M100E Economizer Series Motor Actuator with R81EAA-3 Interface Board for Nickel Sensor Applications

The M100E Series Economizer Motor Actuators are used to control outdoor air, return air, and exhaust air dampers to maintain the M100E mixed air temperature setpoint. The R81EAA-3 electronics within the motor actuator allow economical use of outdoor air for natural or free cooling and reduce energy consumption by minimizing the compressor runtime.

The M100E Economizer Actuator has changeover and refrigeration programming relays, and minimum position, mixed air setpoint, mixed air proportional band, and actuator travel adjustments.

The internal changeover relay and refrigeration programming relay can be wired in various ways that provide control sequences utilizing available natural cooling. For these cooling options, use the M100E with A19 or A319 Temperature Controls (sensible changeover) or an enthalpy changeover control.

The R81EAA-3 is compatible with resistance type sensors. Use TE-6000, TE-631X, or 1000-ohm nickel duct averaging sensors for direct mixed air control or TE-641X Nickel Temperature Sensors for ventilation only systems.

Figure 1: M100E Series Motor Actuator

Features and Benefits	
☐ **Output Versatility**	Allows linkage connections on both ends of output shaft for dampers and full power in both directions
☐ **Load Versatility**	Available in torques of 25, 35, 50, 75, and 150 lb·in
☐ **Top Cover Mounted Circuit Board**	Provides adjustment of proportional band and minimum position potentiometers without removing the cover
☐ **R81 Plug-in Electronic Interface Boards**	Allows faster installation or conversions and when necessary, shorter service times; reduces inventory
☐ **Special Oil Mixture in Gear Case**	Provides the longest life cycle cost/benefits in the industry

Part No. 34-636-216, Rev. B

Theory of Operation

The following is a description of how the M100E accomplishes greater energy savings than non-economizer actuators.

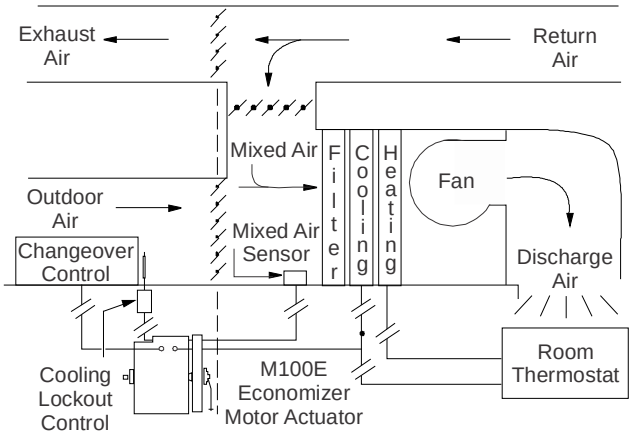

Figure 2: Typical Installation Flow Diagram

When outdoor air can provide natural or free cooling, the first stage of cooling enables control of outdoor air dampers. When outdoor air is not available for cooling (as determined by changeover control), the mechanical cooling stages are enabled.

When the outdoor air parameters are below the changeover control setpoint, the changeover control contacts will close, energizing the changeover relay. On a call for cooling from the room thermostat, the motor actuator is modulated to maintain the mixed air setpoint. Should the outdoor air parameters rise too high for natural cooling, the contacts of the changeover control will open. The changeover relay will then de-energize, and the motor actuator will return to its minimum position, which will position the outdoor air dampers for minimum ventilation.

The refrigeration programming relay is used when two stages of cooling are needed. When outside conditions are low enough for natural cooling, the outside air changeover control energizes the refrigeration programming relay, which switches the first stage of cooling to outside air and the second stage of cooling becomes the first stage of mechanical cooling.

Control Input

M100E Series Motor Actuators receive their input commands from a staged room thermostat and/or remote temperature sensor for accurate positioning of the output shaft.

Other inputs include:

- on-off command for changeover
- on-off command for cooling lockout
- 1000-ohm nickel temperature sensor input
- remote minimum position input
- remote setpoint potentiometer

