Method for P541-BASE and 22-120

1. Install 22-133 over the five barbed fittings, and push down to rear surface of controller body.
2. Place the barbed fittings into the five matching holes of 22-120, or the P541-BASE, and fasten to the base of socket with four 22-134.

DEFINITIONS and CALCULATIONS

The following terms and calculations are used in the calibration of pneumatic receiver-controllers. These definitions are included to familiarize the user with pneumatic terminology and to help in understanding the application of these receiver-controllers and the transmitter inputs to them.

Typical Controlled Variables

In HVAC systems, typical Controlled Variables (all of which can be sensed by TAC Pneumatic Transmitters) are as follows:

- Room (space) Temperature - Air-Handling Unit: Mixed-Air Temperature, Heating- Coil Discharge Temperature, Cooling-Coil Discharge Temperature, Supply Air Temperature, Return Air Temperature, etc.
- Hot Water Supply or Return Temperature
- Chilled Water Supply or Return Temperature
- Room Relative Humidity - Supply or Return Duct Relative Humidity
- Air Pressure - Water Pressure - Steam Pressure
- Refrigerant Pressure
- Supply/Return Water Differential Pressure
- Differential Static Pressure (of Air): Ducts, indoor spaces, mixed-air plenums, outdoor air, across filter, etc.
- Enthalpy (total heat) of Air in Outdoor Air and Return-Air Ducts
- Air Velocity in Ducts

Note: Some uncontrolled variables can also be sensed (measured) by TAC pneumatic transmitters, such as:

- outdoor air temperature,
- outdoor relative-humidity,
- outdoor enthalpy (total heat),
- outdoor air atmospheric pressure (relative to indoor pressure).

Pneumatic Transmitters

A pneumatic transmitter is a measuring device which senses the value of a controlled variable and provides a pneumatic output signal to a receiver-controller (or to other pneumatic devices, such as snap-acting switching relays or sensitive pressure-electric switches).

A pneumatic transmitter operates on a restricted 20 psig main air supply, and produces a pneumatic output signal which varies from 3.0 to 15.0 psig as the value of the measured variable varies from the low end of its range to the high end. Pneumatic transmitters are fixed-range devices, and are factory calibrated.

Note: The *output* of a pneumatic transmitter is also frequently referred to as the *input* to a receiver-controller.

Transmitter Range and Span

TAC pneumatic transmitters are available in a large variety of ranges to cover virtually all normal HVAC applications. The term *range* refers to the extent of the measured (or controlled) variable covered by the transmitter, in engineering units such as °F (or °C), % RH, psi, or inches WC (kPa). The term *span* refers to the width of the range in the same engineering units. Three example(s): A temperature transmitter having a range of -40 to +160°F has a span of 200°F; a differential static pressure transmitter having a range of -0.05 to +0.20 inches WC has a span of 0.25 inches WC; a relative humidity transmitter having a range of 30 to 80% RH has a span of 50% RH.

Transmitter Sensitivity

Transmitter sensitivity refers to the change in transmitter output pressure (psi output change) per engineering unit change in the sensed variable (for example, per change in °F).

Examples: A transmitter with a 200°F span produces a change of 12 psi/200°F, or 0.06 psi/°F. A transmitter with a 100°F span produces a change of 12 psi/100°F, or 0.12 psi/°F.

Therefore, for a given type of engineering unit, the narrower the transmitter's span, the greater its sensitivity (see Table-3). Further, the greater the transmitter's sensitivity, the more precise the control. *For this reason, it is advantageous to use the narrowest transmitter span that completely covers the application in question*.

Note: The term "transmitter sensitivity" accurately applies only to transmitters having linear outputs (output pressures which vary in direct linear proportion to changes in the sensed variable).

Table-3 Transmitter Sensitivity.

