TECHNICAL REFERENCE MANUAL AND INSTALLATION INSTRUCTIONS

MODEL

CS2000

ENERGY MONITOR CONTROLLER

FOR USE WITH BARD AIR CONDITIONERS AND HEAT PUMPS

MANUAL 2100-221 REV. A
SUPERSEDES REV.
FILE VOL. III, TAB 19

Bard
SINCE 1914

MODEL
CS 2000
COMMERCIAL
APPLICATIONS

Model CS 2000
ENERGY MONITOR CONTROLLER
Technical Reference Manual

Model CS 2000
Commercial Applications Model

HOW TO USE THIS MANUAL

This manual provides instructions for installing, testing, and troubleshooting the CS 2000 energy monitor controller. Read these instructions carefully before beginning the installation.

Section of Manual	Description and Use
Preface **Introduction** **Theory of Operation**	Sections briefly describe CS 2000's features and characteristics including basic operation and learning functions. Rules are described that govern CS 2000's learning feature. This information familiarizes installers, specifiers, engineers, and end users with CS 2000.
Function Switches	Detailed description of CS 2000's selectable operating modes. This information explains to field installers how to properly set up CS 2000's function parameters.
Temperature Switches	How to select setup and setback temperatures as well as operation of night setback/setup, adaptive freeze protection, and temperature clamp.
Installation	How to mount and wire CS 2000 to HVAC system. Input/output terminals are described. Precautions are stated.
Testing	Step-by-step instructions on how to test a CS 2000 installation.
Appendix A: Precondtion	How and where to use the precondition feature.
Appendix B: Loads	How to connect CS 2000 to external relays and contactors for controlling loads greater than 24 VAC or 1 Amp. Needed for water heater, lighting, and other applications.
Appendix C: Heat Pumps	How to connect CS 2000 for economic control of second-stage heat.
Appendix D: Abbreviations	Quick reference for abbreviations and acronyms used in the manual.
Appendix E: Forms	(1) CS 2000 installation QA, (2) quick reference for installers, and (3) customer survey.

SPECIFICATIONS
Model CS 2000

INPUTS

Power ..... 10-24 VDC or VAC (< 100 ma) Internally Fused

Precondtion (power fail) ..... Contact closure

Door ..... Contact closure

Remote ..... Contact closure

OUTPUTS

HVAC Relay (pilot) ..... Form C, 24 VAC 1 Amp max

Auxiliary Relay (pilot) ..... Form C, 24 VAC 1 Amp max

Security Relay (reed) ..... Form C, 24 VAC 0.1 Amp max

Fault Relay (reed) ..... Form A, 24 VAC 0.1 Amp max

INSTALLER INTERFACE

Function Selection ..... 10 PCB DIP switches

Temperature Set Points ..... 10 PCB DIP switches

Indication ..... Single LED

PHYSICAL CHARACTERISTICS

Operating Temperature ..... 0 to 122° F (-20 to 50 C)

Case ..... 2 piece, 4 x 7.5 x 2 in., High Impact ABS, U.L. listed

Color ..... Off White

Terminals ..... 12-22 AWG, #3 screw

Mounting ..... 4 screws

FEATURES

Motion Sensor ..... Internal long-range PIR

Temp. Sensor ..... Internal high rel. thermistor

Learning ..... Daily and weekly schedule

Optimal start-up ..... First morning wake-up

HVAC Systems ..... Heat pump& Air Conditioner

Equipment ..... Lighting, water heater, appliances

Access modes ..... With or w/o door switches

Setback temperatures ..... 48-68° F

Setup temperatures ..... 78-90° F

Demand Delay ..... Random time after start-up

Recovery rates ..... Economy or comfort

Search times ..... 5, 30, or 60 minutes

Adaptive Freeze Protection ..... 48 and 54° F

External precondition ..... 3 hours

Temperature clamps ..... 67 and 79° F

Short cycle protection ..... 3 min. off (minimum)

HVAC problem detection ..... Temp. threshold

Security output ..... Based on motion detection

Computer watchdog timer ..... Auto restart

HVAC High-temperature shutdown ..... 122° F

Manual override ..... Resets after 24 hours

Power fail sense ..... Detects AC outage

Maid Control ..... 2nd set of temps for sleep

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PREFACE

Before CS 2000, Energy Monitor Systems (EMS) operated on either a fixed time schedule or an occupancy regulated principle. Each approach has its benefit, but each also has its limitations. The CS 2000 has changed that by combining time-and occupancy-based operation with learning software. This new approach creates an energy management system that takes the best of both principles and makes it automatic. See the comparison below.

