

Series 965

PRELIMINARY

1/16 DIN Microprocessor-Based Auto-tuning Control

User's Manual



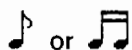
WATLOW

Watlow Controls, 1241 Bundy Blvd., Winona, MN 55987, Phone: 507/454-5300, Fax: 507/452-4507

W965-MA10-9032
August, 1990

\$10.00
Made in the U.S.A.

First...	<i>This manual will make your job easier.</i> Reading it and applying the information is a good way to become familiar with the Series 965. An overview:
Starting Out	Chapter 1, Page 4.
Install/Wire	Chapter 2, Page 6.
Front Panel	Chapter 3, Page 16.
Setup	Chapter 4, Page 18.
Tuning	Chapter 5, Page 27.
Appendix	Specifications, Page 33. Noise Guidelines Calibration Glossary Warranty



NOTE:
Details of a "Note" appear here, in the narrow box on the outside of each page.



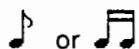
WARNING:
Details of a "Warning" appear here, in the narrow box on the outside of each page.



CAUTION:
Details of a "Caution" appear here, in the narrow box on the outside of each page.

Notes

The user's manual contains informational notes to alert you to important details. When you see a note icon, look for an explanation in the margin.



Safety Information

This user's manual also has **boldface** safety information notes to protect both you and your equipment. Please be attentive to them. Here are explanations:



The Stop Sign in the wide text column alerts you to a "**WARNING**," a safety hazard which could affect you and the equipment. A full explanation is in the narrow column on the outside of the page.



The Deer Crossing Sign in the wide text column alerts you to a "**CAUTION**," a safety or functional hazard which could affect your equipment or its performance. A full explanation is in the narrow column on the outside of the page.

Your Feedback

Your comments or suggestions on this manual are welcome, please send them to: Technical Writer, Watlow Controls, 1241 Bundy Blvd., Winona, MN 55987, or phone 507/454-5300. The Watlow Series 965 User's Manual and integral software are copyrighted by Watlow Winona, Inc., © 1990, with all rights reserved. b1f0890

Technical Assistance

If you encounter a problem with your Watlow Control, review all of your configuration information to verify that your selections are consistent with your application... Inputs, Outputs, Alarms, Limits, etc. If the problem persists after checking the above, you can get technical assistance by dialing: 1-507-454-5300

An Application Engineer will discuss your problem with you. Please have the following information available when calling:

- Complete model number
- Serial Number
- All configuration information
- User's Manual

The model and serial numbers can be found on the outside of the case.

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Chapter 1

Starting Out With The Watlow Series 965, A Microprocessor-Based Control

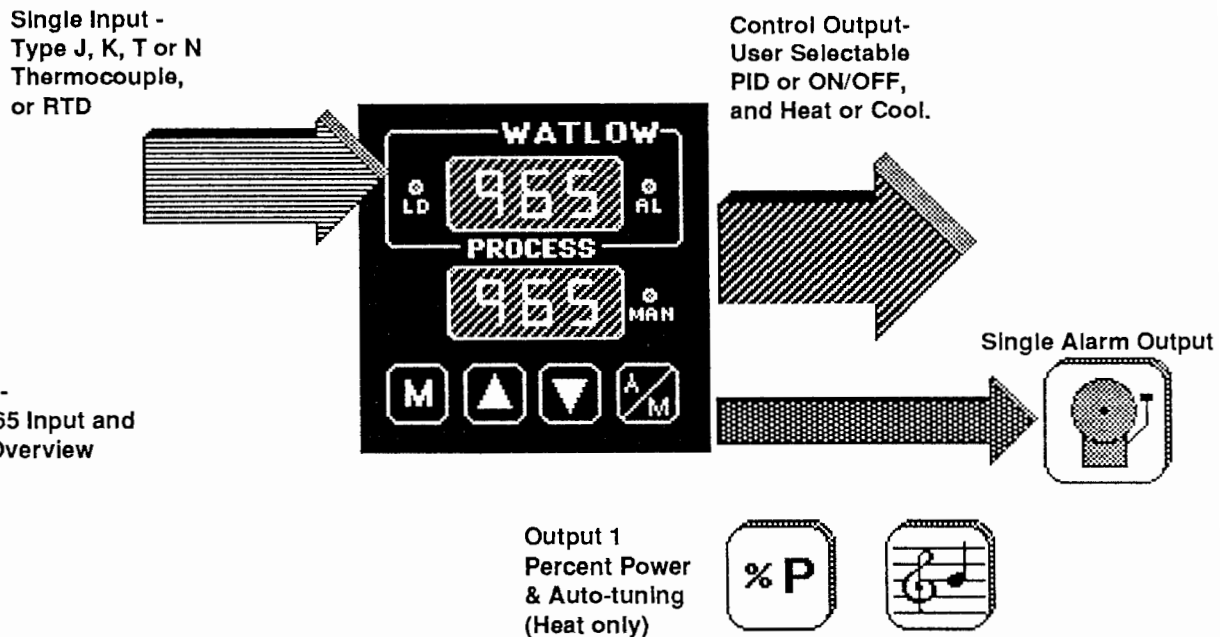


Figure 1 -
Series 965 Input and
Output Overview

General Description

Welcome to the Watlow Series 965, a 1/16 DIN microprocessor-based, single input, output, and alarm auto-tuning temperature control, featuring Automatic/Manual capability with bumpless transfer. In the Auto mode, the 965 has closed loop control with sensory feedback, while the Manual mode has open loop control with user defined output power level. The 965 accepts a Type J, K, T or N thermocouple or RTD input. The primary output is Heating or Cooling, while the secondary output is alarm only.