Range	Span °F	Sensitivity (psi per unit)
Temperature		
-40 to 160°F	200	.06 per °F
-25 to 125°F	150	.08 per °F
0 to 100°F	100	.12 per °F
30 to 80°F	50	.24 per °F
40 to 140°F	100	.12 per °F
40 to 240°F	200	.06 per °F
50 to 90°F	40	.30 per °F
50 to 100°F	50	.24 per °F
50 to 150°F	100	.12 per °F
Relative Humidity		
0 to 100% RH	100	.12 per % RH (average)
10 to 90% RH	80	.15 per % RH (average)
30 to 80% RH	50	.24 per % RH
50 to 90% RH	40	.30 per % RH (average)
Enthalpy		
16 to 40 BTU/lb	24	.50 per BTU/lb (average)
Pressure		
-10 to 40 psig	50	.24 per psi
0 to 150 psig	150	.08 per psi
0 to 300 psig	300	.04 per psi
Differential Pressure		
0 to 50 psi	50	.24 per psi
0 to 100 psi	100	.12 per psi
Differential Static Pressure		
-0.5 to 0.5 in. WC	1	12 per 1" WC
-0.05 to 0.2 in. WC	0.25	48 per 1" WC
0 to 1 in. WC	1	12 per 1" WC
0 to 3 in. WC	3	4 per 1" WC
0 to 10 in WC	10	1.2 per 1" WC
Air Velocity (in ducts)		
200 to 2000 fpm	1800	.0066 per fpm
300 to 3000 fpm	2700	.0044 per fpm
400 to 4000 fpm	3600	.0033 per fpm
500 to 5500 fpm	4950	.0024 per fpm

Receiver-Controller

A receiver-controller is a pneumatic device that receives one (or more) input signals from pneumatic transmitters, and produces its own modulated pneumatic output signal to operate final control devices, such as valve and /or damper actuators, as required to maintain the value of a controlled variable within certain pre-selected limits.

The receiver-controller uses a separate main air supply, usually 20 psig, to amplify the input signal(s) from the pneumatic transmitter(s), and to provide the necessary volume of control air required to move (modulate) the valve and/or damper actuators to any required position; i.e. from one extreme position to the other, if necessary. The receiver-controller can produce any required output pressure between o psi and main-air pressure (nominally 20 psi).

Theses receiver-controllers may be used as single-input, dual-input, or three-input, or three-input receiver-controllers. See “Typical Applications.”

Setpoint

Setpoint is the selected value within the range of the primary transmitter at which the receiver-controller attempts to maintain the value of the controlled variable. The receiver-controller is usually calibrated to provide a 9 psig branch pressure when the actual control point is at its desired value; i.e., when it coincides with the setpoint. However, the controller can be calibrated (by means of the setpoint adjustment) to provide any desired output pressure between 0 psig and main air pressure when required by the application.

Setpoint may be expressed in engineering units of the primary transmitter (for example, °F), or in the equivalent output pressure of the primary transmitter (for example, for a 0-100°F transmitter, the output pressure equivalent to 50°F would be halfway between 3 and 15 psig, or 9 psig).

Control Point

Control point is the actual value of the controlled variable.

Throttling Range

Throttling range (TR) is the number of engineering units (for example, °F) the controlled variable, sensed by the primary transmitter connected to port S, must change to produce a 3 to 15 psig (12 psi) change at the receiver-controller’s branch line (port B).

TR may also be expressed as percentage of the span of the primary transmitter. For example, to obtain a 10°F TR with a primary transmitter span of 100°F connected to port S, the receiver-controller’s TR adjustment should be set at 10%. For a 10°F TR with a 200°F span transmitter, the TR adjustment should be set at 5%.

Note: The TR adjustment should always be made prior to calibration (setpoint adjustment).

Authority Adjustment (and Calculation)

Authority is the adjustment which determines the effect of a secondary transmitter’s input signal at port R on the branch pressure output, as compared to the effect of the primary transmitter’s input signal at port S. A reset pressure increase at port R lowers the receiver-controllers setpoint, and a pressure decrease at port R raises the setpoint.

The extent to which the setpoint is raised or lowered by a given change in reset pressure (i.e., the amount of change in the controlled variable caused by a change at the secondary transmitter) is determined by the Authority setting.

At the 100% setting, the port R effect is equal to that of port S. At 10%, is has one -tenth the effect of port S. At 300%, it has three times the effect of port S.

Since the two transmitters often have different sensitivities, the setting of the authority adjustment must be calculated for each individual application to account for these differences.

The authority calculation also accounts for the effect of the throttling range factor, along with the transmitter sensitivity effect, and the formula for determining Authority Setting is as follows:

$$\text{Authority} = \frac{(\text{desired change @ PT + TR setting of PT}) \times (\text{PT sensitivity}) \times 100\%}{(\text{change @ ST}) \times (\text{ST sensitivity})}$$

Where TR = Throttling Range, PT = Primary Transmitter (connected to port S), and
ST = Secondary Transmitter (connected to port R)

Note:

- Referring to the Hot Water Reset example shown, the TR factor is included to take into account the valve actuator pressure change needed to move the steam valve from the (theoretically) almost closed position at 60°F outdoor air temperature to the wide open position at 10°F outdoor air temperature.
- If a 2351-001 Integral Relay is used to add integral action to the proportional action of the receiver-controller, the "TR Setting of PT" factor is omitted from the equation, since the Integral Relay automatically provides the required valve actuator pressure change as it simultaneously returns the actual control point to the receiver-controller's setpoint. (See "Proportional plus Integral Control.")