System Attribute	Time-Based Principle	Occupancy-Based Principle	CS 2000's Learning Principle
Learning of arrival schedules	**None**	**None**	**Yes** - Learns and constantly adapts to area's arrival schedule
Anticipation of arrival	**Yes** - fixed schedule only	**None** - works at arrival time only	**Yes** - learns daily schedule and prepares for arrival. Starts HVAC in advance of personnel arrival.
Flexibility to variation in occupancy schedule	**Poor** - intolerant to schedule variation, problem since people seldom adhere to rigid schedule	**N/A** - no time base to retain fixed schedule	**Excellent** - responsiveness like occupancy-based system but with anticipation that is updated from daily patterns
User interaction	**Poor** - requires reprogramming as schedules change, bypass needed for unscheduled events	**Good** - generally no user interaction needed	**Excellent** - self adapting, no user interaction whatsoever
Economy of operation	**Medium** - may occasionally heat an unoccupied space leaving HVAC to waste energy	**High** - since HVAC use is on demand only	**Very High** - stops waste in unoccupied areas plus allows deeper setback (setup) because of anticipation feature
Comfort offered to occupants	**Medium** - people working after hours may find themselves in an uncomfortable environment	**Low** - people arriving on the premises may find it uncomfortable until the HVAC restores normal temperature	**High** - occupants arrive to a comfortable living environment and normal temperature is maintained as long as area is occupied.
Difficulty of programming	**Complex** - establishing fixed schedule and temperatures for HVAC requires detailed procedure	**Simple** - search times and setup/setback temperatures only	**Simple** - search times and setup/setback temperatures plus options if desired. No reprogramming needed.
Maintenance	**High** - timers must be adjusted for time change and sometimes at season change	**Medium** - setback must be occasionally readjusted since system has no anticipation	**None** - completely self adjusting with no need for seasonal adjustments

Cs 2000's learning capability, occupancy detection, and self-adjusting time-base provides a high degree of comfort and energy savings. Such effectiveness is not achievable by timers or occupancy detectors alone.

1. INTRODUCTION

The CS 2000 is an energy monitor system for commercial environments that turns off the heatir ventilating, and air-conditioning (HVAC) unit when the room is unoccupied. This interruption of HVAC operation reduces the use of electrical energy for heating or cooling. The CS 2000 senses the presence of humans by infrared motion detection, which emits no energy or radiation into the room. It is therefore harmless to humans, animals, and plants. The CS 2000 operates as a stand-alone controller in a commercial environment. Usually, one CS 2000 controller connects to each HVAC unit.

The CS 2000 incorporates innovative micro-processor technology. Its unique features increase energy savings without disturbing occupant comfort. The CS 2000's features are switch selectable., this flexibility enables tailoring of each CS 2000 to a facility's energy management strategy.

The CS 2000 senses occupancy and occupancy patterns, and measures room temperature and rates of temperature rise and fall. Based on these data, CS 2000 controls the HVAC system's operation as needed by interrupting existing low-voltage wiring to the thermostat. The CS 2000's control-relay contacts connect in series with the main (red) wire to the thermostat. When CS 2000 takes control for energy savings, it opens the thermostat circuit. This action is the same as reducing the thermostat's temperature setting (or increasing for the cooling season). During unoccupied periods, CS 2000 operates the HVAC unit only as needed to maintain temperature at an energy-saving level.

The CS 2000 can operate in installations that do not permit direct access to the thermostat. This would be true for a thermostat enclosed within a through-the-wall HVAC unit. For this situation, CS 2000 drive an external power relay that interrupts line current to the HVAC unit. System operation is the sam whether CS 2000 controls low voltage to the thermostat or main power to the unit.

Please read this manual thoroughly to acquaint yourself with the CS 2000's features, installation procedures, and requirements. As a complement to the full manual, a two-page summary of CS 2000's switch settings, wiring terminals, and test procedures is provided in Appendix E.

2. THEORY OF OPERATION

2.1 BASIC CS 2000 OPERATION

The most often used mode is limited access, which works like this: Regardless of previous state, opening an entry/exit door causes CS 2000 to give control of the HVAC system to the room thermostat. The CS 2000 then starts a search for occupancy through its built-in passive infrared motion detector (PIR). Once the area becomes occupied, CS 2000 returns control of the HVAC system to the thermostat. If the search fails to confirm occupancy, CS 2000 regains control to resume e a setback or setup condition. A secon mode of operation (unlimited access) may be selected that bases setback on motion only (no door switches).

The CS 2000 measures room temperature through its built-in thermistor during unoccupied periods. As the room temperature drops below or rises above the preset temperatures, CS 2000 returns control to the room thermostat, which turns on the HVAC. As room temperature reaches the preset temperature, CS 2000 again takes control, thus disconnecting the thermostat. Typical operation of a CS 2000 controller appears in Table 1.