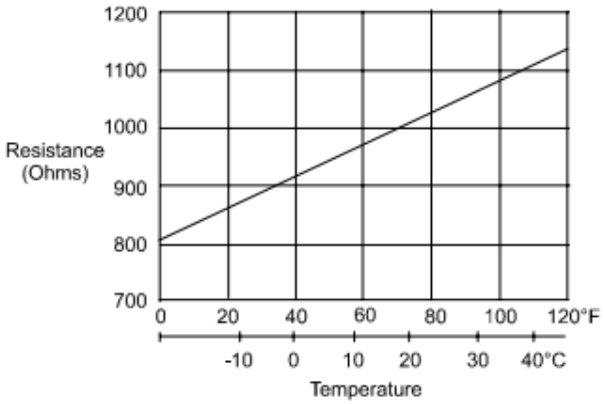

Figure 3: Nickel Sensor Characteristics

Direction of Rotation

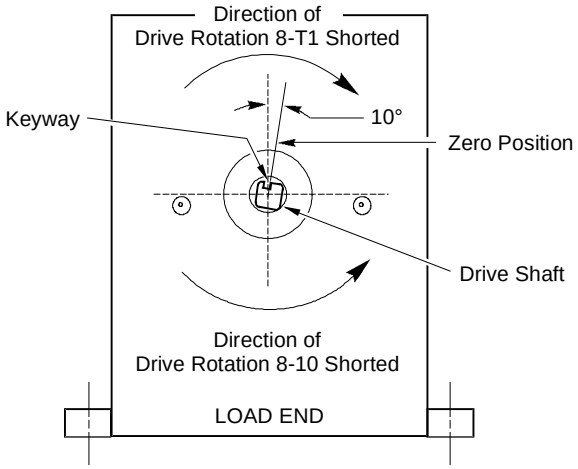

Figure 4: Direction of Rotation

All reference to the direction of rotation is when viewing the load end as stamped on the actuator housing shown in Figure 4. From this view, the Counterclockwise (CCW) limit is the zero position. The actuators are factory set and shipped at the zero position, which is 10 degrees Clockwise (CW) from vertical, allowing 90 degrees of CW travel. (See Figure 4.)

Note: Direction of rotation is CW with temperature increase. Spring return models always return CCW to the zero position when power is removed.

Dimensions

Figure 5 shows the dimensions for a standard M100E Series Spring Return Motor Actuator. Allow additional space for options such as a switch kit. (See Figure 6.) Figure 7 shows the dimensions for a weather-resistant cover.

