

System 350™ R353/S353 Modular Electronic Sequencer

The System 350 R353/S353 Modular Electronic Sequencer provides multistage control in HVAC/R applications. The R353 Signal Input Module accepts input signals of 0 to -2 VDC, 0 to 10 VDC, 0 to 20 mA, or 135 to 10K ohm slidewire potentiometer to drive up to ten S353 modules. The S353 Staging Modules contain a single-pole, double-throw relay with an LED indicator for relay status. The sequencer's modular design provides easy, snap-together connections for quick installation and future system expansion. The R353/S353 can be used as a direct replacement for the Johnson Controls/Penn R23 Actrol™ Sequencer.



Figure 1: R353 Signal Input Module and S353 Staging Module

Features and Benefits	
<input type="checkbox"/> Modular Design	Provides the flexibility to add up to ten staging modules
<input type="checkbox"/> Four Relay Time Constant Selections: <1, 40, 70, or 110 Seconds	Allows S353 response time to be customized to the application
<input type="checkbox"/> Plug-in Connectors and 35 mm DIN Rail Mounting	Eliminates wiring between modules, which reduces installation costs
<input type="checkbox"/> R353 Accepts Inputs of 0 to -2 VDC, 0 to 10 VDC, 0 to 20 mA, and 135 to 10K ohm Slidewire Potentiometer	Compatible with a wide range of electronic controllers
<input type="checkbox"/> Onboard 21.5 VDC Power Supply	Permits use with Johnson Controls R93 and R94 Temperature Controls
<input type="checkbox"/> Selectable Jumpers for Direct, Reverse, or Mixed Acting Applications	Works in many combinations of heating, cooling, humidity, or pressure applications
<input type="checkbox"/> Electronic Equivalent of the R23 Series Actrol Sequencer	Provides a replacement with more versatility and accuracy

Theory of Operation

The R353 Signal Input Module acts as an interface between a proportional controller and up to ten S353 Staging Modules. The R353 accepts an input signal from a controller and converts this input into a proportional signal (Figure 2) that is sent to the S353. This signal controls the S353 relay, which opens or closes the circuit to an electrical load. The S353 LED indicator lights whenever the relay is energized.

The R353 and S353 modules feature screw-type terminals for easy wiring. Four adjustments (operational mode selector, relay time constant, offset, and differential) allow greater user control in various HVAC/R applications.

Operational Mode Selector

The R353 and S353 modules' mode of operation is selected using circuit board jumpers (Figures 3 and 4). The R353 can be set for either direct, reverse, or mixed acting modes

of operation, and an S353 can be set for either direct or reverse operation.

Relay Time Constant

A relay time constant, the time lag between any increase or decrease in the signal from the controller and the corresponding output response to 2/3 of the input signal change, can be selected to allow a time delay between stages if short cycling of the electrical loads is unsuitable for the application. A circuit board jumper on the R353 (Figure 3) allows selection of one of four delay time constants: <1, 40, 70, and 110 seconds. The <1 second, or minimum delay time, can be used in situations where very fast response is required.