Table 1 Typical Operating Sequence of the *Unlimited Access Mode.*

OCCUPANT'S BEHAVIOR	CS 2000'S RESPONSE	COMMENT
Entering area	HVAC control contacts to thermostat close. Area occupied contacts close	HVAC operates as long as movement is detected every 30 or 60 minutes (DIP switch selectable)
Area occupied		PIR blanks for 2.5 seconds. Person search timer starts.
Walks across PIR detection zone	Security relay contacts close momentarily.	CS 2000 detects person and confirms area occupied. Search timer stops. 24-hour timer starts.
Remains in area		No further change in status unless night setback begins, or 24 hours elapse without movement.
Closes door, leaving area unoccupied		PIR blanks for 2.5 seconds after door closes. Person search timer starts
	HVAC control contacts to thermostat open. Area occupied contacts open ‡	Search time elapses — no one found
	HVAC contacts to thermostat close	Time passes. Room temperature drops 2 °F below CS 2000's setback switch setting.
	HVAC contacts to thermostat open	Room temperature rises 2 °F above setback detting due to operation of HVAC unit.
	Normal setback/setup operation	Setback cycling continues as needed until door opens or two motion events occur in field of view.

2.2 LEARNING OCCUPANCY PATTERNS

CS 2000's unique software learns and records each day's occupancy patterns as observed through door sensors and built-in motion sensor. This allows the HVAC system to restore normal room temperature before occupant's morning arrival. The CS 2000 is specifically designed for the occupancy patterns found in commercial and school environments.

2.2.1 First Arrival Learning

The first morning's arrival after an unoccupied evening cancels the setback (or setup) mode. The CS2000 records the arrival time and averages it with the previous time one week earlier.

The unoccupied night cycle must last at least seven continuous hours. Motion detected before completion of a 7-hour night-cycle is considered invalid and is not registered. This prevents confusing an extended unoccupied day period with a business closed for the night.

The CS2000 records occupant arrival times for seven days in succession. For each morning, the measured arrival time is averaged with the recorded time from the previous week. The average of the current and previous times is set aside for use the same day in the coming week (see equation below)

$$\left[\begin{array}{c}\textit{next week's}\\ \textit{expected}\\ \textit{arrival time}\end{array}\right] = \frac{\left[\begin{array}{c}\textit{today's actual}\\ \textit{arrival time}\end{array}\right] + \left[\begin{array}{c}\textit{this week's}\\ \textit{expected time}\end{array}\right]}{2}$$

By updating the arrival time in this way, theCS 2000 always makes a reasonably accurate prediction of the arrival time for each new day. The CS 2000 permits a different arrival time for each of seven days.

A grace period of four hours is permitted before and after the expected arrival time. As long as the new arrival time is within the grace period, averaging occurs. Otherwise, the CS 2000 considers the new arrival time *out-of-range* and uses the previous time without averaging for the next week. If personnel arrive outside the permitted grace period for the same day of the week two weeks in succession, CS 2000 drops the old arrival time and registers the new one, without averaging. This feature allows the CS 2000 to conform to schedule changes. (1) Minor schedule changes are followed by averaging daily arrival times on a weekly basis. (2) Major schedule shifts are accommodated by complete relearning on the third week.

2.2.2. Response to Power-up

The user does not set CS 2000's internal clock. Rather, the CS 2000 sets its own clock by observing occupant behavior. After applying power, CS 2000's internal seven-day clock remains inactive until the first morning occupants arrive. This is the initial synchronizing point. For the first week after synchronization, that first morning's arrival time is used for each subsequent day of the week. In the followir weeks, new arrival times are averaged with the previous week's values.

NOTE: The CS 2000 returns total HVAC control to the room thermostat after a power outage. Only after synchronization does energy saving operation begin. Then CS 2000 must relearn the actual schedule.

Loss of schedule does not create an uncomfortable environment. However, energy savings may not be realized until synchronization occurs. To prevent loss of schedule, a battery-back power supply may be used to supply 12 VDC to the CS 2000. See Sections 3.6 and 5.5 for connection of battery supply.

2.2.3 Optimal Start-up

The CS 2000 starts the HVAC in advance of arriving personnel to create a comfortable environment. Start-up times can range be as short as 6 minutes or as long as 8 hours. The warming (or cooling) period depends on outside temperature, room temperature, and the HVAC system's performance. The CS 2000 conducts performance checks during setback (setup) operation. These checks include season identification, HVAC performance measurement, and room heat-loss calculation. These performance data allow calculation of the best time to start the HVAC system. Mild weather conditions may not require HVAC operation to meet setback temperature. Under such mild conditions, the CS 2000 operates the HVAC system for a short period to get necessary performance data for calculation of the optimal start time.

2.4. Weekends and Vacations

The CS 2000 learns the days for which it should not expect personnel arrival. It identifies weekends by observing that the same day of the week for two weeks in succession is not occupied. On weekends, the CS 2000 will not preheat (or cool) before arrival. However, the CS 2000 will relearn the weekend schedule after two weeks, if the schedule changes so the area becomes occupied on those days.

The CS 2000 recognizes when a business is closed for vacation by noting that three successive (normally occupied) days have passed without the area being occupied. After the third day, anticipation stops. The CS 2000 recalls the old schedule and normal operation resumes when the area becomes re-occupied.

3. FUNCTION SWITCHES

The CS 2000 must be customized to each installation by setting the two 10-position DIP switches. These are located on the main circuit board. The left-hand switches select modes and features. The right-hand switches determine setup and setback temperatures. The function switches appear on the location diagram shown in Fig. 1. To simply installation, CS 2000 has been designed so the normal function-switch positions are to the left for most installation.