Control Point Adjustment

The Control Point Adjustment (CPA) feature is used to raise or lower the receiver-controller's setpoint (from a remote location) in response to input pressure changes to port C from a remotely located device such as a manual gradual switch, or a transducer operated by a building automation system.

An increase in port C pressure raises the setpoint, and a decrease in port C pressure lowers the setpoint. A 3 to 15 psig (12 psi change) in pressure to port C will shift the receiver-controller's setpoint 20% of the primary transmitter's span. If the primary transmitter has a 100°F span, twenty percent represents 20°F. In most applications, port C is preloaded with 9 psi prior to setpoint calibration, which permits both lowering and raising the setpoint by 10% of the primary transmitter's span as the pressure at port C is decreased to 3 psig or raised to 15 psig, respectively.

Alternatively, using a 3 psig port C preload before setpoint adjustment permits a 20% setpoint increase (only) as the pressure is increased to 15 psig. Using a 15 psig port C preload permits a 20% decrease (only) as the pressure is decreased to 3 psig.

CALIBRATION

Single Input

1. Set the desired throttling range (TR).
2. Move Authority adjustment to minimum position (10%).

Note: Always set TR and Authority adjustments before calibration. Adjustment of either after calibration affects calibration.

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3. Note the actual value of the controlled variable (from receiver-gauge, or from other reference).
4. Turn the setpoint adjustment to obtain 9 psig branch pressure (or other desired pressure, such as the mid-spring-range pressure of connected actuators).
5. Lift setpoint scale to disengage, turn scale to align actual value of controlled variable (also called control point) - or the transmitter output pressure representing the actual value - with the setpoint scale pointer and release scale.
6. Turn the setpoint adjustment (at center of scale, using either a Phillips screwdriver, and N2-4 Calibration Tool, or a 1/4" hex wrench) to the desired value (or to the pressure representing same). Then observe the control point of the changing controlled variable. If necessary to obtain desired control point, repeat steps 3 through 6.

Single Input With CPA

1. Set input pressure at port C. This pressure is usually set a 9 psig which permits a ±10% effect on the controller's setpoint. (See "Control Point Adjustment.")
2. Proceed with calibration procedure as described in "Single Input", steps 1 through 6.

Dual Input

In the typical application shown in Figure-3, a steam to hot water converter (heat exchanger) is used to generate the hot water supply for the system. The hot water supply temperature leaving the converter is being controlled, and the hot water temperature is being reset (by an outdoor-air transmitter) in response to changes in outdoor air temperature.

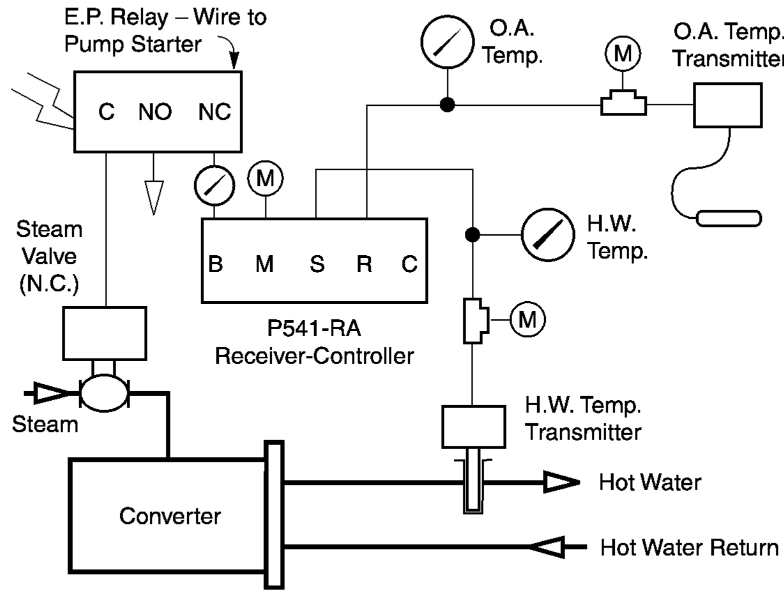

Figure-3 Typical Application (Hot Water Reset).