With the Series 965 you can select either PID or ON/OFF for Output 1. You may input a complete set of PID parameters, and select automatic tuning in the heating mode from the front panel for Output 1. This includes proportional band, reset and rate. By setting the proportional band to zero, the Series 965 becomes a simple ON/OFF control with the switching differential selectable under the HYS Setup parameter.

Operator-friendly features include automatic LED indicators to aid in monitoring and setup, as well as a calibration offset at the front panel. The Watlow Series 965 automatically stores all information in a non-volatile memory.

Steps To Put Your Control To Work

To put your Series 965 to work, we suggest the following steps:

- Read the User's Manual.
- Plan your installation and wiring.
- Cut the panel mounting hole and install the control.
- Wire your Series 965 to the system.
- Start the system and tune the Series 965.
- Make final adjustments to the control parameters and record the data.
- That's all there is to it.

Overview of the Series 965 Menus

Before getting into the details of installing and wiring the Series 965, take a look at Figure 2, and at the three different menus. "Setup," "Operation," and "Calibration." After you feel comfortable with the names and their functions, move on to installation and wiring.

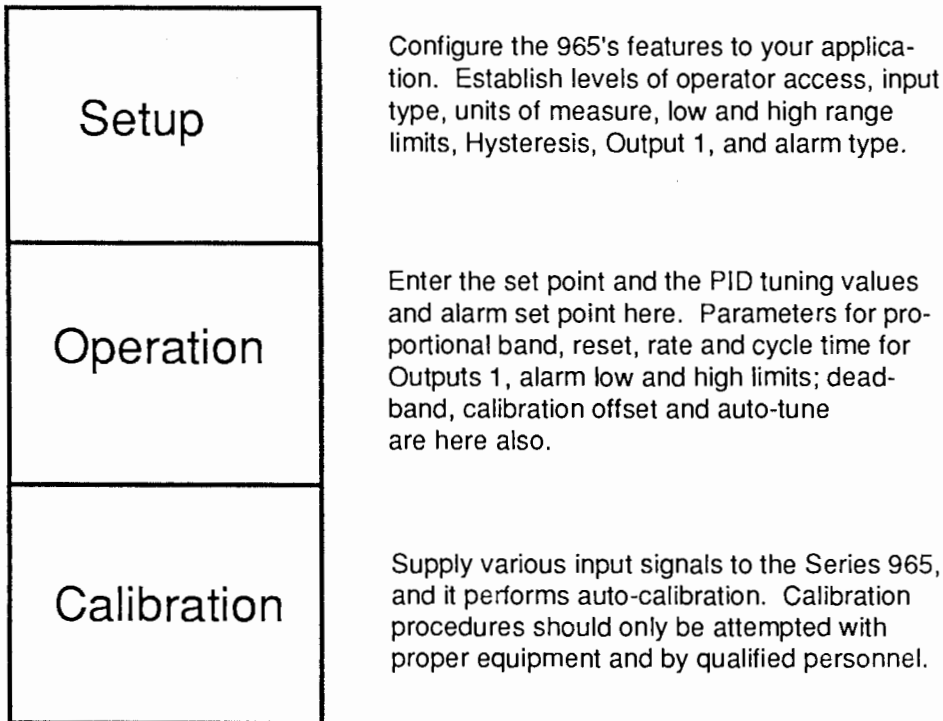


Figure 2 - Overview of the Series 965.

Where To Go From Here

If your Series 965 is already installed and wired, go directly to "How to Use the Keys and Displays," Chapter 3. If not, turn the page to Chapter 2, "How to Install and Wire the Series 965," and proceed from there.

Chapter 2

How to Install and Wire the Series 965

System Planning

This chapter tells you how to install the Series 965. All mounting and wiring information is right here. Because Watlow controls are thoroughly tested and "burned in" before leaving the factory, the Series 965 is ready to install when you receive it.

But before you begin working, read through this chapter to gain an understanding of the entire installation. Consider sensor installation carefully. For detailed information you'll need to look at the noise reduction guidelines in the Appendix of this manual before making your panel cutout.

Installation Information

The Series 965 mounts in a panel cutout with one mounting slip collar. This collar holds the case against the front panel. The Series 965 behind-panel dimensions are 1.8" (46 mm) high by 1.8" (46 mm) wide by 4.1" (104 mm) deep. Figure 3 shows the dimensions of the front panel bezel. The 965 weighs 0.5 lbs. (0.2 kg) max.

For unit dimensional and mounting information, including the mounting slip collar and size of the front panel cutout, see Figures 3 through 5. Your panel's thickness can be from 0.06" (1.5 mm) to 0.38" (9.7 mm).

 **NOTE:**

Removing the Series 965 chassis from its case may make mounting easier.

Installation Procedure

Follow this procedure to mount the Watlow Series 965 Temperature Control:

1. Make a panel cutout per the dimensions in Figure 4.
2. Remove the 965 from its case. Holding each side of the bezel, press in firmly on the side grips of the control until the tabs pop out. Grip the bezel, and pull the control chassis out of the case.
3. Place the case in the cutout you just made. Make sure the gasket is between the panel cutout and the front panel edge of the control.
4. Slide the mounting slip collar over the back of the control. The tabs on the collar must line up with the ridges on the case for secure installation. Press the collar firmly against the panel.

When removing the mounting slip collar, we suggest sliding a thin tool such as a putty knife or screwdriver under all three ear tabs on each side at once and pulling it back off the case.

5. Insert the control chassis into its case and press the bezel to seat it. The hardware installation is complete. Proceed to the wiring section from here.