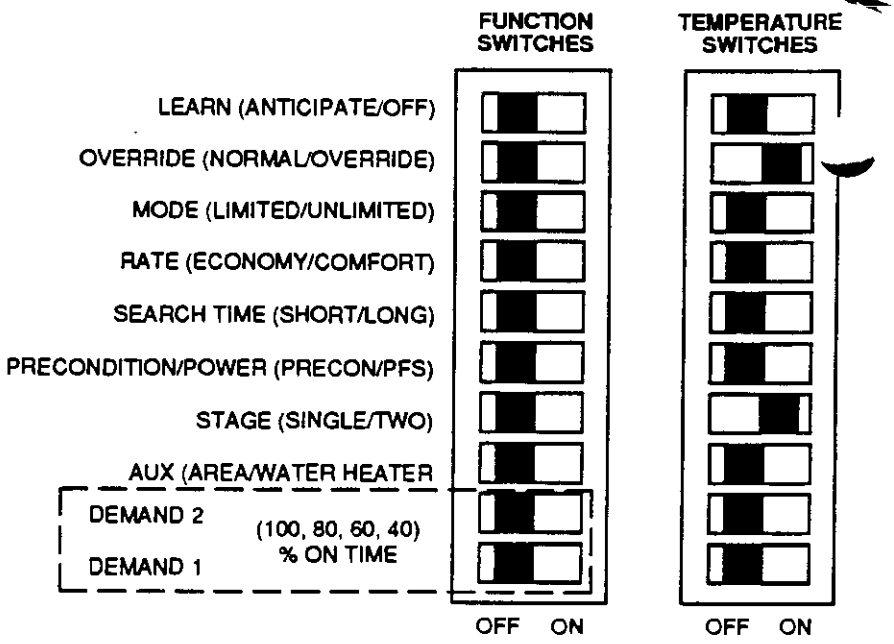
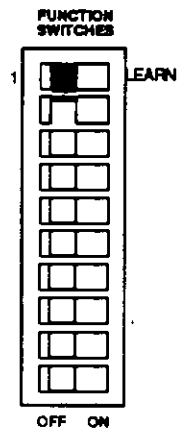


Figure 1 CS 2000 Function Switches.

3.1 LEARN (Anticipation/Non-anticipation)



The CS 2000 learns the first arrival time for each day. Every morning, using the schedule it has learned, Cs 2000 prepares the environment for occupancy. Figure 2 shows the effect of anticipation on room temperature. For installations that do not conform to a regular pattern of occupancy, the anticipatory action of learning mode should be turned off. The *learn* switch determines whether CS 2000 preconditions the environment before scheduled personnel arrival. See Table 2 for setting *learn* switch position.

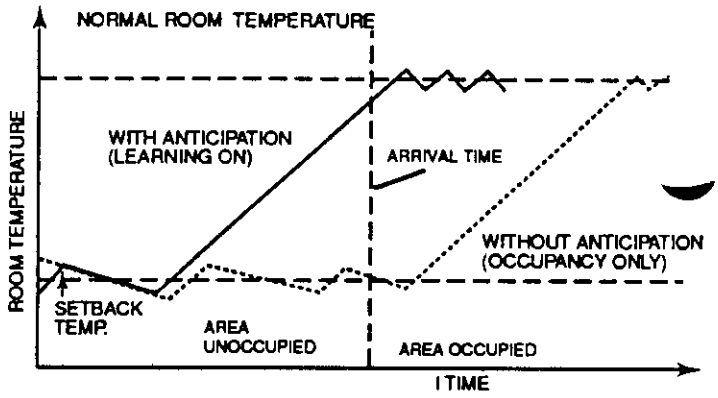


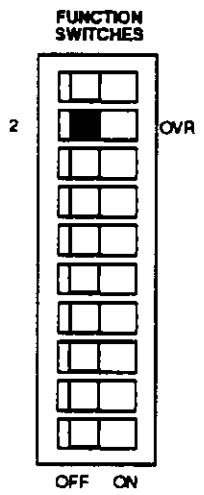
Figure 2 Room Temperature Control With and Without Learning.

NOTE: Changing mode from *anticipate* to *non-anticipate* erases any learned schedule.

Table 2 Learn Switch Functions

Learn Switch Position	Learn Mode	Description
Left	Anticipate	CS 2000 learns morning occupancy schedules Optimally starts HVAC system in advance of arrival. Only arrival time learned per day.
Right	Non-Anticipate	No advance start of HVAC before arrival. Operation restricted to occupancy-based mode only. Used for areas with radically varying schedules or for maximum energy savings in infrequently used facilities.