To calibrate the receiver-controller for dual input (reset application, it is necessary to calculate the desired reset schedule (usually specified to suit a particular building's location and mechanical system).

In the following example, it is desired to reset the water temperature downward from 180°F to 100°F as the outdoor air temperature rises from 10°F to 60°F, as shown in Table-4.

Table-4 Reset Schedule.

Reset Schedule °F	
Outdoor Air Temperature	**Hot Water Temperature**
10	180
35	140
60	100

Transmitter Selection

Transmitters must be selected to meet the needs of the system. Normal procedure is to select transmitter ranges that place the temperature that must be sensed toward the middle of the transmitters' ranges. For the example, we have selected these ranges:

Outdoor Air Transmitter: -25° to 125°F

Hot Water Supply Transmitter: 40° to 240°F

Throttling Range Selection

A throttling range of 30°F has been chosen to provide stable control. Note: Wide throttling ranges are more stable than narrow ones. The narrower the throttling range, the greater the tendency of the system to cycle (hunt). Generally, the TR should be set as narrow as possible without causing hunting.

Authority Calculation

The following formula is used to determine the Authority Setting for dual-input receiver-controller application. For clarification of terminology used in the formula, refer to the Authority Adjustment section.

$$\text{Authority} = \frac{(\text{desired change @ PT} + \text{TR setting of PT}) \times (\text{PT sensitivity}) \times 100\%}{(\text{change @ ST} \times \text{ST sensitivity})}$$

Where TR = Throttling Range, PT = Primary Transmitter (connected to port S), and ST = Secondary Transmitter (connected to port R).

Using the information shown in the reset schedule, the transmitter ranges chosen, and the desired throttling range, we can determine the values for our formula.

ΔT @ Hot Water (Primary) Transmitter = 80°F

Throttling Range = 30°F

Primary Transmitter Sensitivity = 0.06 psi/°F

Δ T @ Outdoor Air (Secondary) Transmitter = 50°F

Secondary Transmitter Sensitivity = 0.08 psi/°F

The formula now becomes:

$$\text{Authority} = \frac{(80 + 30) \times (0.06) \times 100\%}{(50 \times 0.08)}$$

Authority = 165%

Calibration Steps

Note: Always set TR and Authority adjustments before calibration. Adjustment of either after calibration affects calibration - necessitating recalibration.