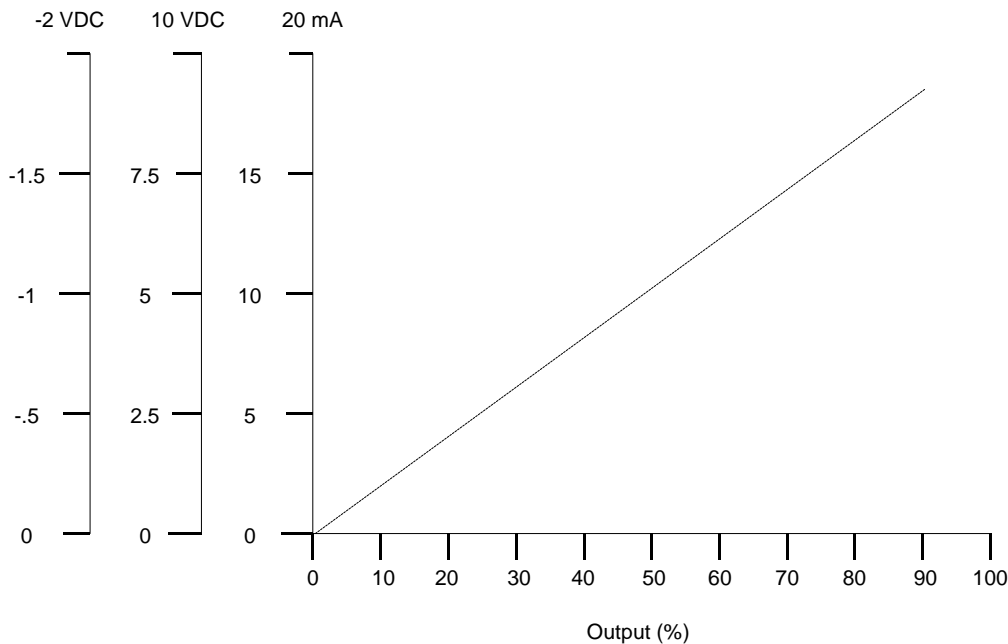


Figure 2: R353 Signal Output for Different Controller Inputs

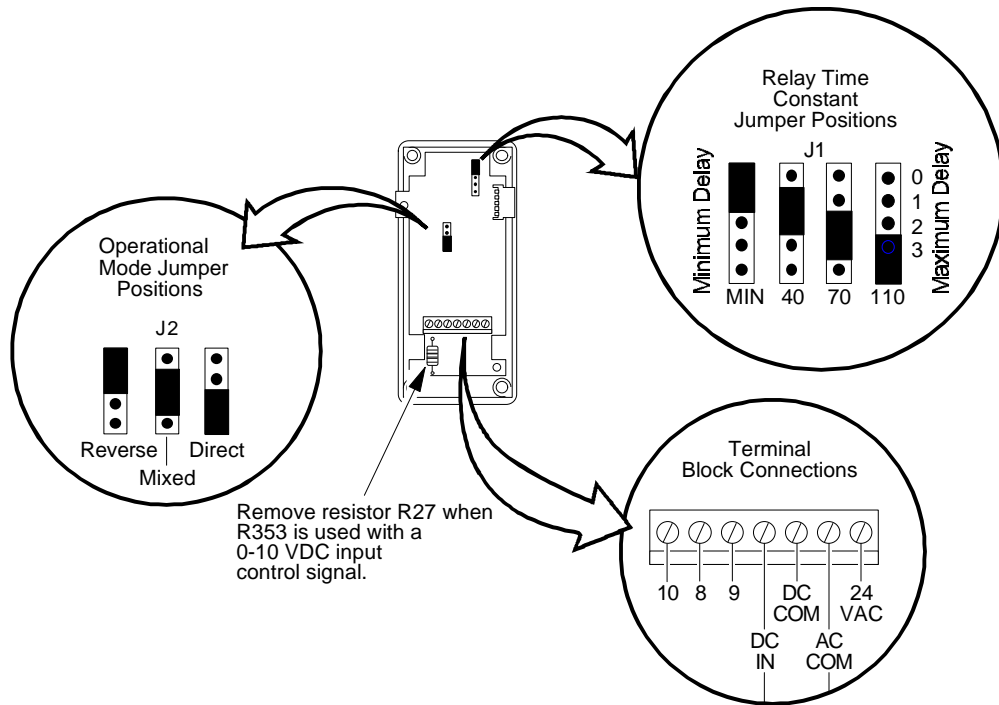


Figure 3: R353 Circuit Board

Offset

Offset is the point at which the S353 relay deenergizes. An offset potentiometer located on the S353 circuit board (Figure 4) can be adjusted from 0 to 75% of the R353 input range.

Differential

Differential is the difference between when the S353 relay is energized and when the relay is de-energized. The differential potentiometer (Figure 4) on the S353 circuit board allows for a differential adjustment of between 1 and 7% of the R353 input range.

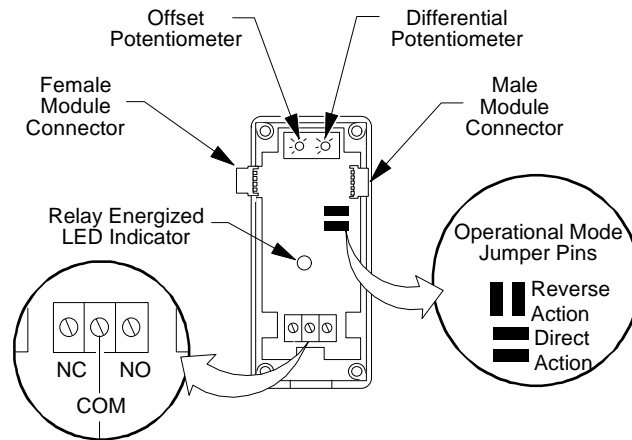


Figure 4: S353 Circuit Board

Power for the R353 and five S353s can be provided by either a Y350R Power Supply Module or an external 24 VAC Class 2 transformer. Applications with more than five S353 modules require an external 24 VAC Class 2 transformer with a 40 VA or greater rating (such as our Y65 series). The Y350R can be plugged into the R353 or any of the S353 modules.

The R353 and S353 modules are housed in compact, NEMA 1 plastic enclosures with 5-pin connectors, which eliminate wiring between the modules. Both the R353 and S353 can be snapped onto a standard 35mm DIN rail or mounted on a surface using the four key-hole slots on the back of the modules.

IMPORTANT: R353 and S353 modules are designed for use only as operating controls. Where an operating control failure would result in personal injury and/or loss of property, it is the responsibility of the installer to add devices (safety, limit controls) that protect against, or systems (alarm, supervisory systems) that warn of control failure.

Application Overview

The R353 is designed to be compatible with 0 to 10 VDC and 0 to 20 mA control systems, 135 to 10,000 ohm slidewire control systems and Johnson Controls R93 and R94 Temperature Controllers. This feature makes the R353/S353 a direct replacement for the Penn/Johnson R23 Actrol Sequencer in addition to being compatible with many other systems. The R353 will drive up to ten S353 staging modules to provide multistage control in temperature, pressure, humidity, and other HVAC/R applications.

Typical applications for the R353/S353 Sequencer include:

- electric boiler heating element staging
- boiler staging
- refrigeration and air conditioning capacity control
- multistage combination heating and cooling systems
- heat pumps
- multistage fan systems for farm and industry
- heat recovery systems