3.2 OVERRIDE (Normal/Override)



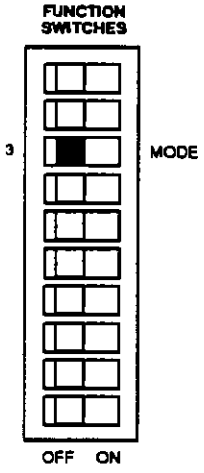
An override switch is provided to help troubleshoot problems with the HVAC system. Override operates up to 24 hours after activation by placing switch to right. Override drops out when either 24 hours elapses or when the switch is returned to the left position. See Table 3 for setting *override* switch position.

NOTE: To continue the *override* function after the 24-hour limit, turn the override switch off then on again.

Table 3 Override Switch Functions

Override Switch Position	Override Mode	Description
Left	Normal	CS 2000 produces normal control relay operation.
Right	Override	Forces closure of N/C HVAC and auxiliary relay contacts. This returns control to the room thermostat. Note that compressor protection may delay the onset of override for three minutes. LED blinks rapidly to show that override is working.

3.3 ACCESS MODE (Limited/Unlimited)



The CS 2000 operates in one of two basic occupancy modes - *Limited Access* or *Unlimited Access.* This mode gets its name depending on whether one or more doors limit entry to the room. Select the mode to match the type of area under control. This is done at the time of installation. See Table 4 for setting *access mode* switch position.

Table 4 Access Switch Functions

Mode Switch Position	Access Mode	Description
Left	Limited	*Limited access mode* uses both entry-exit doors and the built-in PIR sensor to determine occupancy. Once occupied, the thermostat retains continuous control even if the occupants remain inactive or hidden from CS 2000's field-of-view after initial detection. Choose the *limited access mode* for commercial business and offices, where occupants may be out of the infrared detection zone for long periods. See Fig. 3 for details.
Right	Unlimited	*Unlimited access mode* depends on motion detection signals for control of HVAC and auxiliary relays. The *unlimited access mode* works best in buildings, restaurants, and warehouses, where activity is more or less continuous. The *unlimited access mode* may also be used to control other equipment such as office equipment (a copy machine for example), lighting, and recreational equipment. See Fig. 4 for details.

Limited Access mode requires that CS 2000 be connected to switches on all access doors. The CS 2000 senses when a room door opens or closes by these switches. When a switch-equipped door opens, CS 2000 gives control of the HVAC system to the thermostat. Then the CS 2000 searches for motion through its built-in PIR sensor. The search period can be set for 5 or 30 minutes (see *Search Time* function switch). CS 2000 declares the room occupied if movement occurs during the search period. CS 2000 gives control to the room thermostat during occupied conditions. If the search discovers no activity, CS 2000 regains control of the HVAC system. During unoccupied periods, CS 2000 regulates the setup or setback temperature to conserve energy. See Fig. 3 below for *limited access* flow diagram.

In the *limited access mode*, a 24-hour timer monitors operation to be sure that long-term operation in the occupied state is justified. The CS 2000 must detect motion at least once within a 24-hour period to continue operation in the occupied state.

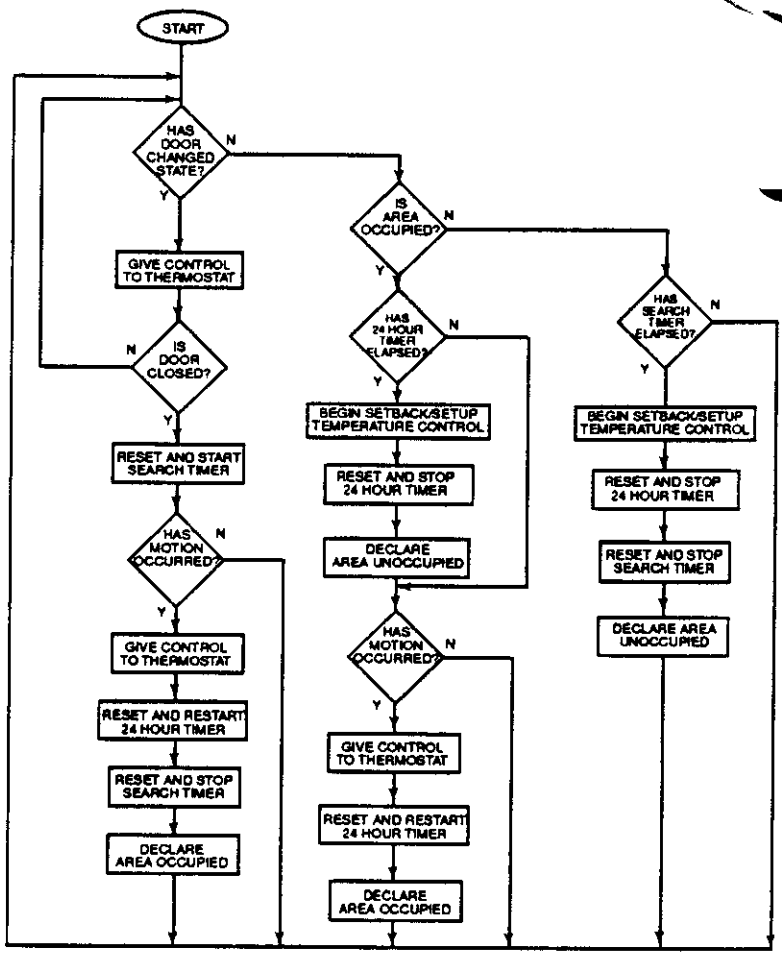


Figure 3 Simplified Flow Chart for CS 2000's Limited Access Mode. (24-hour occupancy recheck also shown.)