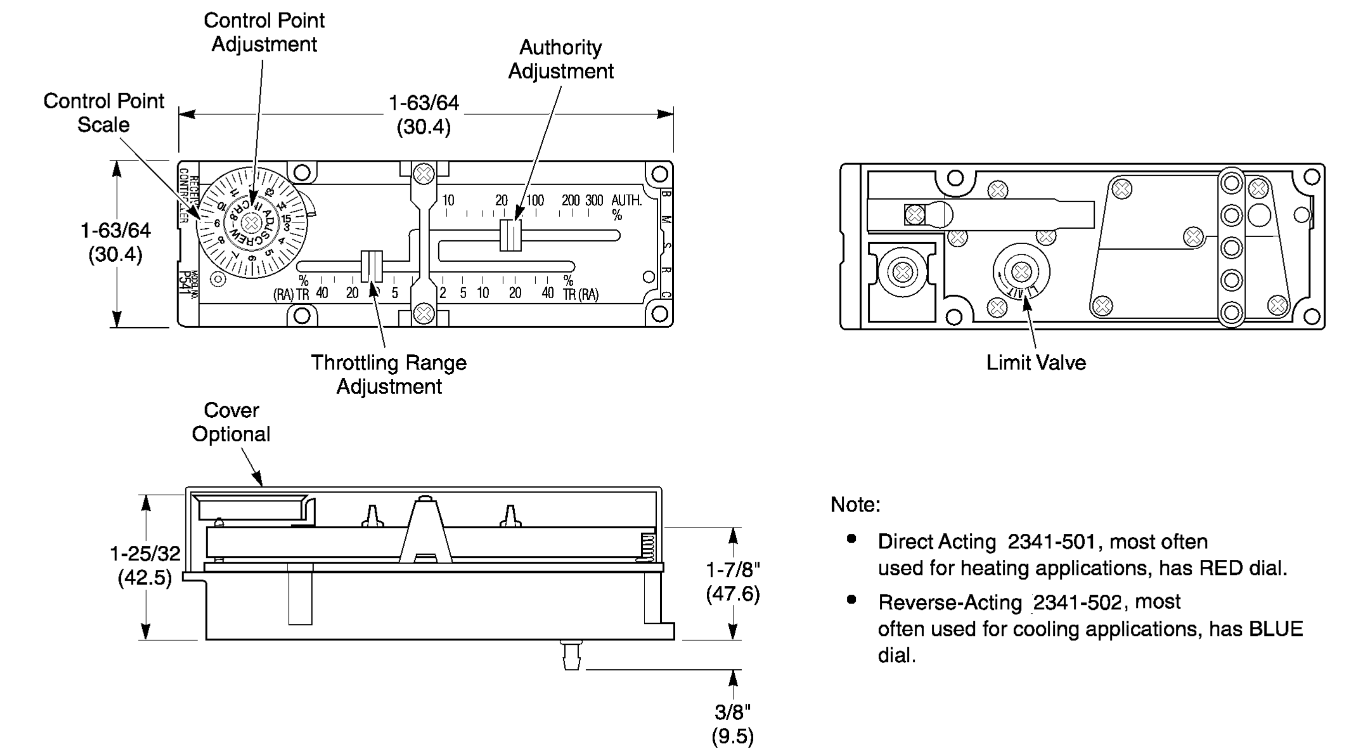

Figure-4 Details of Receiver-Controllers.

Using Calibration Kit

Note: The values mentioned below refer to the Hot Water Reset example shown.

If a Receiver-Controller Calibration Kit such as the 900-012 or another source for simulated inputs is being used, proceed as follows:

1. Set Throttling Range at the (15%) setting that produces an actual TR of 30°F. Since the span of the primary transmitter is 200°F, the correct throttling range setting is 30°F/200°F or 0.15 (15%). Then set Authority at the calculated 165%. Refer to Figure-4.
2. Set inputs to match the mid-points of the reset schedule. This may be done in units of temperature (as read on the receiver gauge scale matching the transmitter range) or in pressure (taken from a transmitter output pressure chart). In this example: 140°F (or 9.0 psig) at port S, and 35° (or 7.8 psig) at port R.
3. Turn the control point adjustment until the branch pressure is 9 psig (or the mid-spring range pressure of the controlled device).
4. Disengage the control point scale by lifting. Rotate the scale until it equals the mid-point of the reset schedule (at primary input port S). This may be read as a corresponding temperature (using a setpoint scale) or in psig on the dial itself. In this example: 140°F or 9.0 psig. Re-engage the setpoint scale).

   The Receiver-Controller is now calibrated to the desired setpoint of a 140° hot water supply at a 35° outdoor air temperature.

   To verify the correct throttling range, the primary input only may be varied (port S). Varying this input over the span of the desired throttling range should change the branch pressure from 3 to 15 psig. Then set back to 9 psig.

   To verify the correct Authority setting, the simulated inputs should be raised and lowered. Example: Port S to 180°F and port R to 10°F, or port S to 100°F and port R to 60°F. Both conditions should give a branch pressure equal to that obtained when both inputs are at the mid-points of the reset schedule, 140°F and 35°F.
5. Connect transmitters to proper ports.

Live Adjustment

If the Receiver-Controller is being calibrated “live” or under actual operating conditions, proceed as follows:

1. Set the Throttling Range and Authority. (See “Throttling Range Selection” and “Authority Selection.”)
2. Turn the control point adjustment until the branch pressure is 9 psig (or mid-spring range of the controlled device).
3. Note the input temperature (or corresponding pressure) at port S. Disengage the control point scale by lifting, and rotate the scale until it matches the input temperature (or corresponding pressure) at port S, and re-engage the scale.

Note: The Supply Temperature (or other controlled variable) must be within the range of the reset schedule. If it is not, the system should be brought into range before final calibration.

4. Turn the control point adjustment until the scale corresponds to the required temperature indicated by the input temperature at port R. Temperature (or other secondary transmitter input) at port R must be within the desired reset schedule to allow for proper calibration. To determine the correct supply temperature, it is necessary to draw a graph of the reset schedule as shown in Figure-5.

Note: The setpoint scale only represents the hot water supply temperature (in this example) at the one point which corresponds to that given input at port R. With any change in the sensed condition at port R, the setpoint of the controller is reset to correspond to the new port R input, as shown in example below.

Examples: Use reset schedule shown in Figure-5, Which corresponds to our example schedule shown in Table-4.

- Input at port R indicates 35°F. Corresponding HWS temperature should be 140°F.
- Input at port R indicates 20°F. Corresponding HWS temperature should be 164°F.
- Input at port R indicates 50°F. Corresponding HWS temperature should be 116°F.