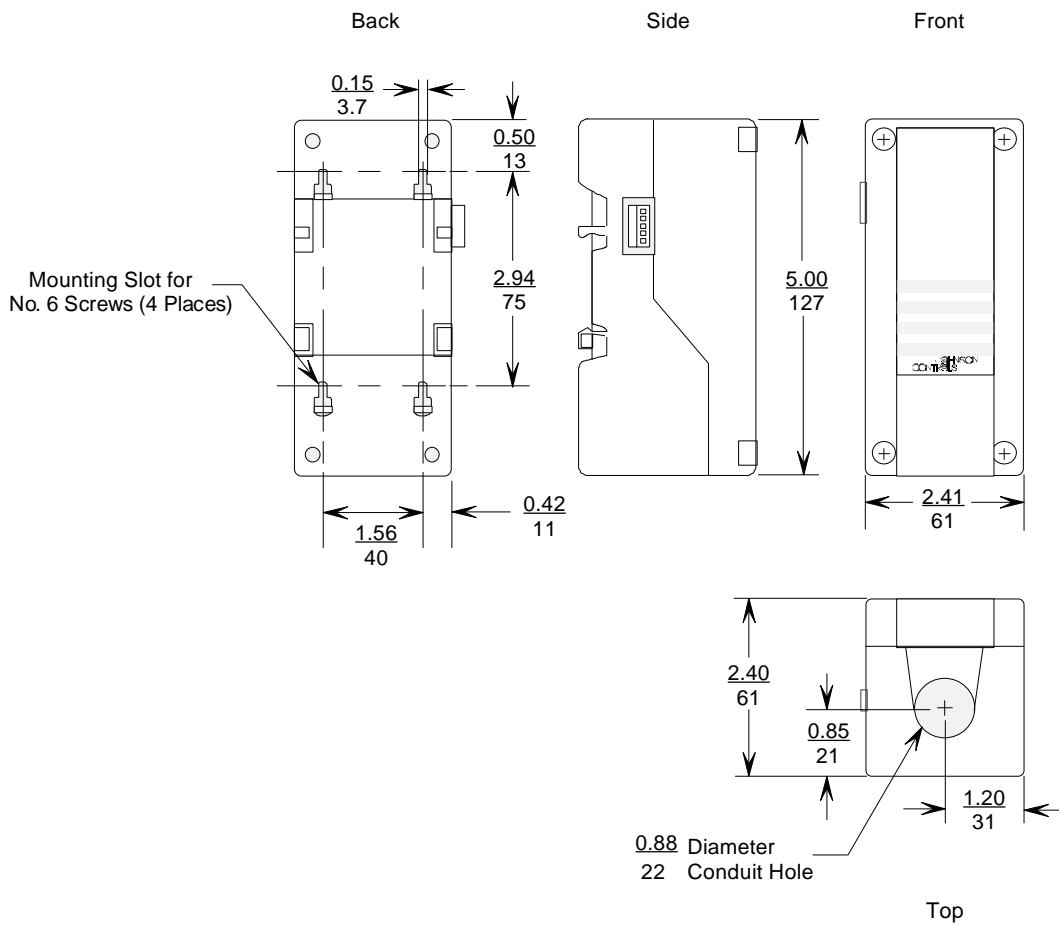



Figure 5: Dimensions of the R353 or S353 Module (in./mm)

Installation and Wiring

1. Mount the R353 and S353 modules on a standard 35 mm DIN rail or a surface using the four keyhole mounting slots on the back of the control cases and four No. 6 screws (not included). The R353 and S353 snap together at the plug-in connectors located on the modules' sides. The modules are not position sensitive but should be mounted so they can be easily wired and adjusted with the R353 module at the left-most position.

Note: When mounting the R353 and S353 (or any System 350 module) to rigid conduit, attach the hub to the conduit before securing the hub to the control enclosure.



WARNING: Shock Hazard Disconnect power supply before wiring connections are made to avoid possible electrical shock or damage to equipment.

2. Remove the covers from the modules by loosening the four captive cover screws.
3. Route the wires from the controller to the R353 module through the conduit hole in the housing. Wire to the terminal block located on the circuit board. Refer to Figures 11 through 16 for wiring diagrams.

Notes: All wiring should conform to the National Electrical Code and local regulations.

When using a 0 to 10 VDC controller, cut and discard resistor R27, which is located below the terminal block (Figure 6).

4. On the R353, set the mode of operation (direct, reverse, or mixed) by positioning the operational mode jumper located in the center of the circuit board (Figure 6). The R353 is shipped from the factory in the direct acting mode.

Note: The mixed mode is required for any application that will require the S353 modules to perform direct and reverse acting sequencing from one proportional input signal.