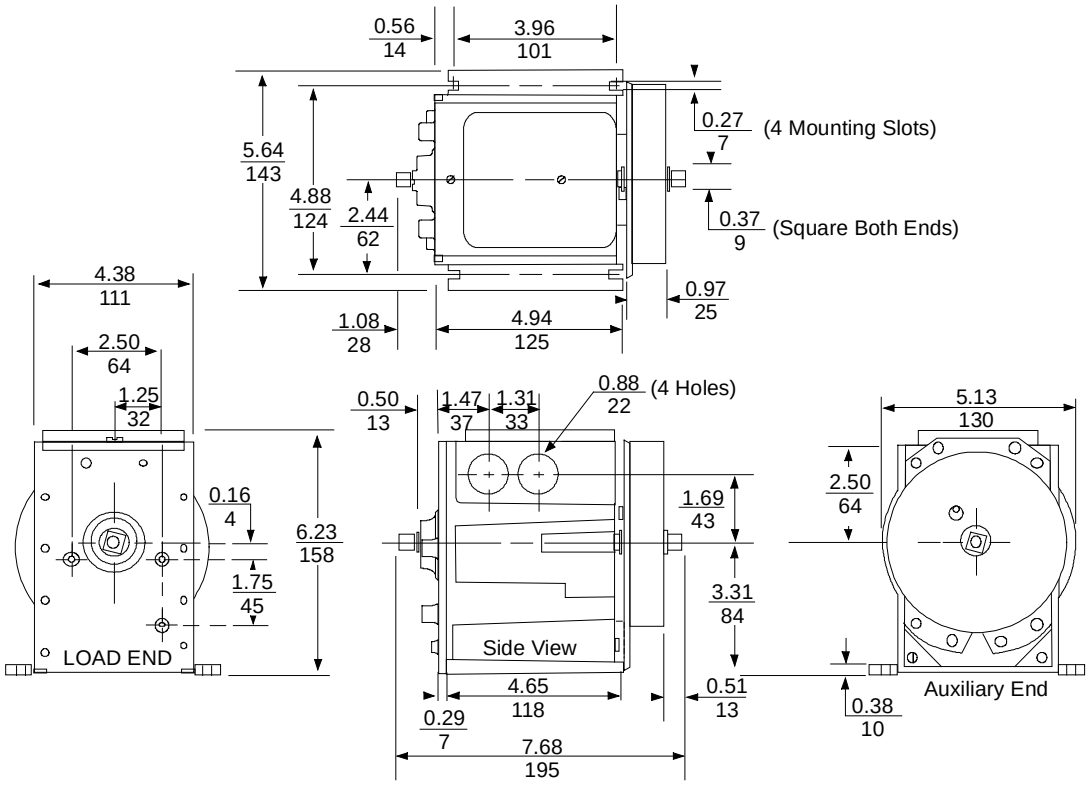

Figure 5: M100E with Spring Return Dimensions, in./mm

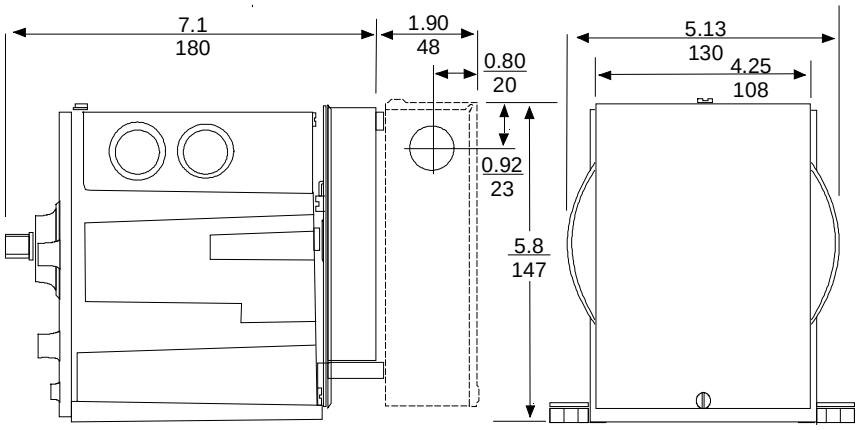

Figure 6: Spring Return with Switch Kit Dimensions, in./mm

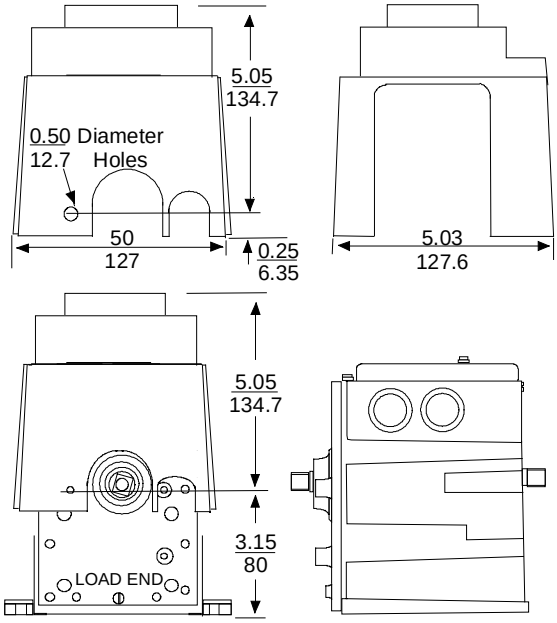

Figure 7: CVR83A-600R Dimensions, in./mm

Installation Procedures

Parts Included

When ordering an M130E Series Motor Actuator, the following parts are included:

- economizer, spring return motor actuator
- LVR27A-602 crank arm

When ordering an R81EAA-3 Interface Board Kit, the following parts are included:

- top cover electronics assembly
- terminal board
- insulating barrier
- two No. 6-32 x 5/16 in. self-tapping Phillips-head recess screws

Note: An R81EAA-3 can be used with an M100X Motor Actuator. (See *Table 2: Ordering Information*.)

Tools Needed

- screwdriver, Phillips-head (No. 2 tip)
- screwdriver, flat-blade, 1/8 in. tip

Precautions and Code Requirements

IMPORTANT: Use this M100 Series Motor Actuator only to control equipment under normal operating conditions. Where failure or malfunction of the motor actuator could lead to personal injury or property damage to the controlled equipment or other property, additional precautions must be designed into the control system. Incorporate and maintain other devices, such as supervisory or alarm systems or safety or limit controls, intended to warn or protect against failure or malfunction of the motor actuator.

IMPORTANT : Utiliser ce M100 Series Motor Actuator uniquement pour commander des équipements dans des conditions normales de fonctionnement. Lorsqu'une défaillance ou un dysfonctionnement du motor actuator risque de provoquer des blessures ou d'endommager l'équipement contrôlé ou un autre équipement, la conception du système de contrôle doit intégrer des dispositifs de protection supplémentaires. Veiller dans ce cas à intégrer de façon permanente d'autres dispositifs, tels que des systèmes de supervision ou d'alarme, ou des dispositifs de sécurité ou de limitation, ayant une fonction d'avertissement ou de protection en cas de défaillance ou de dysfonctionnement du motor actuator.