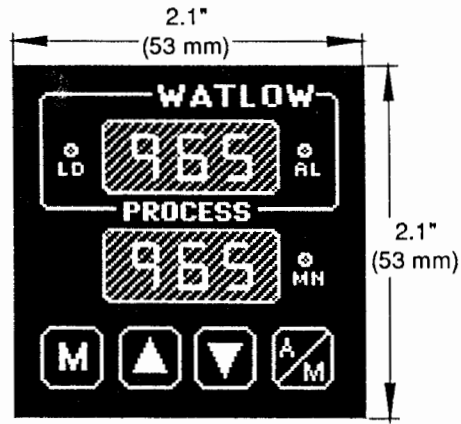


Figure 3 -
Series 965
Faceplate
Dimensions

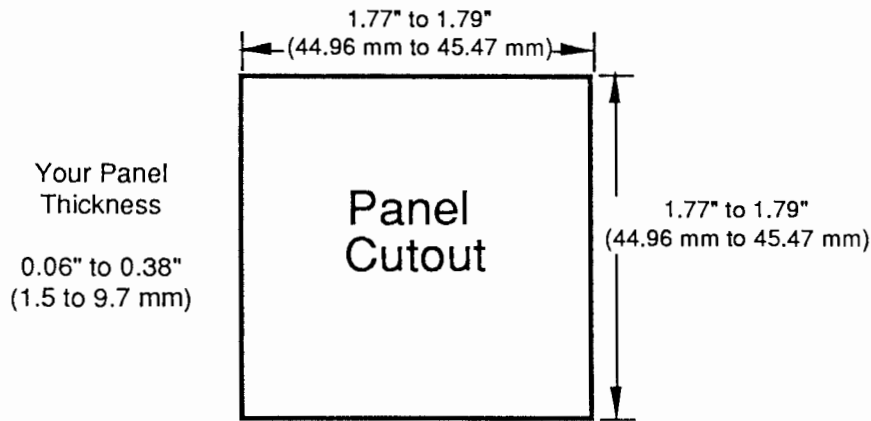


Figure 4 -
Series 965
Panel Cutout
Dimensions

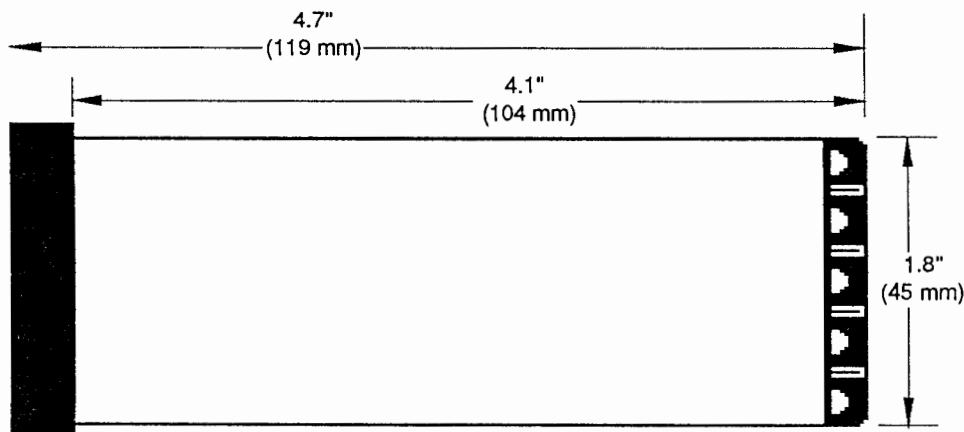


Figure 5 -
Series 965
Sideview
Dimensions

How to Wire the Series 965

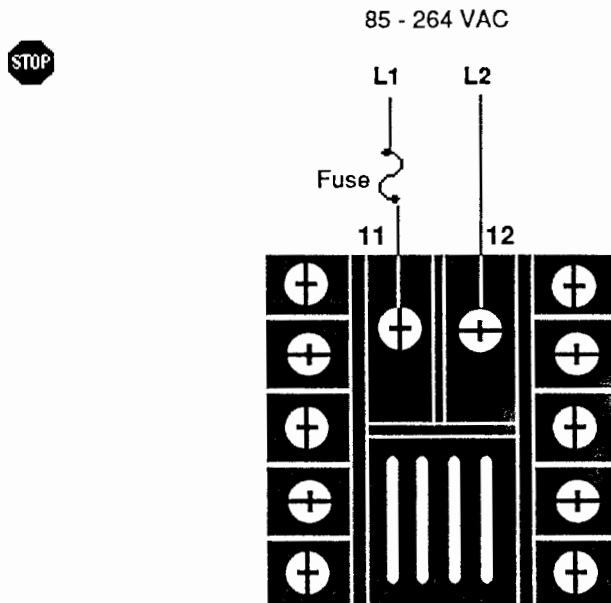
The Series 965 wiring is illustrated by model number option. Check the unit sticker on the control and compare your model number to those shown here and also the model number breakdown in the Appendix of this manual.

Series 965 internal circuits appear "inside" the line drawing of the 965, while connections and terminal designations appear "outside" the line drawing. All outputs are referenced to a de-energized state. The final wiring figure is a typical system example.

When you apply power without sensor inputs on the terminal strip, the Series 965 displays "- - - -" in the Upper display, and a "0" in the Lower display. Press the AUTO/MANUAL key twice, and ER 7 is displayed for one second. This error indicates an open sensor or A/D error. Remove power to the control and connect the sensor properly, see Page 9. All wiring and fusing must conform to the National Electric Code and to any locally applicable codes as well.

Figure 6 -
Power Wiring

STOP **WARNING:**
To avoid potential electric shock, use National Electric Code (NEC) safety practices when wiring and connecting this unit to a power source and to electrical sensors or peripheral devices.