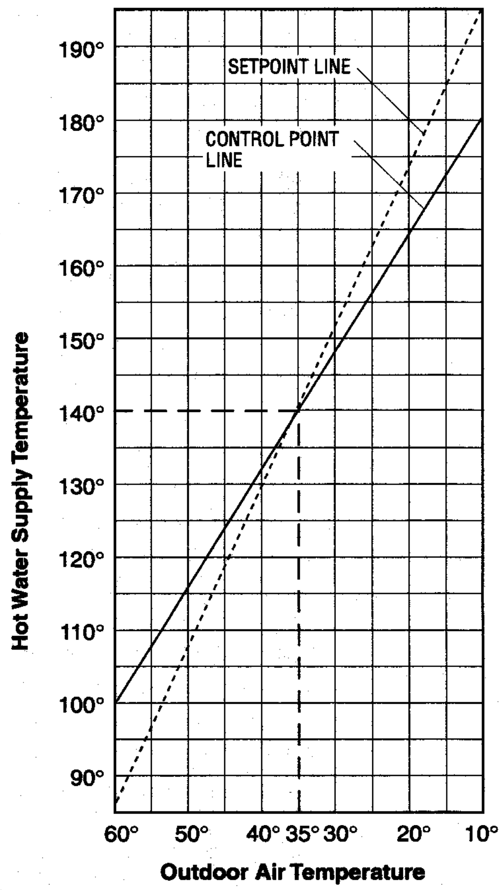

Figure-5 Graph of Sample Reset Schedule.

With proportional control, in order to provide for *the change in valve actuator pressure* needed to move the steam valve from the *almost closed position* at 100°F hot water temperature (when outdoor air temperature is 60°F) to the *wide open position* at 180°F (when outdoor temperature is 10°F) it is actually necessary to move the *setpoint* beyond each end of the desired reset span, in order to make the *control point* follow the desired reset line.

Notice that since a 30°F throttling range (TR) was selected for the example, the Setpoint Line (dotted) extends 15° below the lower limit, and 15° above the upper limit, of the selected Hot Water Supply Temperature reset span. The "TR factor" is included in the Authority Calculation to take this necessity into account. For further explanation, see "Authority Adjustment."

Limit Control Applications

For limit control applications (use direct-acting receiver-controller for low-limit; reverse-acting for high-limit), move the limit valve located on the rear of the controller to the limit position as follows: Loosen the Phillips-head screw holding the limit-valve; lift the valve disc and rotate it approximately 60° clockwise to the new position, and re-tighten the screw.

Note: When the limit valve is in the limit position, main air must be connected to the receiver-controller through port C, and the variable pneumatic signal form the primary controller must be connected to port M.

In the sample application shown in Figure-6 (a simple heating and ventilating air-handling unit serving a single space), the room temperature controller is the primary controller, and the mixed-air temperature controller serves as a low-limit controller. As long as the mixed-air temperature is above the low-limit controller's setpoint (55°F), the branch pressure from the room temperature controller passes through the limit-controller (from port M to port B), and onto the valve and damper actuators. As the mixed-air temperature decreases, and approaches 55°F, the low-limit controller reduces its branch output as necessary to prevent the mixed-air temperature from going below 55°F.

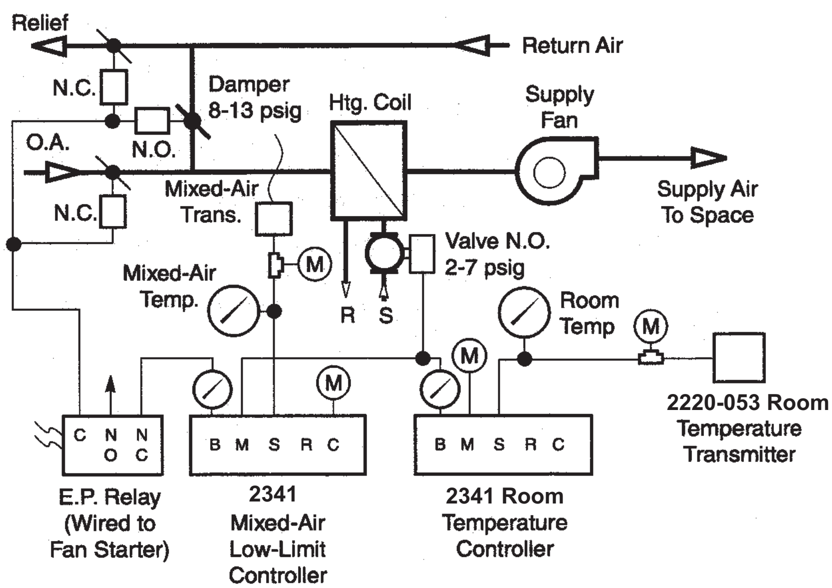

Figure-6 Sample Low-Limit Application.