- Follow National Electric Code (NEC) and local electrical codes.
- Disconnect all power supplies.
- Do not install the motor actuator in atmospheres with explosive vapors or escaping gases, or where vapors having deteriorating properties might attack the actuator’s metal parts.
- Seal wiring into return air systems to prevent entry of corrosive air into the actuator.

Mounting

Observe the following recommendations when mounting:

- Mount the motor actuator upright.
- Locate the motor actuator where the shaft and wiring terminals are accessible.

To mount the motor actuator:

1. Follow installation procedures for the linkage kit used to couple the motor actuator and the controlled device.

Note: When not utilizing a damper linkage kit, use four 1/4 x 1 in. bolts for mounting the actuator.

2. Connect control and 24 VAC wiring as described in the *Wiring* section.
3. Perform travel and calibration adjustments as described in the *Adjustments* section.

R81E Installation

M100X Base Motor Actuators are provided with no circuit boards mounted within the unit. Remove the top cover and proceed to *Installing Boards*. To replace the electronic circuit boards in an existing Series M100E motor actuator, proceed as follows:

Removing Boards

WARNING: Risk of Electric Shock.
Disconnect all electric power sources from the electric power supply before remnoving the wiring connection and boards. Contact with internal components carrying hazardous voltage can cause electric shock and may result in severe personal injury or death.

ADVERTISSMENT : Risque de décharge électrique. Déconnecter toutes les sources d'alimentation électrique de l'electric power supply avant de déposerle board de l'wiring connection. Tout contact avec des composants internes conducteurs de tensions dangereuses risque d'entraîner une décharge électrique et de provoquer des blessures graves, voire mortelles.

To remove the vertical board and terminal board:

1. Remove the motor actuator's top cover by loosening the two cover screws. The old cover will be replaced by the new cover furnished.
2. Verify that power is removed from the unit and disconnect all wiring connections to the terminal board.
3. Loosen the bracket screw and remove the bracket.
4. Pull the vertical board straight upward. Be careful not to bend or damage the pin terminals.
5. Remove the two screws from the terminal board.
6. Remove the terminal board by grasping the receptacles and lifting straight upward. Be careful not to bend or damage the pin terminals.

Installing Boards

To install the vertical board and terminal board:

1. Install the insulating barrier into the wiring compartment so that all metal surfaces are covered.
2. Install the terminal board by carefully placing the terminal receptacles onto the pin terminals. (See Figure 8.)
3. Fasten the board in place using the No. 6-32 x 5/16 in. Phillips-head terminal board screws that are supplied with the R81 kit.

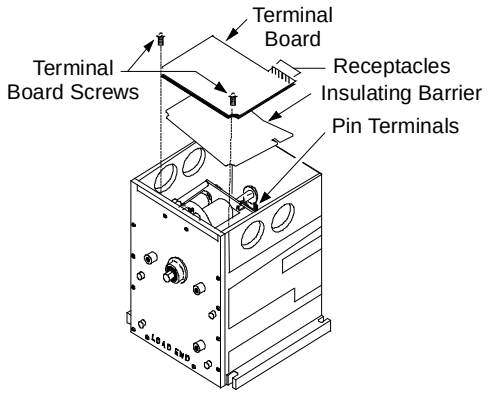

Figure 8: Installing Terminal Board

4. Install the vertical board with ribbon attached cover mounted board by carefully placing the terminal receptacles onto the two sets of pin terminals. (See Figure 9.)

Note: Align all pins within the receptacle.

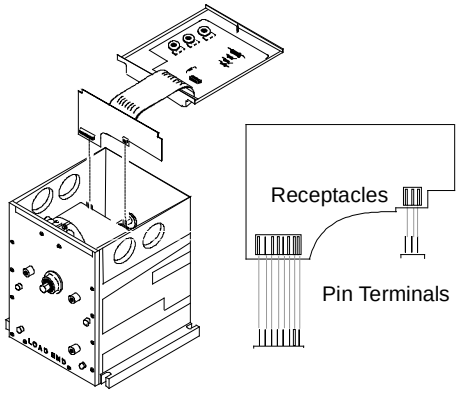

Figure 9: Installing Vertical Board

5. Place the bracket, supplied with the motor actuator, over the vertical board and fasten the bracket in place with captive screw. (See Figure 10.)

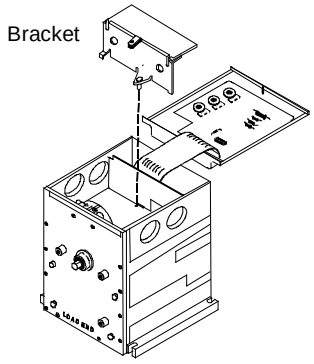

Figure 10: Installing Bracket

6. Install the adhesive backed label supplied in the R81 kit.

IMPORTANT: As shown in Figure 11, locate the label on the insulation barrier. The letter on the R81 label will complete the number that identifies the Series M100 with the R81 installed.