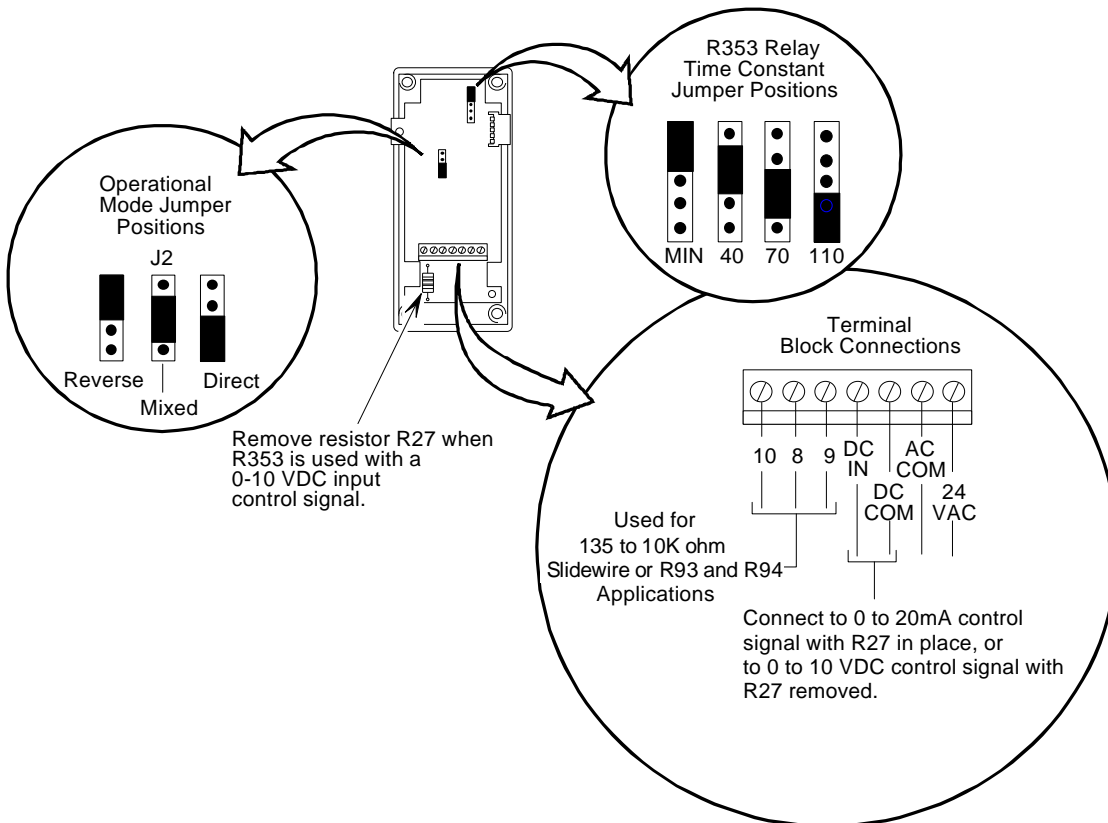


Figure 6: R353 Wiring Terminals and Jumper Selections

5. On the R353, set the relay time constant. The time constant represents the time lag between any increase

or decrease in the signal from the controller and the corresponding output response to 2/3 of the input

signal change. (This assumes the S353 offset adjustments are spaced evenly across the control band.) A jumper block is located on the right-side of the circuit board

(Figure 6) and can be positioned for <1 (minimum), 40, 70, or 110 seconds. The jumper is factory set in the <1 position.

6. Wire the S353 modules to the electrical load using the terminal block on the circuit board. When powered-up, the S353 LED will light when the relay is energized.

7. Set the S353 operational mode jumper pins located on the right side of the circuit board (Figure 7 and Table 1).

- If the R353 is in the direct mode-the S353 modules **must** be set in the direct mode and will energize the electrical loads as the input signal increases.
- If the R353 is set in the reverse mode-the S353 modules **must** be set in the reverse mode and will energize the electrical loads as the input signal decreases.

- If the R353 is set in the mixed mode-the S353s can be set in any combination of direct and reverse modes. In the mixed mode, input signals greater than 50% of the R353 input range will energize S353 modules set in the direct mode, and input signals less than 50% will energize S353 modules set in the reverse mode.

8. Set the offset adjustment at the potentiometer located at the top of the S353 board marked OFFSET. The offset is the point at which an S353 module will de-energize and is adjustable from 0 to 75% (0 to 50% for mixed modes) of the R353 input range (Table 1 and Figures 8 and 9).

Notes: There is a 10% fixed minimum offset of the R353 output range that cannot be used in the direct and reverse modes (Table 1 and Figure 10).

In the mixed mode the sum of the offset adjustment and differential cannot be more than 50%.

9. Adjust the differential using the potentiometer located at the top of the S353 board marked DIFF. The differential is the difference between where the S353 module energizes (turns on) and de-energizes (turns off) and is adjustable from 1 to 7% of the R353 input range.

10. Replace the covers on the modules.

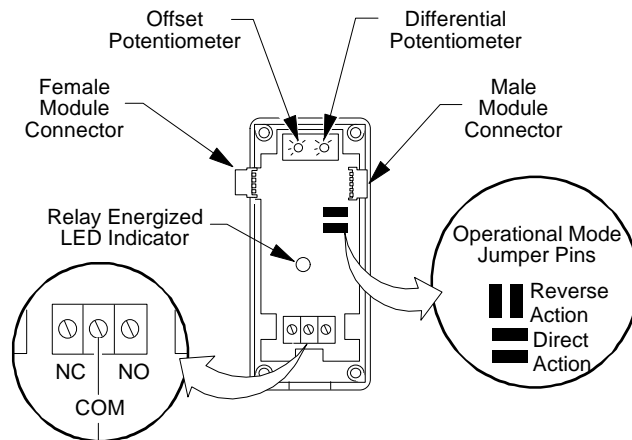


Figure 7: S353 Wiring Designations and Jumper Selections

Table 1: S353 Adjustments Calculation

Mode of Operation		Offset Adjustment		Differential Adjustment		Notes				
❶ Depending on the mode of the R353 module (left column), select the S353 mode of operation (right column).		❷ Select the point (X) where the S353 will de-energize.		❸ Calculate the offset adjustment (OFF). Note: The offset adjustment is from 0 to 75% of the R353 input range.		❹ Select the point (Y) where the S353 will energize.		❺ Calculate the differential adjustment (DIFF). Note: The differential adjustment is from 1 to 7% of the R353 input range.		
R353	S353									
Direct	Direct	X = 10 to 85 % of R353 input range	OFF = X - 10% Note: There is a built-in, 10% minimum offset.	Y must be 1 to 7% above X.	DIFF = Y - X				Refer to Figure 8.	
Mixed	Direct	X ≥ 50% of R353 input range	OFF = X - 50%	Y must be 1 to 7% above X.	DIFF = Y - X Note: OFF + DIFF ≤ 50%				Refer to Figure 10.	
Mixed	Reverse	X ≤ 50% of R353 input range	OFF = 50% - X	Y must be 1 to 7% below X.	DIFF = X - Y Note: OFF + DIFF ≤ 50%				Refer to Figure 10.	
Reverse	Reverse	X = 90 to 15% of R353 input range	OFF = 90% - X Note: There is a built-in, minimum offset of 10% (100 - 10% = 90%).	Y must be 1 to 7% below X.	DIFF = X - Y				Refer to Figure 9.	

Note: To use Table 1, follow the steps in sequence.