Adjustable Ratio-Relay Applications

There are occasional special applications for which it is necessary to modify a pneumatic signal; i.e. to change its value. For example, it may be necessary to change the limited 3-15 psig output of an I to P transducer to 0-21 psig in order to obtain the maximum extension and retraction force of an 8-13 psig pneumatic damper actuator. This example would increase the pressure change form 12 psi to 21 psi, a "gain" of 21÷12, or 1.75. Refer to Figure-7.

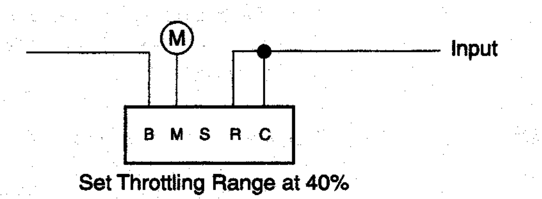

Figure-7 Piping Diagram, Adjustable Ratio-Relay.

In this type of case, it is advantageous to use either the direct- or reverse-acting receiver-controller (depending on the action required) as an adjustable ratio-relay. With the receiver-controller piped as shown above, the "gain" of the output signal (explained below) is adjustable from 0 to a maximum of 700% of the input signal (a maximum gain of 7.0).

Gain is the change in output signal divided by the change in input signal; i.e.:

$$\text{Gain} = \frac{\text{output signal change}}{\text{input signal change}}$$

The following formula for determining the required setting of the Authority Adjustment is based upon the *Throttling Range Adjustment* being set at 40%.

Auth. Setting = [(required Gain x 0.4) + (0.2)] x 100

Applying the equation to the example mentioned above:

Authority Setting = [(1.75 x 0.4) + 0.2] x 100

Authority Setting = 90%

For maximum accuracy, connect accurate pressure gauges (preferably with 0.1 psi accuracy and 0.1 psi divisions) to the input and output signal lines, and fine-tune the Authority Adjustment (and Setpoint Adjustment) as required to obtain the desired gain (leaving the TR setting at 40%).

Proportional Plus Integral Control

Note: Some HVAC processes require more precise control than can be obtained with proportional control alone (whether the controller is pneumatic, electronic, or digital).

The main benefit of PI control is that it returns the "control point" (the actual valve of the controlled variable) to the setpoint (the desired value) of the receiver-controller.

The use of the 2351-001 Integral Relay, along with a proportional receiver-controller, adds "Integral Control" action to the "Proportional Control" action of the receiver-controller, (or any other proportional controller having adequate throttling-range and setpoint adjustment capability). The resulting control mode is called "Proportional plus Integral (or PI) Control."

For example, consider a heating-cooling air-handling unit that must provide a constant supply of 58°F air to a laboratory room where it is necessary to maintain precise control of both temperature and humidity.

In the example shown in Figure-8, the supply-air (fan-discharge) temperature is sensed by a duct-mounted temperature transmitter having an averaging type sensing element.

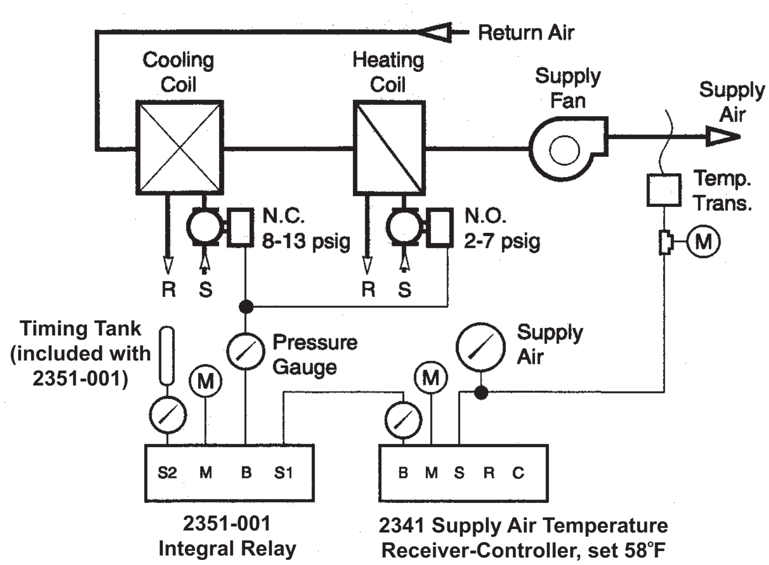

Figure-8 Example: PI control Application.