Sensor Installation Guidelines

We suggest you mount the sensor at a location in your process or system where it reads an average temperature. Put the sensor as near as possible to the material or space you want to control. Air flow past this sensor should be moderate. The sensor should be thermally insulated from the sensor mounting.

Operation

ALO

Alarm Low: This parameter represents the low process alarm or low deviation alarm for the alarm. This parameter will not appear if ALt = no or your unit does not have alarms. See the model number. If ALt = dE:

Range: 0 to -99°F/0 to -99°C **Default:** -99°F
If ALt = Pr: **Range:** rL to AHI **Default:** rL

AHI

Alarm High: This parameter represents the high process alarm or high deviation alarm for the alarm. This parameter will not appear if ALt = no or your unit does not have alarms. See the model number. If ALt = dE:

Range: 0 to 99°F/0 to 99°C **Default:** 99°F
If ALt = Pr: **Range:** ALO to rH **Default:** rH

Ct1

Cycle Time 1: Expressed in seconds for a controller to complete one ON/OFF cycle for Output 1. Time between successive turn ons. This parameter will not appear if Pb 1 = 0.

Range: 1 to 60 seconds **Default:** 5

CAL

Calibration Offset: Adds or subtracts degrees from the input signal.

Range: -180°F to 180°F/-100°C to 100°C **Default:** 0

AUt

Auto-Tune: This parameter initiates auto-tune for Output 1. This parameter only appears if Ot 1 =ht.

Range: 0 = off, 1 = slow, 2 = medium, 3 = fast **Default:** 0

Table 3 -
Operation Menu
Prompts and
Descriptions.

Operation Menu

Use this page as a master copy for your Series 965 Operation Parameters.
Do not enter any values here; make photocopies instead.

Operation Parameters	Value	Range	Factory Default
Pb1		0 - 999°F/0 - 555°C 0=ON/OFF control. HYS =switch. diff.	25°F
rE1		0.00 to 9.99 repeats/minute 0.00 = No Reset. Won't appear if Pb1 = 0 and dFL = SI.	0.00 repeats/minute
rA1		0.00 to 9.99 minutes 0.00 = No Rate. Will not appear if Pb1 = 0 and dFL = SI.	0.00 minutes
It1		00.0 - 99.9 minutes/rpt. 0.00 = No Integral. Won't appear if Pb1 = 0 and dFL = US.	00.0 minutes/repeat
dE1		0.00 - 9.99 minutes. 0.00 = No Derivative. Won't appear if Pb 1 = 0 and dFL = US.	0.00 minutes
ALO - Deviation dE Process Pr		-99° to 0° rL to A1HI Will not appear if AL1 = no, or no alarms.	-99° rL
AHI - Deviation dE Process Pr		0° to 99° ALO to rH Will not appear if AL1 = no, or no alarms.	99° rH
Ct1		1 to 60 seconds Won't appear if Pb1 = 0.	5 seconds
CAL		±180°F/±100°C	0
AUt		0-3 Appears if Ot1 = Ht.	0

Input Option "1", Thermocouple Input

Terminals 3 & 5

Model # 965A - 1 _ _ 0 - 0000

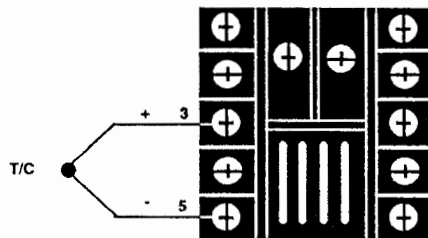


Figure 7 -
Input Option "1",
Thermocouple
Wiring Diagram.

NOTE:

Extension wire for thermocouples must be of the same alloy as the thermocouple itself to limit errors.

Input Option "2", for 2 or 3 Wire RTD

Terminals 2, 3 & 5

Model # 965A - 2 _ _ 0 - 0000

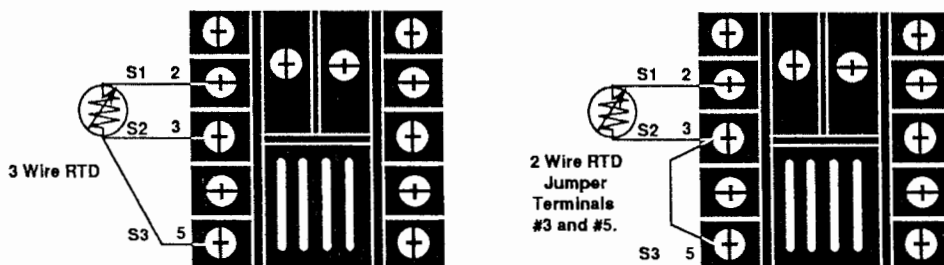


Figure 8 -
Input Option "2",
for a 2 or 3 wire RTD
Sensor Wiring.

NOTE:

Long lead lengths create electrical resistance. There could be a $\leq 4^\circ\text{F}$ input error for every 1Ω of lead length resistance. That resistance, when added to the resistance of the RTD element, can result in erroneous input to the instrument. When extension wire is used for a three wire RTD, all three extension wires must have the same electrical resistance. (i.e. same gauge, length, copper stranded).

Output 1 Option "C", DC Output (Open Collector) Terminals 8 - 10

Model # 965A - _ C _ 0 - 0000

8 Not Used
9 DC +
10 DC -

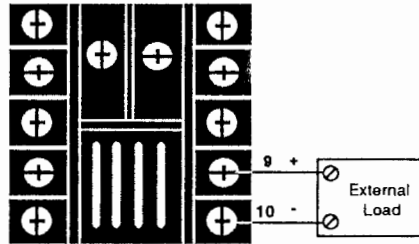


Figure 9 -
DC Output 1 (Open
Collector), Option
"C" Wiring Diagram.