- Example: **❶** With the R353 in direct mode, the S353 must also be in the direct mode.
- ❷** If an S353 module should de-energize at 40% of the R353 input signal, then, X = 40%.
 - ❸** 40% - 10% (Built-in Minimum Offset) = 30% (Offset Adjustment)
 - ❹** If the S353 module should energize at 45%, then, Y = 45%.
 - ❺** 45%(Y) - 40%(X) = 5% (Differential Adjustment)

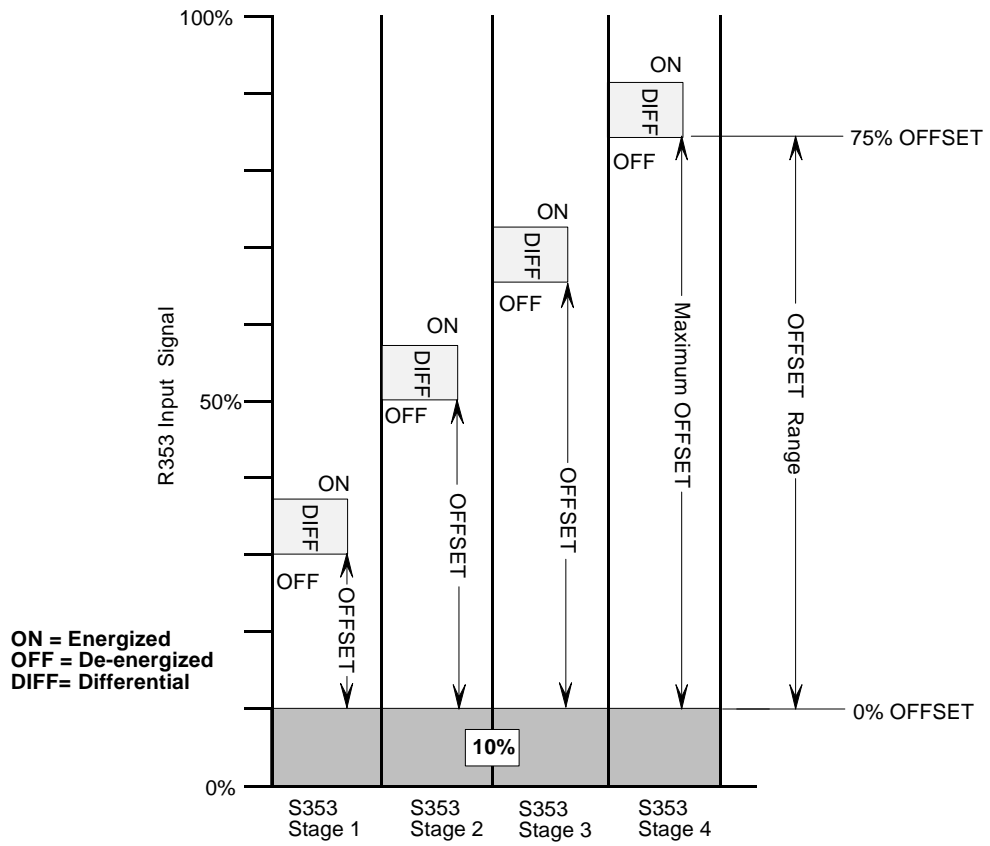


Figure 8: Four S353 Staging Modules Operating in Direct Acting Mode

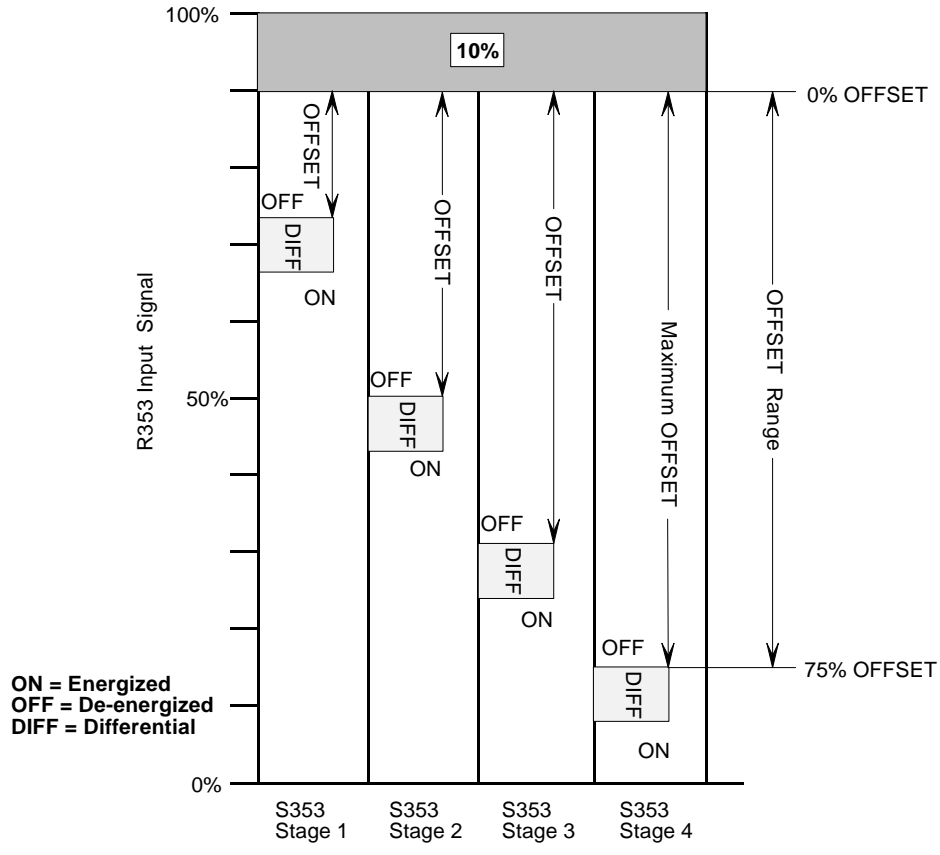