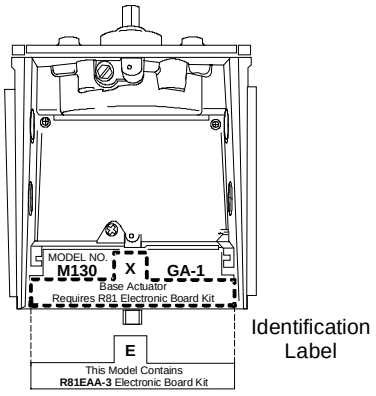

Figure 11: Installing Identification Label

Wiring

WARNING: Risk of Electric Shock.
Disconnect the power supply before making electrical connections. Contact with components carrying hazardous voltage can cause electric shock and may result in severe personal injury or death

ADVERTISSEMENT : Rique de décharge électrique.
Débrancher l'alimentation avant de réaliser tout branchement électrique. Tout contact avec des composants conducteurs de tensions dangereuses risque d'entraîner une décharge électrique et de provoquer des blessures graves, voire mortelles.

Make all wiring connections using copper conductors only. Wire in accordance with NEC and local regulations.

Make all splices in junction boxes using approved solderless connectors, or by soldering and then taping the connections. Locate all splicing and excess wiring outside the motor actuator wiring compartment. If desired, add a standard electrical box to the wiring compartment of the motor actuator. (See Figure 12.)

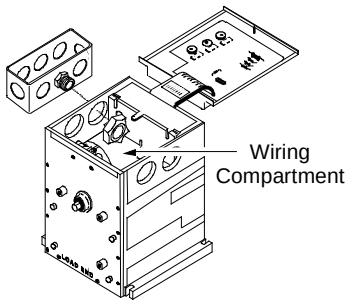

Figure 12: Wiring Junction Box Attached to M100E

The M100E does not require shielded cable on runs shorter than 50 ft/15m. Avoid running low voltage sensor wiring in the same conduit as line voltage wiring, 24 VAC wiring, or other conductors that supply highly inductive loads (contactors, coils, motors, generators, etc.).

Use shielded cable if the control wiring is longer than 50 ft/15m, run in a common conduit, or located near inductive loads. Use 22 AWG, Beldfoil 8761 or equivalent for runs up to 250 ft/76m. For 250 ft/76m to 500 ft/152m runs, use 18 AWG Beldfoil 8760 or equivalent. Connect the shield only at Terminal T1 (common). Do not connect shield to any other point.

To connect the wiring:

1. Loosen the two screws securing the top cover and remove the top cover for access to the wiring terminals.
2. Use a hammer and punch to drive out one of the access hole plugs.
3. Install the conduit connector to the motor actuator and secure using the conduit nut provided with the connector.
4. Connect the sensor and control wiring as appropriate for the application. (See Table 1.)
5. Connect 24 VAC to Terminals T1 and T2.

Note: To avoid potential miswiring or control signal problems, use separate transformers on each M100.

Table 1: Wiring Terminals

Terminal	Description	
T1	Power Common	
T2	24 VAC Power	
S1	1000-ohm Nickel Sensor	
S2	1000-ohm Nickel Sensor	
A	Changeover Relay Coil (24 VAC)	
B	Refrigeration Programming Relay Coil (24 VAC)	
C	Relay Coil Common	
X	Do Not Connect	
8	Remote	Slave Actuator
9	Minimum	Not Used
10	Position	Slave Actuator
Refrigeration Programming Relay Contacts		
B1	NO	
B2	COM	
B3	NC	

Note: The changeover relay contacts are internally connected to the circuit.

Figure 13 shows a typical wiring configuration.

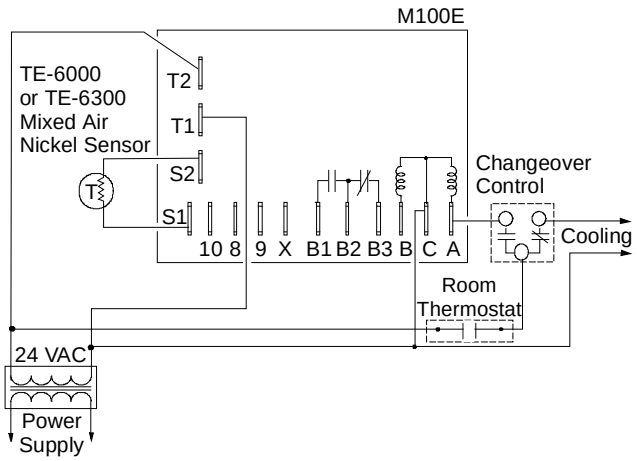

Figure 13: Single-stage Cooling

Adjustments

Travel

The rotational travel is field adjustable from 65 to 270 degrees rotation by turning the travel adjustment potentiometer located on the R81E terminal board. (See Figure 14.) Changing the travel adjustment affects the CW limit of the actuator's rotation.