Unlimited access mode requires only the motion detector signal to search for occupancy. The occupant(s) must periodically move to maintain normal temperature level - once every 30 minutes or once every 60 minutes (see *Search Time* function switch). Each detection event restarts CS 2000's search timer. If no movement occurs during the search time, CS 2000 begins setup or setback operation. However, CS 2000 returns control to the room thermostat when motion occurs. See Fig. 4 below for *unlimited access* flow diagram.

NOTE: *Unlimited access mode* requires no connections to the door input terminals.

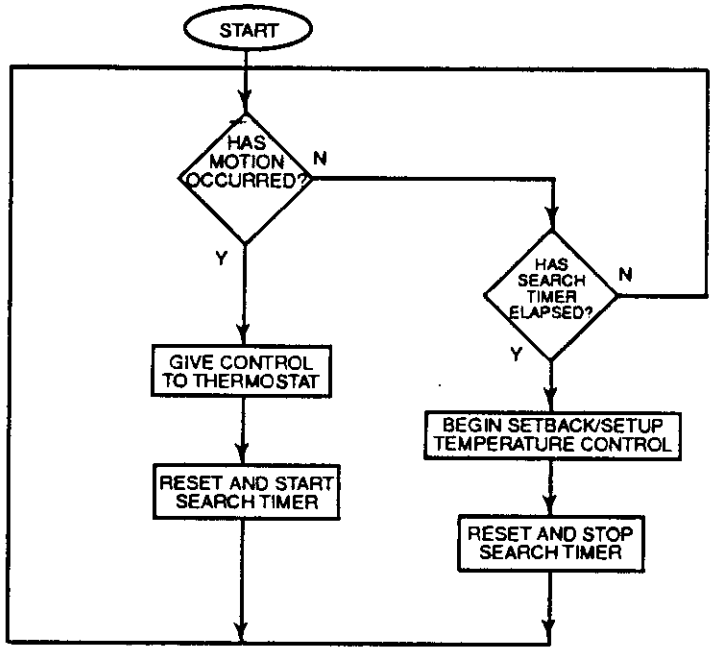
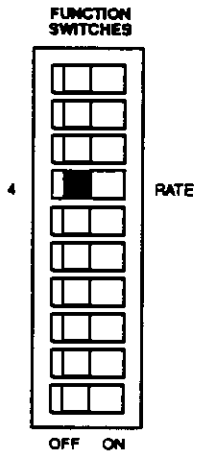


Figure 4 Simplified Flow Chart for CS 2000's Unlimited Access Mode.

3.4 RATE (Economy/Comfort)



Rate switch affects two operations of CS 2000: (1) the length of time after expected wake-up or arrival that CS 2000 holds normal room temperature before returning to energy conserving temperature; (2) the set point for temperature rate-of-increase for operation of second-stage heat (heat-pump strip-heat, for example). A comparison of economy and comfort rates appears in Fig. 5. See Table 5 for setting *rate* switch position.

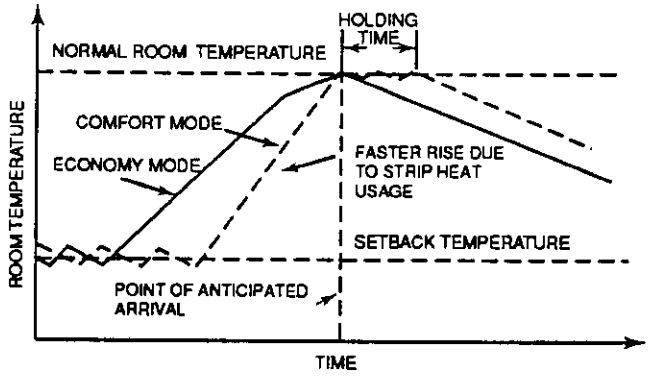
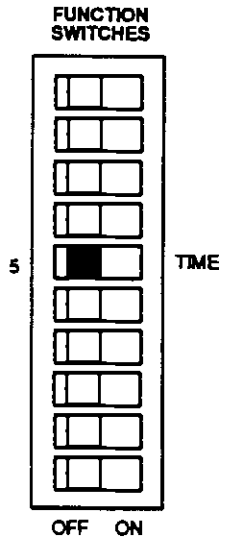


Figure 5 Comparison of Economy and Comfort Rates. For this example, the expected occupant did not arrive.