Switched DC

Watlow's solid state switch is a low current DC output (open collector) used to switch an external power switching device such as an SSR or an electro-mechanical relay. The input specifications of the power switching device must match those listed for the SS switch output. The power switching device must provide isolation between the SS switch output and load power since the SS switch output is a non-isolated output. Minimum load resistance is 500Ω. Available current is minimum 9mA, 22mA maximum.

Output 1 Option "D", Mechanical Relay, Form C, 5 Amp Terminals 8 - 10

Model # 965A - _ D _ 0 - 0000

8 N.C.
9 COM.
10 N.O.

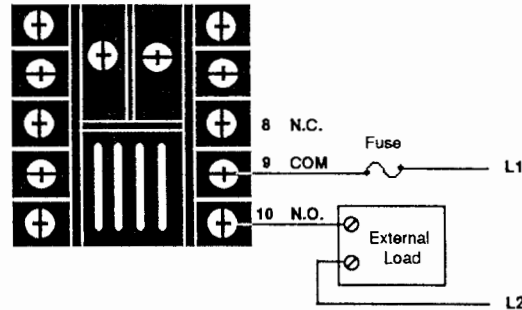


Figure 10 -
6 Amp Mechanical
Relay, Output 1,
Option "D" Wiring
Diagram.

Mechanical Relay

The electro-mechanical relay is an electrical and mechanical device with moving parts. When power is applied to the relay solenoid, contact closure is created through movement of the "common" contact of the relay.

Output 1 Option "F", Process, 4-20mA Terminals 17 - 18

Model # 945A - _ F _ _ - _ 000

8 Not Used.
9 4-20mA +
10 4-20mA -

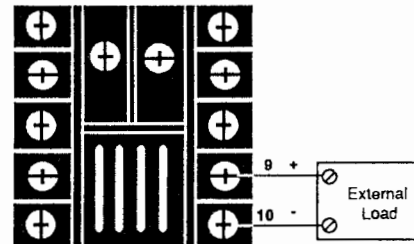


Figure 11 -
4-20mA, Output 1,
Option "F" Wiring
Diagram.

Process Output

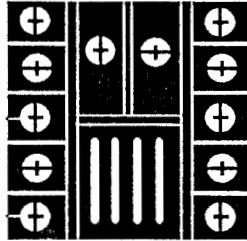
Proportional value determined by the control to balance the sensor input and set point. This value will fall between 4 - 20 mA depending on your process output type.

NOTE:

For more information on alarms and alarm jumper selection, see Pages 29 and 30.

Output 2 Option "A", No Alarm Output 2

Model # 965A - __ _ A 0 - 0000



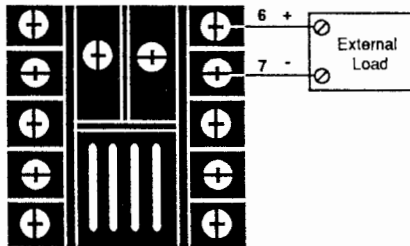
1 Not Used
⋮
6 Not Used
7 Not used

Figure 12 - None Used, Alarm Output 2, Option "A" Wiring Diagram.

Output 1 Option "C", DC Output (Open Collector)

Terminals 1, 6 & 7

Model # 965A - __ _ C 0 - 0000



6 DC +
7 DC -

Figure 13 - DC Alarm Output 2 (Open Collector), Option "C" Wiring Diagram.

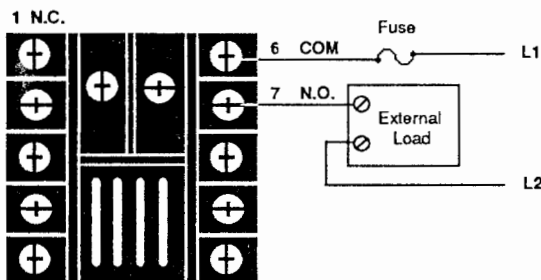
Switched DC

Watlow's solid state switch is a low current DC output (open collector) used to switch an external power switching device such as an SSR or an electro-mechanical relay. The input specifications of the power switching device must match those listed for the SS switch output. The power switching device must provide isolation between the SS switch output and load power since the SS switch output is a non-isolated output. Minimum load resistance is 500Ω. Available current is minimum 9mA, 22mA maximum.

Output 1 Option "D", Mechanical Relay, Form C, 5 Amp

Terminals 1, 6 & 7

Model # 965A - __ _ D 0 - 0000



1 NC
⋮
6 COM
7 N.O.

Figure 14 - 6 Amp Mechanical Relay, Alarm Output 2, Option "D" Wiring Diagram.

Mechanical Relay

The electro-mechanical relay is an electrical and mechanical device with moving parts. When power is applied to the relay solenoid, contact closure is created through movement of the "common" contact of the relay.

Wiring Example



WARNING:

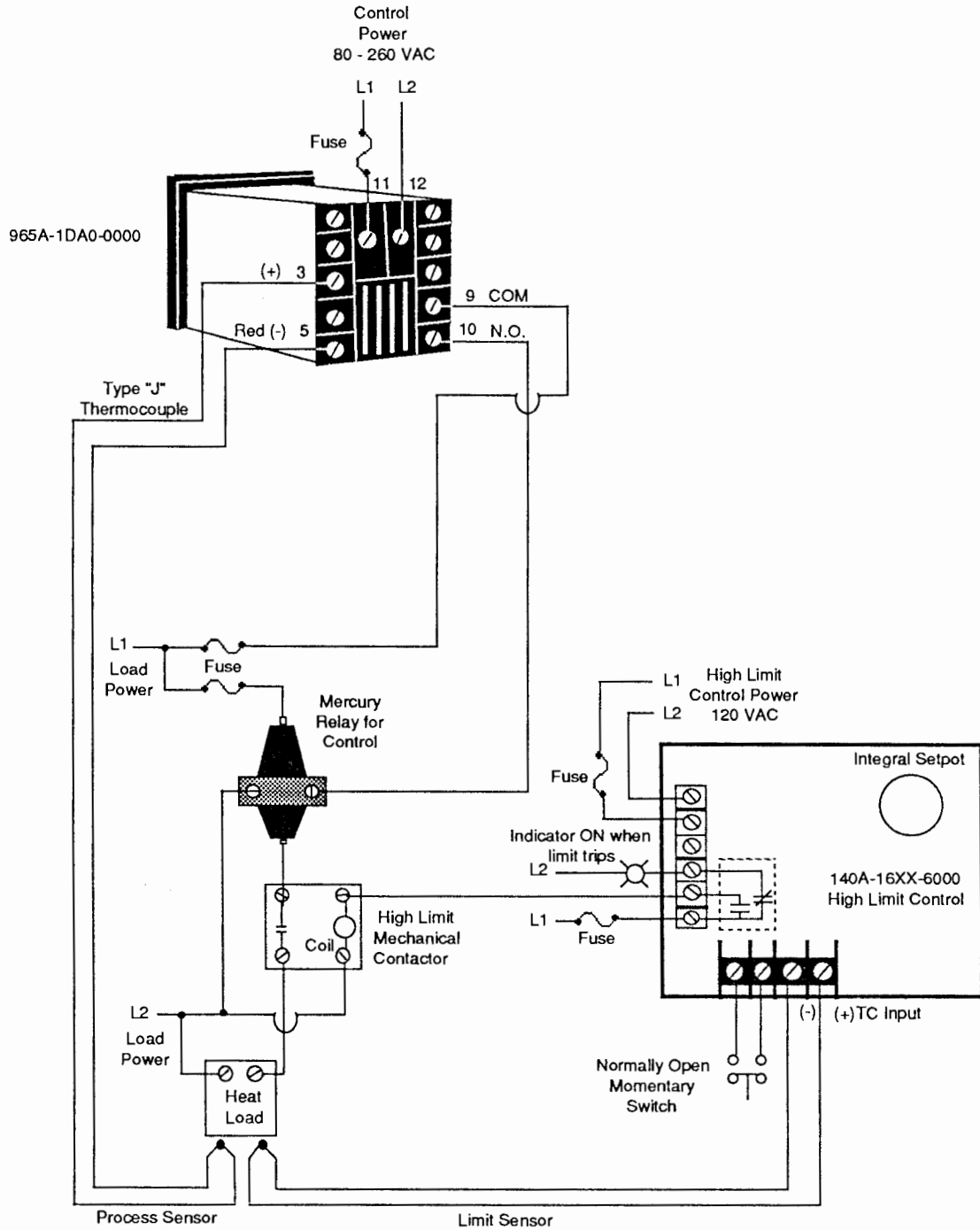
All wiring and fusing must conform to the National Electric Code NFPA70. Contact your local board for additional information. Failure to observe NEC safety guidelines could result in injury to personnel.



CAUTION:

Watlow mercury relay loads must have a unity power factor. For RESISTIVE LOADS ONLY.

Figure 15 - System Wiring Example



How to Use the Keys and Displays

Use this page to learn the nature and function of the Series 965's keys and displays.

Series 965 Displays and Load LED's

Upper Display

Red, 0.3" (8 mm) high, seven segment, three digit LED display, indicating either process actual temperature, the operating parameter values, or an open sensor. When powering up, the Process display will be blank for 8 seconds.

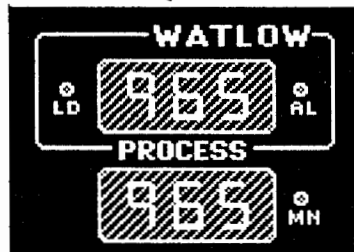


NOTE:

The Upper display will automatically display the process value after 1 minute without key strokes.

LD

When lit, this LED tells you when Output 1 is energized.



AL

When lit, this LED tells you when the Alarm is active. Only appears on those units with alarms option.

Lower Display

Red 0.3" (8 mm) high, seven segment, three digit LED display, indicating the set point, output value, prompts for data in the upper display, or error and alarm codes.

Figure 16 - Series 965 Keys and Displays

UP/DOWN keys

When pressed simultaneously for 3 seconds, the Setup Menu appears displaying the LOC parameter. Continue to press the UP/DOWN keys, and the Calibration Menu appears.

MODE Key

Steps the control through the Operating menu; also, in the Auto mode, enters new data selected less than 5 seconds previously.



AUTO/MAN Key

Pressed once, it clears any latched alarms. If pressed again within 5 seconds, the control toggles between Auto and Manual mode. While in Manual mode, percent power is in the lower display.

UP Key

Increases the value of the displayed parameter. A light touch increases the value by one. Holding the key down increases the value at a rapid rate. New data is self entering in 5 seconds.

DOWN Key

Decreases the value of the displayed parameter. A light touch decreases the value by one. Holding the key down decreases the displayed value at a rapid rate. New data is self entering in 5 seconds.

How To Setup The Series 965

Setting up the Series 965 is a simple process. First configure the 965's features to your application in the Setup Menu, and then enter values in the Operating Menu. Both tasks use the MODE key to move through the menus and the UP/DOWN keys to select data. **For information on entering the Setup menu, refer to the next page.**

NOTE:
While in the Setup menu, all outputs are OFF.

Figure 17 - The Setup Menu.

NOTE:
When using a process input such as 0-5VDC or 4-20mA, the rL and rH settings scale the display to match the measured range of the process signal.