1. Apply 24 VAC to Terminals T1 (common) and T2.
2. Run the motor actuator to its CW limit by jumpering Terminals 8 and T1.
3. Turn the adjustment potentiometer CW to increase the travel, and CCW to decrease the travel.
4. For further information on travel adjustment, refer to the damper linkage instruction sheet.

Setpoint

An internal setpoint adjustment for the remote sensor is located on the R81E terminal board and has a calibrated dial adjustable from 40 to 90°F/5 to 30°C. (See Figure 14.) When a remote setpoint control is used, turn the R81E setpoint knob CCW to its limit at the low temperature end of the dial in order to adjust the setpoint from the remote location.

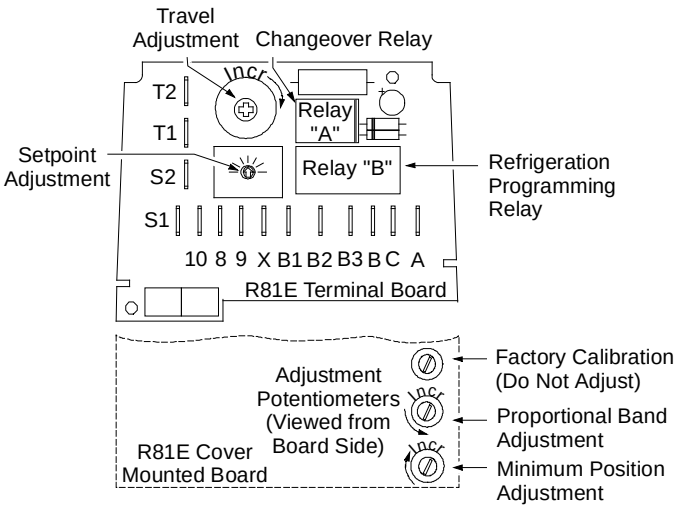

Figure 14: Adjustment Potentiometers

Figure 16: Top Cover Adjustment Access for Proportional Band and Minimum Position

Proportional Band

The proportional band adjustment controls the amount of change in the sensor temperature that is required to drive the actuator between zero position and full stroke. The proportional band is adjustable to a minimum of 6F°/3.3C°.

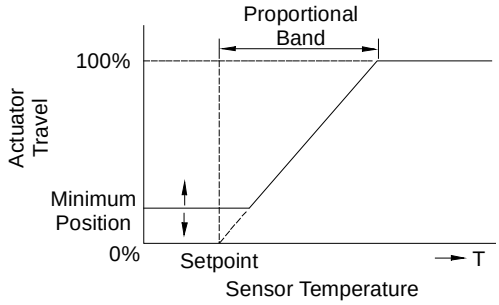

Figure 15: Proportional Band

The proportional band adjustment potentiometer is located on the cover mounted circuit board as shown in Figure 14, and is accessible without removing the cover by removing its corresponding plug. (See Figure 16.) To increase the proportional band, turn the potentiometer CW through the cover, or CCW from the board side.

IMPORTANT: While narrowing the proportional band is usually desirable, too narrow a proportional band may result in poor control. Increase the proportional band if the motor actuator cannot maintain a stable position when the system is operating. Instability causes the motor actuator to oscillate (hunt).

Minimum Position

The minimum position adjustment controls the CCW travel limit that the actuator will drive to when powered. The minimum position is CW from the zero position. When power is removed, the actuator will spring return to the zero position. (See Figure 4.) The minimum position is adjustable between 0 and 70% of full travel, and is affected by the full travel adjustment. Set the minimum position after linkage and full travel adjustments are complete.

The minimum position potentiometer is located on the cover mounted circuit board (Figure 14) and is accessible without removing the cover by removing its corresponding plug. (See Figure 16.) To increase the minimum position, turn the potentiometer CCW through the cover or CW from the board side.

Manual Override

Use the following procedures to manually override the motor actuator. Refer to Figure 14 for terminal locations.

> **IMPORTANT:** This procedure is for checkout of the actuator only, and not for continuous operation. Ensure that overriding the actuator will not damage the system or components connected to the actuator.