Figure 9: Four S353 Modules Operating in Reverse Acting Mode

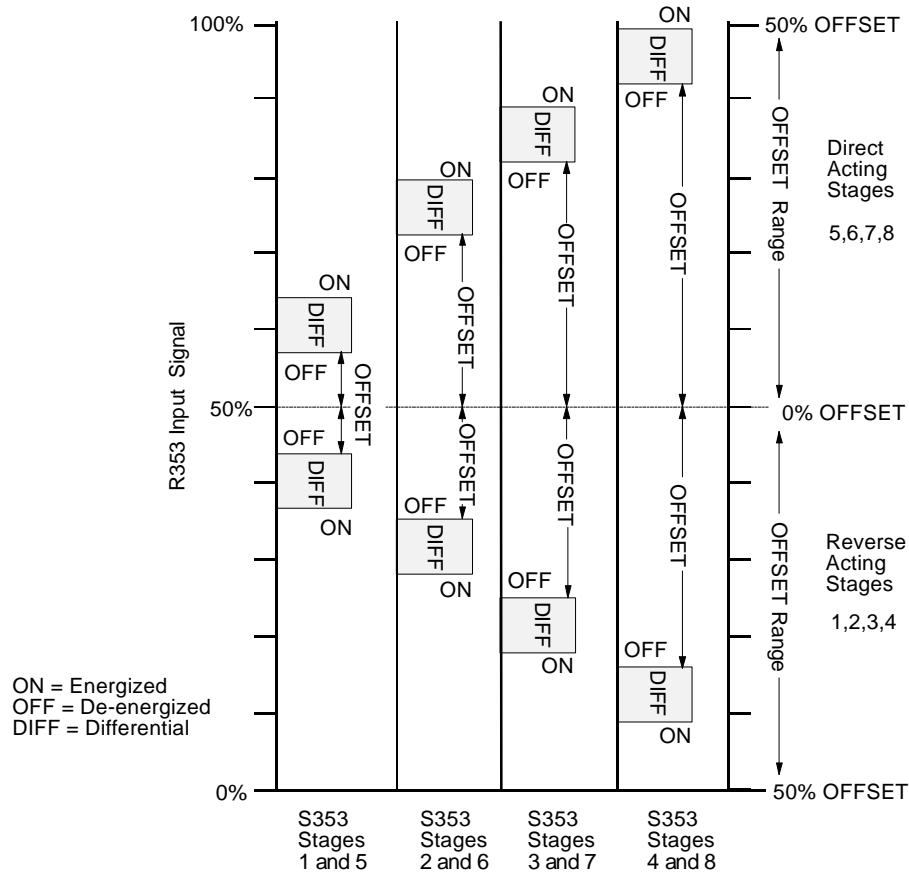


Figure 10: Eight S353 Modules with Four Operating in Direct Mode and Four Operating in Reverse Mode (The R353 is in the mixed mode.)

Checkout Procedure

Before applying power, make sure installation and wiring connections are according to job specifications.

After all necessary adjustments and electrical connections have been made, put the system in operation and observe at least three complete operating cycles before leaving the installation.