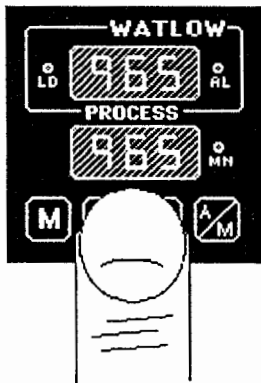
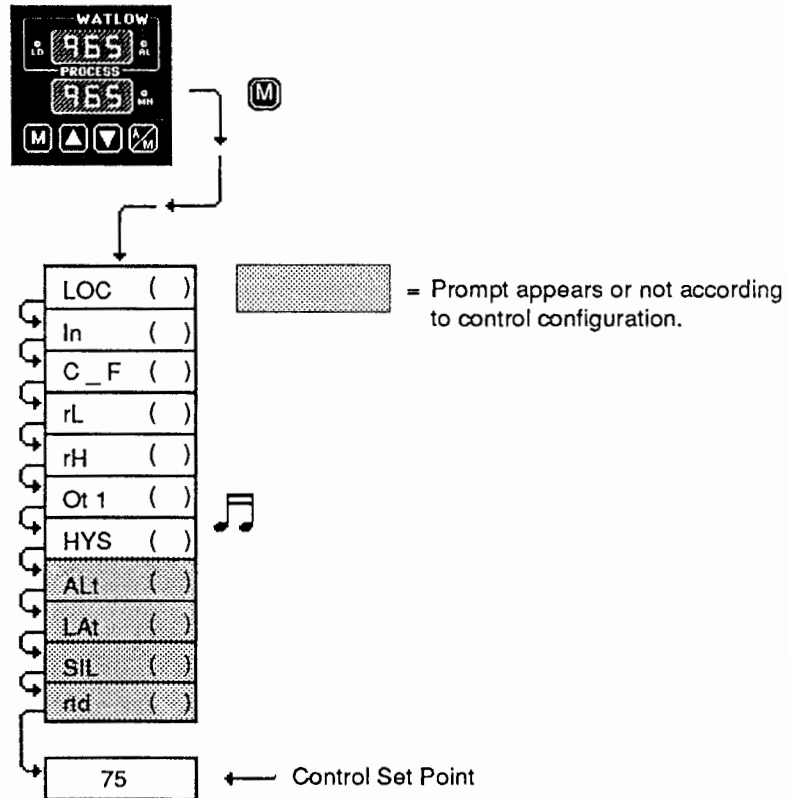


Figure 18 - Entering the Setup Menu.

Entering the Setup Menu

The Setup Menu displays the parameters that configure the Series 945's features to your application.

To enter the Setup Menu, press the UP and DOWN keys simultaneously for 3 seconds. See Figure 18. The Lower display shows the LOC parameter, and the Upper display shows its current level. All keys will be inactive until you release both keys. You can get to the LOC parameter from anywhere.

Use the MODE key to cycle through the menu; use the UP/DOWN keys to select Setup data. You may not see all parameters in this menu, depending on the unit's configuration and model number. After stepping through the menu, you will return to the control set point parameter under the Operation menu.

Setup Parameters

When you are at the top of the menu, the Series 965 displays the user level of operation in the Upper display, and the LOC parameter in the Lower display.

When you press the MODE key, the value of the next parameter appears in the Upper display, and the parameter appears in the Lower display.

Lock: Selects the level of operator lock-out as defined below.
Range: 0 - 4 **Default:** 0

LOC

LOC 0: All operating parameters may be viewed or changed. Manual operation **is** permitted.

LOC 1: The set point and actual are the only visible parameters, set point **is** adjustable in this level. Manual operation and auto-tune **is** permitted.

LOC 2: The set point, actual, and L-r (if enabled) are the only visible parameters, set point **is** adjustable in this level. Manual operation **is** permitted. When in manual operation, percent power and alarm set point is also adjustable.

LOC 3: The set point, actual, and L-r (if enabled) are the only visible parameters, set point **is** adjustable in this level. Manual operation is **not** permitted.

LOC 4: The set point and actual are the only visible parameters, set point is **not** adjustable in this level of lock-out. Manual operation is **not** permitted.

Input: Selects the sensor input type. Only those input types which are compatible with your unit will appear. See the model number information for your type.
Range: J, K (appears as H), t, n, rtd **Default:** J or rtd

In

Celsius _ Fahrenheit: Selects the units of temperature measurement for the control. The default is dependent on the dFL parameter located in the Calibration menu. If dFL = US, the default is F. When dFL = SI, the default is C.
Range: C or F

C_F

Range Low: Selects the low limit of the operating range. See the model number and specification in the Appendix for range values. See Table 1 on Page 16.
Range: Sensor range low to rH **Default:** Low limit of sensor type

rL

Range High: Selects the high limit of the operating range. See the model number and specification information in the Appendix for your range values.
Range: Sensor range high to rL **Default:** High limit of sensor type

rH

Output 1: Selects the output action for the primary output. Action in response to the difference between set point and process variable.
Range: ht, CL **Default:** ht

Ot1

Hysteresis: Selects the switching hysteresis for Output 1 when you select 0 (ON/OFF) under the Pb1 parameter. See Page 17 for the Pb1 parameter.
Range: 1°F - 99°F/1°C - 55°C **Default:** 3°F

HYS

ALt

Alarm Type: Determines whether the alarm type is process, deviation, or none. A process alarm is set at an absolute temperature to prevent over/underrange. This parameter only appears if you ordered alarms with your unit. Check the model number. **Range:** Pr, dE, no **Default:** Pr

LAt

Latching: Selects whether the alarm is latching or non-latching. Latching alarms must be cleared before the alarm output will reset. Non-latching automatically resets the alarm output when the condition clears. This parameter will not appear if ALt = no, or your unit does not have alarms. Check the model number. **Range:** LAt or nLA **Default:** nLA

SIL

Silencing: Selects alarm silencing (inhibit) for the alarm. This parameter appears only when ALt = dE. For more information see Chapter 5, "Using Alarms." **Range:** On or OFF **Default:** OFF

rtd

RTD: Selects the RTD calibration curve for RTD inputs. This parameter will not appear unless In = rtd or rt.d. JIS = $0.003916\Omega/\Omega^{\circ}\text{C}$, DIN = $0.003850\Omega/\Omega^{\circ}\text{C}$. **Range:** din or JIS **Default:** din

Table 1 -
Input Ranges.