1. Disconnect all inputs before manually overriding the actuator.
2. With 24 VAC applied to Terminals T1 (common) and T2:
   - Jumper Terminals T1 and 8 to drive the motor actuator in the CW direction to the full travel limit.
   - Jumper Terminals 8 and 10 to drive the motor actuator in the CCW direction to Zero Reference position.
3. With 24 VAC applied to Terminals T1 (common) and T2, and with 24 VAC applied to Terminals A and C (common), which energizes the changeover relay:
   - Open sensor Terminal S1 or S2 to drive the motor actuator in the CW direction to full travel limit.
   - Jumper sensor Terminals S1 and S2 to drive the motor actuator in the CCW direction to minimum position.
4. Restore all original connections.

Checkout Procedure

Changeover Relay "A"

1. Apply 24 VAC to Terminals T1 (common) and T2.
2. Turn the minimum position potentiometer full CCW from the board side of the cover or CW through the cover.
3. Energize the changeover relay by applying 24 VAC between Terminals A and C (common). This simulates the availability of outside air for natural cooling.
4. Adjust the setpoint to approximately midrange, 65°F/18°C.
5. Open sensor Terminal S2, which will simulate a rise in mixed air temperature. The motor actuator will rotate CW and the outdoor air dampers willopen.
6. Jumper sensor Terminals S1 and S2. This now simulates a drop in mixed air temperature. The motor actuator will rotate CCW and the outdoor air dampers will close.
7. Restore all original connections and settings.

Minimum Position

1. Apply 24 VAC to Terminals T1 (common) and T2.
2. De-energize the changeover relay by removing power from Terminals A and C. This simulates that outside air is no longer available for natural cooling.
3. Turn the minimum position potentiometer CW (board side), or CCW (through cover), to increase the minimum position. The motor actuator will rotate CW and the outdoor air damper minimum position will increase.
4. Turn the minimum position potentiometer CCW (board side) or CW (through cover) to decrease the minimum position. The motor actuator will rotate CCW and the outdoor air damper minimum position will decrease.
5. Restore all original connections and settings.

Refrigeration Relay "B"

1. Remove connections from Terminals B, B1, B2, and B3.
2. Apply 24 VAC between Terminals B2 and C.
3. Use an AC voltmeter to verify that there is 24 VAC across Terminals B3 and C, and 0 VAC across Terminals B1 and C.
4. Energize the refrigeration programming relay by applying 24 VAC between Terminals B and C.
5. Use an AC voltmeter to verify that there is 24 VAC across Terminals B1 and C, and 0 VAC across Terminals B3 and C.
6. Remove the 24 VAC from Terminals B2 and C, and from Terminals B and C.
7. Restore all original connections.

Troubleshooting

To troubleshoot the M100:

1. Verify that the M100 is powered by an isolated 24 VAC supply.
2. Cycle the actuator manually as described in the *Manual Override* section.
3. Perform the steps described in the *Checkout Procedure* section.
4. Verify that the voltage at Terminal 10, with reference to Terminal T1, is approximately +12 VDC.
5. Verify that the voltage at Terminal 9, with reference to Terminal T1, is approximately +10 VDC.
6. Verify that the voltage at Terminal 8, with reference to Terminal 10, is between 0 and approximately -2 VDC as the actuator drives from zero to full travel.

Replacement

The drive motor and gear train are immersed in oil and sealed in a die cast case. Therefore, maintenance is not necessary.

Do not make field repairs except for replacement of R81E plug-in electronic board kits. For replacement kits or actuator, contact the nearest Johnson Controls representative.

Table 2: Ordering Information

Model	Description
R81EAA-3	1000-ohm Nickel Sensor Input Economizer Control Electronic Kit (Replacement Electronics for M100E Actuator)*
M130EGA-9	50 lb·in/5.6 N·m Torque, Spring Return Proportional Economizer Motor Actuator
M130XGA-1	50 lb·in/5.6 N·m Torque, Spring Return Motor Actuator (Requires R81 Electronics Kit)*
*This unit is not UL Recognized for use as a new installation.	