Table 5 Rate Switch Functions

Rate Switch Position	Rate Mode	Holding Period After Expected Arrival Time	Rate of Strip Heat Usage in a Two-Stage System such as a Heat Pump	When to Use
Left	Economy	No wait - CS 2000 resumes energy saving operation if no activity occurs at the expected wake-up or arrival time.	Second-stage cycled as needed to achieve 7.5 deg/hr minimum heat-up rate on recovery from setback. Rate changes to 15 deg/hr for occupied area.	*Economy* mode yields maximum energy savings. This is the normal mode.
Right	Comfort	30-minute temperature hold after expected recovery time - in case people wake-up or arrive late.	Second-stage cycled to achieve 15 deg/hr minimum heat-up rate during recover from setback conditions. Rate changes to 30 deg/hr for occupied areas.	*Comfort* position trades some economy for additional comfort.

3.5 SEARCH TIME (Short/Long)

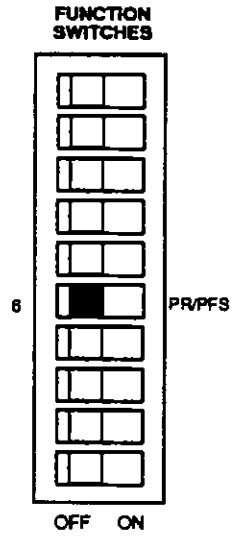


This switch sets the time that the CS 2000 searches for occupancy before taking control of the HVAC system. The search time depends on the setting of the *Mode* switch. Search times appear in Table 6 below.

Table 6 Search-Time Switch Functions.

Search-Time	Access Mode	
	Limited Access Mode	Unlimited Access Mode
Left	5 Minutes	30 Minutes
Right	30 Minutes	60 Minutes

3.6 PRECONDITION/POWER FAIL SENSE (Precondition/Power Fail Sense)

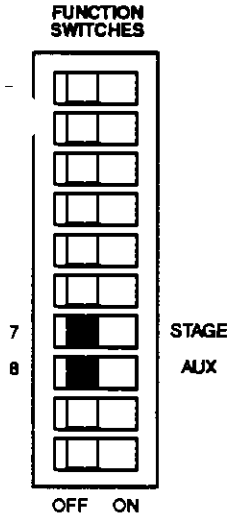


The precondition input serves a dual purpose. This switch's position determines the function of the precondition input as shown in Table 7 below. (See also Section 5.5.1)

Table 6 Search-Time Switch Functions.

Switch Position	Precondition Input Usage	Description
Left	Precondition	Input available for starting the *precondition* feature. A momentary closure starts precondition. This action returns control to the room thermostat for three hours to begin heating or cooling for later occupancy. A continuous closure to this input causes CS 2000 to remain in precondition.
Right	Power Fail Sense	Input available for signaling a *failed power condition* to the CS 2000. A change in state at this input signals the CS 2000 that all HVAC power-up functions should begin such as the three-minute lock-out timer and random delay for utility demand reduction. This input is useful when CS 2000 is powered by an uninterruptable power supply (UPS) such as a battery-charger system.

3.7 AUXILIARY RELAY OPERATION (Next two switches)



The *stage and aux* switches work together to determine the function of the auxiliary relay contacts. The four possible combinations, area occupied, water heater, second stage heat, and second HVAC system, appear in Table 8. Table 9 describes the possible operating modes and their uses.

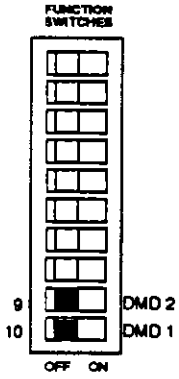
Table 8 Stage and Aux Switch Settings

Function Switches		Control Relay Operation	
Stage	**Aux**	**HVAC**	**Auxiliary**
Single (*left*)	Area (*left*)	Single Stage	Area Occupied
Single (*left*)	Water heater (*right*)	Single Stage	Water Heater
Two (*right*)	Area (*left*)	1st Stage HVAC	2nd Stage Heat
Two (*right*)	Water heater (*right*)	HVAC #1	HVAC #2

Table 9 Auxiliary Relay Operation

Mode	Relay Action	Typical Use
Area Occupied	*N/C* contacts close when the area is occupied.	Lighting, office equipment (copy machine, ...), appliances, or signal other systems.
Water Heater	*N/C* contacts close 60 min. before scheduled wake-up or occupancy and remain closed while occupied. Contacts open and close with HVAC contacts during sleep and unoccupied periods. A five-second delay separates HVAC and water heater turn-on.	Water heaters, boiler control, and other systems which require a fixed start-up time before occupancy.
2nd Stage Heat	*N/C* contacts close when calling for strip or auxiliary heat.	2nd stage controls strip heat or perimeter heater for heat pump or similar system. The Cs 2000 operates strip heat only as needed to conserve energy.
HVAC #2 lave system)	*N/C* contacts close when main HVAC relay contacts close. A five-second delay between the two prevents line-current surges.	Electrical isolation between CS 2000's two sets of relay contacts allows CS 2000 to control two separate HVAC systems. The second HVAC unit runs in parallel with the primary system.