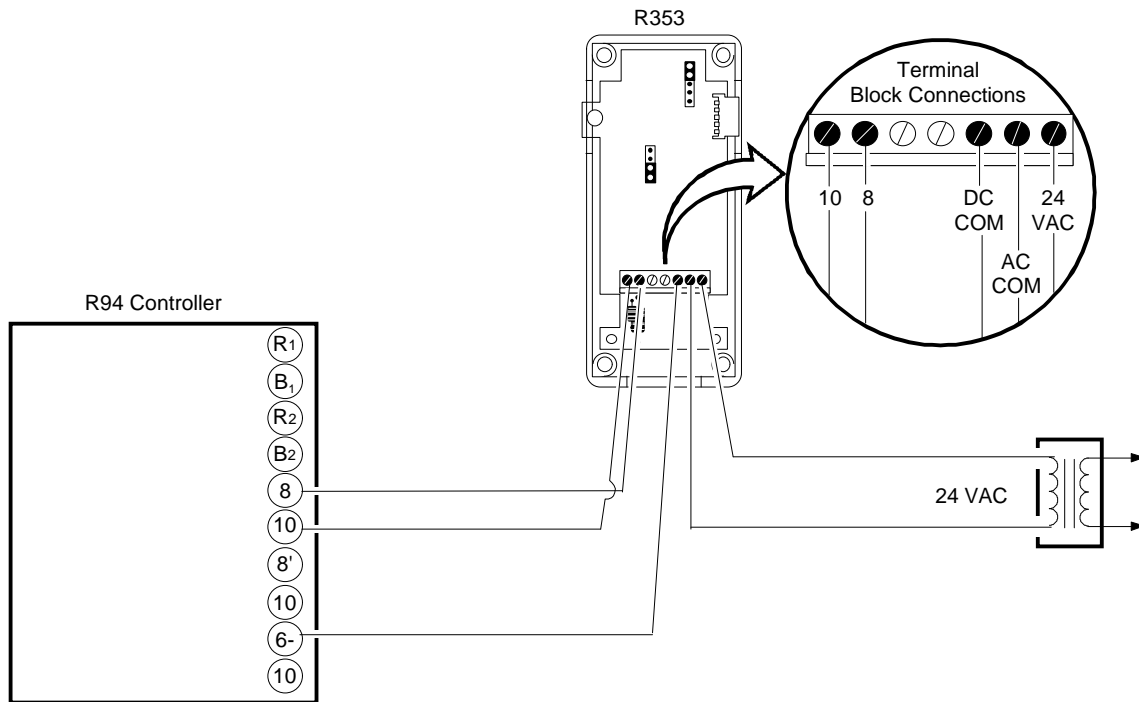


Figure 11: R353 Controlled by an R94 Controller

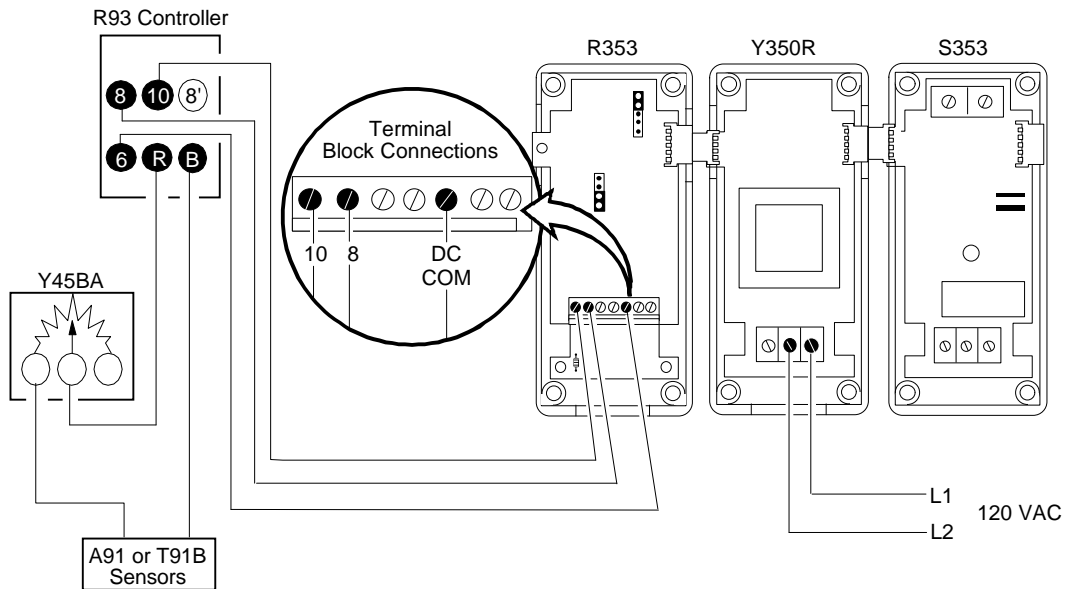


Figure 12: R353 Controlled by an R93 and Powered by a Y350R

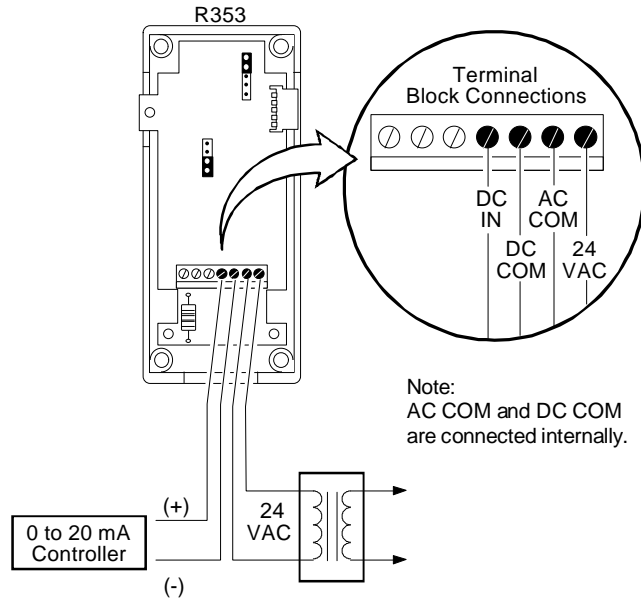
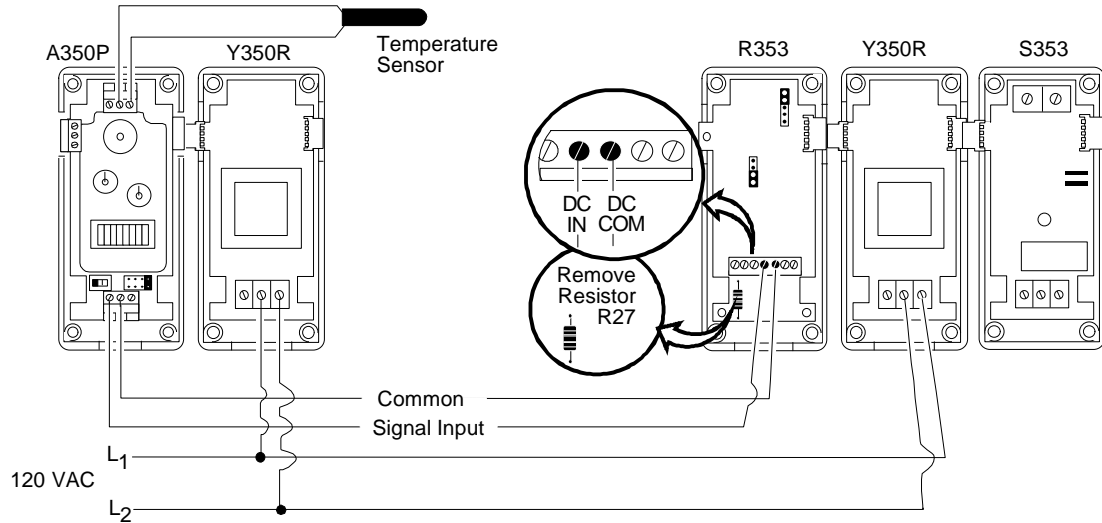