The supply air temperature transmitter's output signal pilots the receiver-controller, and the supply air temperature is indicated by the receiver-gauge.

The receiver-controller's proportional output signal (at port B), in turn, is connected to the integral relay's input port (S1) and pilots the integral relay, which adds the integral mode of operation to the receiver-controller's proportional output. The resulting output signal to the heating and cooling valves is PI Control, which operates the heating and cooling valves in sequence as required to return the fan-discharge temperature to the receiver-controller's setpoint following a disturbance.

Brief explanation of the Integral Control Mode

The 2351-001 Integral Relay is capable of producing any output pressure (between zero and main air pressure) needed to move the actuators to the position required to return the control point to the receiver-controller's setpoint; i.e. the value of the controlled variable at which the receiver-controller's branch pressure is equal to 9 psig.

Note: The integral relay is designed so that it "wants to receive 9 psig" from the receiver-controller's B port (at its S1 port). If the pressure at S1 rises above 9 psig, the integral relay begins to increase its output pressure at a steady (timed) rate, moving the actuators slowly until the controlled variable (in the example, supply air temperature) returns to the receiver-controller's setpoint.

If the pressure at S1 falls below 9 psig, the integral relay begins to decease its output pressure at a steady (timed) rate until the controlled variable returns to the receiver-controller's setpoint.

When the pressure at S1 becomes steady at 9 psig, the *control point has returned* to the controller's *setpoint*, and the integral relay's branch pressure stabilizes (somewhere between zero and main-air pressure) at the point necessary to move the actuators to the position required to return the *control point to setpoint*.

For more information of the 2351-001 integral relay, refer to **2351 Series, Integral Relays General Instructions, F-23902**.

Dimensional Data

Figure-9 and Figure-10 show the dimensions of mounted Receiver-Controllers in inches (mm).

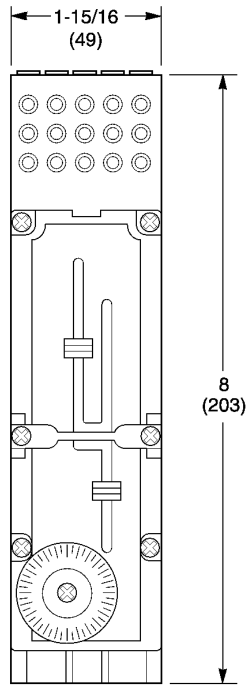

Figure-9 Mounted on 22-120.

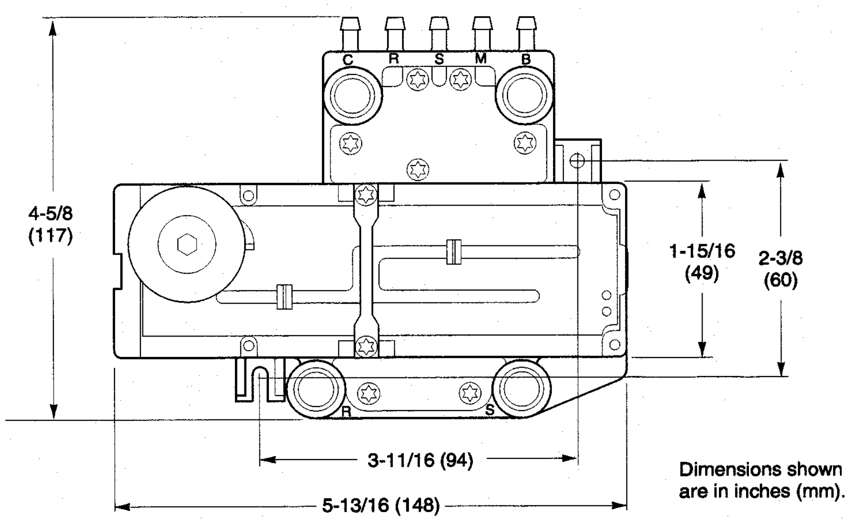

Figure-10 Mounted on P541-BASE.

On October 1st, 2009, TAC became the Buildings business of its parent company Schneider Electric. This document reflects the visual identity of Schneider Electric, however there remains references to TAC as a corporate brand in the body copy. As each document is updated, the body copy will be changed to reflect appropriate corporate brand changes.

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