Table 3: Accessories

Part Number	Application/Description
Transformers	
Y65AS-1	Transformer, 120/24 VAC, 40 VA, 60 Hz, Class 2
Y65BS-1	Transformer, 240/24 VAC, 40 VA, 60 Hz, Class 2
Y65GS-1	Transformer, 24/24 VAC, 40 VA, 50/60 Hz
Switch and Potentiometer Kits	
S91DJ-1	Auxiliary switch kit with one SPDT switch
S91EJ-1	Auxiliary switch kit with two SPDT switches
S91PT-1	Auxiliary potentiometer kit, 1000-ohm, 1/3 watt
Cover	
CVR83A-600R	Weather-resistant cover
Damper Linkage	
BKT19A-600	Blade arm to connect linkage to damper blade
BKT22A-602	Mounting bracket, right angle
LVR27A-600	Crank arm for use on 1/2 or 7/16 in./12.7 or 11.1 mm diameter damper shafts with adjustable radius from 3/4 to 4-1/2 in./19 to 114 mm.
LVR27A-602	3/8 in. square drive crank arm for use on all motor actuators with adjustable radius from 1-11/16 in. to 2-7/8 in. (furnished with spring return motor actuators and can be ordered separately).
ROD16-1	Push rod, 5/16 in. diameter x 12 in. long plated steel shaft
ROD16-3	Push rod, 5/16 in. diameter x 24 in. long plated steel shaft
SWL10A-603Y	Ball joint, 1/4 -20 UNC stud with hex nut and washer to be used with LVR27A-602, LVR27A-600, and BKT19A-600 crank arms. Qty 1.
D-9999-154	Ball joint, 1/4 - 20 UNC stud with hex nut and washer. Bag of 10 SWL10A-603Y.
SWL10A-604	Sealed ball joint with 1/4 -20 UNC stud with hex nut and washer to be used with LVR27A-602, LVR27A-600, and BKT19A-600 crank arms. Qty 1.
Y20DAA-2	Mounts actuator to top of duct or any flat surface. Contains LVR27A-602, LVR27A-600, SWL10A-603Y, and ROD16-3.
Y20DAB-2	Mounts actuator to side of duct or wall. Contains LVR27A-602, LVR27A-600, SWL10A-603Y (Qty 2), ROD16-3, and BKT22A-602.
Y20DFC-1	Mounts actuator to CD-1300 dampers only. Rack and pinion damper linkage includes a universal mounting bracket for inside or outside damper frame mounting. Using this kit increases the rated output torque by a factor of 2.3.

Specifications

Product	M100E Economizer Series Motor Actuator with R81EAA-3 Interface Board
Power Requirements	24 VAC, Class 2, (20 to 30 VAC) at 50/60 Hz, 25 VA spring return, 20 VA non-spring return
Input Signal	Proportional control, 1000-ohm nickel sensor input (use TE-6000, TE-631X, or TE-641X sensors)
Input Signal Adjustments	Mixed air setpoint 40 to 90°F/5 to 32°C Adjustable proportional band 6F°/3.3C° minimum Adjustable minimum position 0 to 70% of full travel
Mechanical Connection	3/8 inch/9.5 mm square shaft (both ends) Maximum dead weight on output shaft: 200 lb/91 kg on load end 10 lb/4.5 kg on auxiliary end
Mechanical Output	**Running Torque** / **Breakaway and Stall (minimum)** M130: 50 lb·in/5.6 N·m spring return / 200 lb·in/23 N·m
Rotation Range	Fixed zero, adjustable full travel 65 to 270°, factory set at 90°
Rotation Timing (at rated load)	60 seconds for 160° travel nominal, 60 Hz 38 seconds for 90° travel nominal, 60 Hz 75 seconds for 90° spring return
Cycle Life	M130EGA-9: 150,000 cycles at rated load
Electrical Connection	1/4 inch spade terminals
Action	CW rotation on temperature increase (fixed)
Factory Settings	M130EGA-9: Setpoint 55°F/13°C; Proportional band 6F°/3.3C° minimum; Minimum position 10%
Programming Relay	Contacts: SPDT, Class 2 circuit Coil: 24 VAC, 1 VA, Class 2 circuit
Changeover Relay	24 VAC, 1 VA, Class 2 circuit (contacts connected internally)
Ambient Operating Conditions	Spring Return: -35 to 125°F/-37 to 52°C, 90% RH
Ambient Storage Conditions	-40 to 140°F/-40 to 60°C, 90% RH
Enclosure	NEMA 2, IP52
Dimensions (H x W x D)	Spring Return: 6.23 in. x 5.64 in. x 7.68 in./158 mm x 143 mm x 195 mm
Shipping Weight	Spring Return: 9 lb/4.1 kg
Agency Compliance	UL: M130EGA-9: UL 916 Listed, File E107041, Guide PAZX UL 873 Recognized, File E27734, Guide XAPX2 M100X and R81: No UL Listing CSA: M130EGA-9: C22.2 No. 24 Certified, File LR948, Class 4813 02 M100X and R81: No CSA Certifications
EU Directive Compliance	89/336/EEC (CE Mark)

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.

Building Efficiency
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