Figure 13: R353 Controlled by a 0 to 20 mA Controller



**Figure 14: R353 Controlled by the 0 to 10 VDC Output of an A350P
(Each unit is powered by a Y350R Power Module.)**

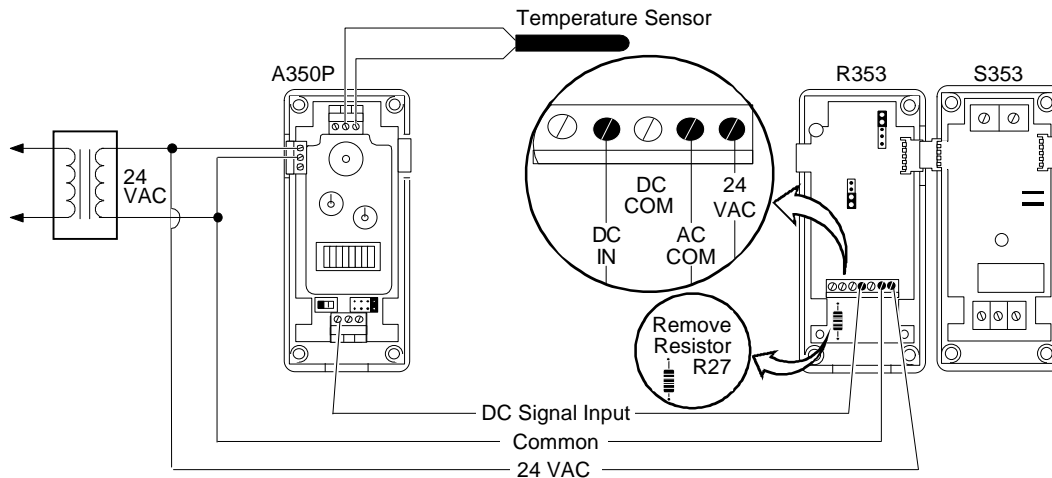


Figure 15: R353 controlled by an A350P
 (Both units are powered by a common transformer.)

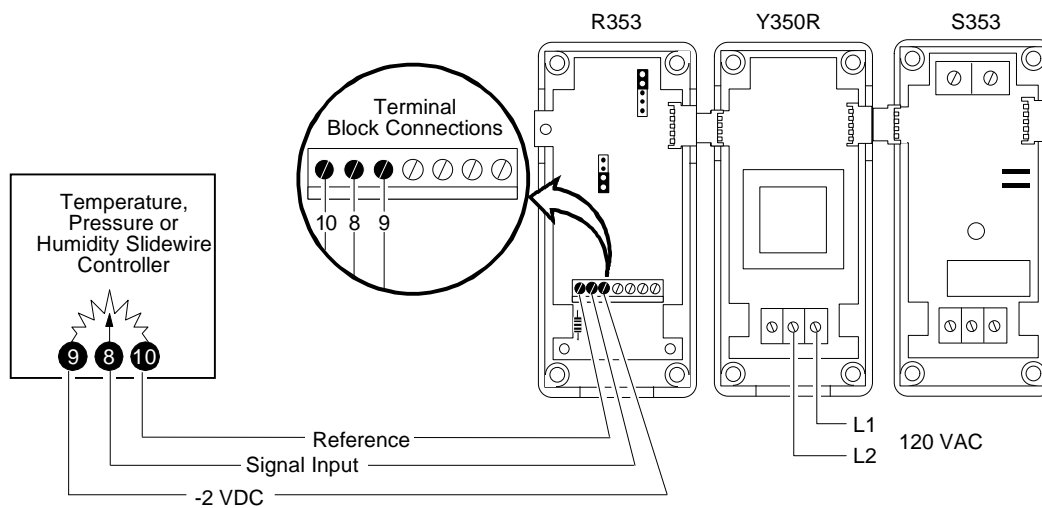


Figure 16: R353 Controlled by a Potentiometer Controller

Repairs and Replacement

Field repairs cannot be made. For a replacement R353 or S353, contact the nearest Johnson Controls distributor or branch office.

Ordering Information

Item	Product Code	Description
Electronic Sequencer R353 Module	R353AA-1C	Signal Input Module
Electronic Sequencer S353 Module	S353AA-1C	Staging Module
Power Module	Y350R-1C	Rectified 24 VAC from 120/240 VAC Source
DIN Rail Sections	BKT287-1R	35 x 7.5 mm, 0.305 m (12 in. long)
	BKT287-2R	35 x 7.5 mm, 0.904 m (36 in. long)
DIN Rail End Clamps	PLT344-1R	Package of Two End Clamps
Cable for Remote Mounting	WHA29A-600R *	3 ft (0.9 m)

* WHA29A-600R can also be used to daisy chain S353 Stage Modules together.

Specifications

Product	R353/S353	Modular Electronic Sequencer	
Case Material		High Impact Thermoplastic	
Supply Voltage	R353 S353	20 to 30 VAC 50/60 Hz, Class 2 Provided by R353	
Power Consumption	R353 S353	1 VA Maximum 1.25 VA Maximum	
Input Impedance	R353	0 to 10 VDC Input:	27 K ohms * (20 VDC Maximum)
		0 to 20 mA Input:	500 ohms
Temperature	R353/S353	Operating:	-40 to 150°F (-40 to 66°C)
		Shipping:	-40 to 185°F (-40 to 85°C)
Humidity	R353/S353	0 to 95% RH Non-condensing, 85°F Maximum Dew Point	
Relay Time Constant	R353	<1, 40, 70, 110 Second Time Constant (Factory Shipped at <1 Jumper Setting)	
Differential Range	S353	1 to 7% of the Input Signal Range	
Offset Range	S353	0 to 75% of the Input Signal Range	
Relay	S353	Single-Pole, Double-Throw (SPDT) Enclosed Relay	
Contact Ratings	S353	120 VAC	208/240 VAC
		Full load Amps	9.8 4.9
		Locked Rotor Amps	58.8 29.4
		10 Amps Non-inductive at 24/240 VAC	
		Pilot Duty 125 VA at 24/240 VAC	
Wiring	R353 S353	16 to 22 AWG Copper Conductor 14 AWG Maximum Copper Conductor	
Agency Listings	UL Guide No. XAPX File E6688; CSA Class No. 4813 02 File LR948		

* If resistor R27 is not clipped, the input impedance is 500 ohms. A voltage controller may still be able to drive the sequencer, but the current requirement will be 20 mA at 10 VDC.

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, consult the local Johnson Controls office. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.



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