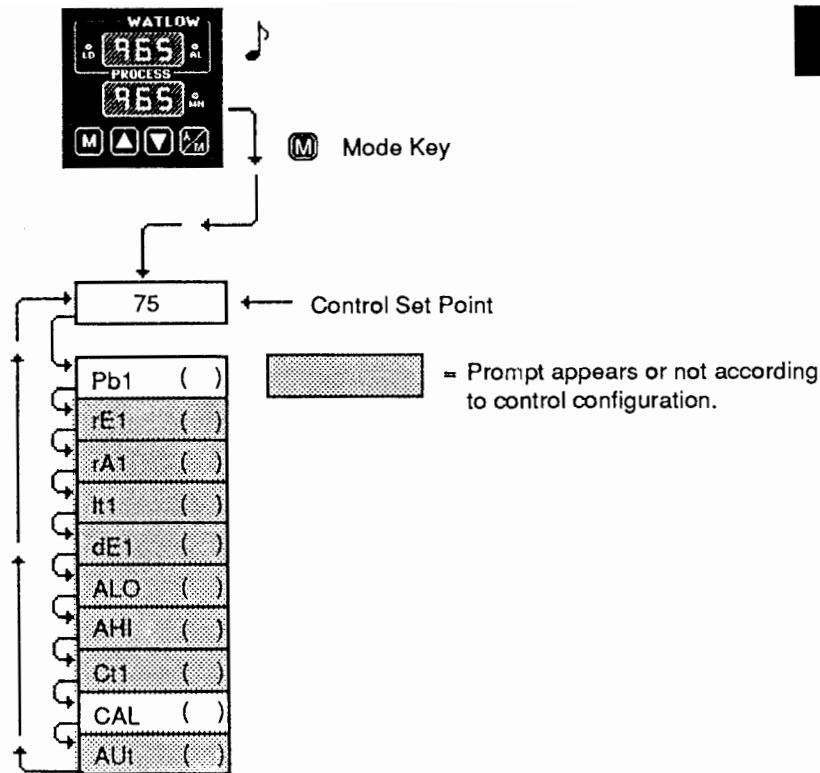
Input Type	Sensor Range Low	Sensor Range High
J	32°F/0°C	999°F/750°C
K (appears as H)	-99°F/-99°C	999°F/999°C
t	-99°F/-99°C	662°F/350°C
n	32°F/0°C	999°F/999°C
rtd (1°)	-99°F/99°C	999°F/600°C

Setup Menu

Table 2 -
Setup Menu
Prompts and
Descriptions.

Use this page as a master copy for configuring your Series 965.
Do not enter any values here; make photocopies instead.

Setup Parameters	Value	Range	Factory Default
LOC		0 - 4	0
In		J, K (appears as H), t, n, rtd Dependent on model number.	
C_F		C or F	Dependent on dFL.
rL		rL to rH	Input selection dependent.
rH		rH to rL	Input selection dependent.
Ot1		ht or CL	ht
HYS		1°F - 99°F, 1°C - 55°C	3°F
AL1		Pr, dE or no	Pr
LAt 1		LAt or nLA Dependent on AL = Pr or dE.	nLA
SIL		On or OFF	OFF
rtd		JIS or din	din



NOTE:
The Upper display will always return to the process value after 1 minute without key strokes.

Figure 19 - The Operation Menu.

Operation Parameters

Set Point: Sets the operating set point for Output 1. Represents the process value the system will try to achieve for Output 1. The "SP1" parameter does not appear, the control set point value will.

[SP]

Proportional Band 1: A proportional band expressed in degrees, within which a controller proportioning function is active for Output 1. When Pb1 = 0, the unit functions as an ON/OFF control. The switching differential is then determined by the HYS parameter.

Pb1

Range: 0 to 999°F/0 to 555°C **Default:** 25°F/2.5°F

Reset 1: A reset (integral) control action for Output 1 that automatically eliminates offset, or "droop," between set point and actual process temperature in a proportional control. This parameter will not appear if Pb1 = 0 and dFL = SI.

rE1

Range: 0.00 to 9.99 repeats/minute **Default:** 0.00

Rate 1: The rate (derivative) function for Output 1 of the Series 945. The rate is determined by how fast the error is changing. This parameter will not appear if Pb1 = 0 and dFL = SI.

rA1

Range: 0.00 to 9.99 minutes **Default:** 0.00

Integral Time 1: An integral control action for Output 1 that automatically eliminates offset, or "droop," between set point and actual process temperature in a proportional control. Entering 00.0 disables integral. This parameter will not appear if Pb1 = 0 and dFL = US.

It1

Range: 00.1 to 99.9 minutes/repeat **Default:** 00.0

Derivative 1: The derivative function for Output 1 of the Series 965. The derivative is determined by how fast the error is changing. This parameter will not appear if Pb1 = 0 and dFL = US.

dE1

Range: 0.00 to 9.99 minutes **Default:** 0.00