3.8 DEMAND DUTY-CYCLE (Next two switches)



The demand switches determine the duty cycle of the HVAC during unoccupied periods. (The duty cycle is the ratio of *on* time to *total* time.) Table 10 shows switch settings for duty cycles of 40%, 60%, 80% and 100%. The 100% setting produces no duty cycling. Duty cycling occurs during temperature recovery time from power outage and while the CS 2000 preconditions an area.

When power is first applied, the CS 2000 always *locks out* the HVAC unit for three minutes. Duty cycling begins after the lock out period. Duty cycling of HVAC units reduces the highest average kilowatt (kw) usage during a utility company's averaging period. This lowers demand charges to less than they would be if all HVAC units operated continuously and recovered room temperature together.

Table 10 Demand Duty-Cycle Switch Settings.

Switch Positions		Duty Cycle (% On Time)	On Time (Minutes)	Off Time (Minutes)
Upper Switch	**Lower Switch**			
Left	Left	100	—	—
Left	Right	80	15	4
Right	Left	60	15	10
Right	Right	40	15	22.5

Demand duty cycling operates during unoccupied periods when recovering from a power failure if the room temperature is less than the setback control temperature by 2.5° F. Duty cycling also operates when recovering room temperature for occupancy. Duty cycling stops whenever the area becomes occupied or *adaptive freeze protection* takes over.

4. TEMPERATURE SWITCHES

4.1 BASIC TEMPERATURE SETTINGS

.ne temperature switches determine the setback and setup temperatures for an unoccupied area. Place a minimum of two temperature switches in the *on* position. One switch corresponds to heating setback and one to cooling setup. Two additional switches may be set to enable the *maid control* feature (see below). The LED flashes indicate an improper number of temperature switches set.

Ten switches provide six setback temperatures (48, 54, 58, 62, 65, 68) and four setup temperatures (78, 81, 84, 90) [°F]. These are shown in Fig. 6. Select 48 and 90° for maximum savings.

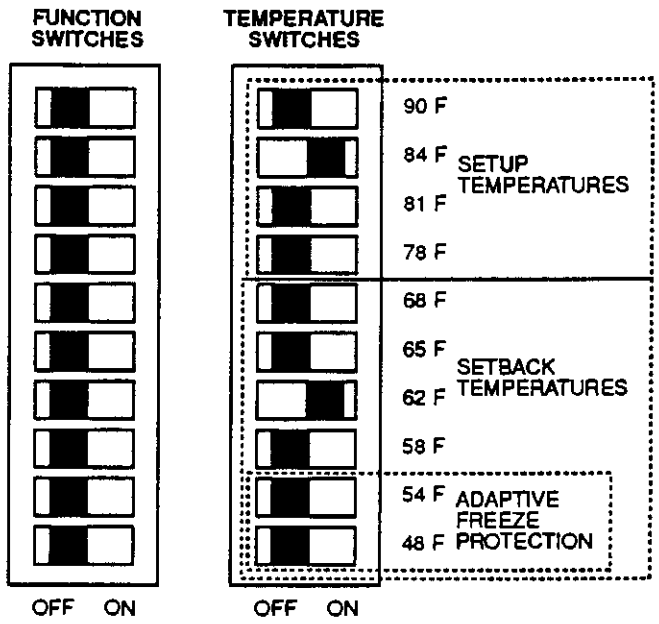
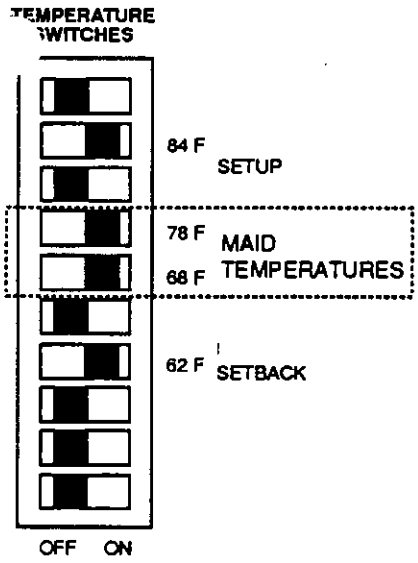


Figure 6 CS 2000
Temperature Switches

NOTE: Many users find 62°F and 84°F for setback and setup a reasonable compromise between energy savings and comfort.

4.2 MAID CONTROL



Many times in a commercial environment, service personnel perform their duties after normal working hours. These duties include janitorial work and security checks. Some facility managers prefer not to recover normal room temperature fully for the benefit of service personnel. The CS 2000's *maid* function allows a partial recovery to an intermediate temperature during the late-night hours when personnel are present. The *maid* control feature becomes functional once the area becomes unoccupied after having been occupied for at least eight hours following the initial arrival time. *Maid* control stops after eight hours of operation.

NOTE: The *maid* feature works only in *anticipation* model

Selecting either three or four temperature switches enables the *maid* function. For four temperature switches selected, the two inner switches become the setup and setback values for maid control. For three switches, the following applies: (1) two switches placed in the setup range and a third in the setback range - CS 2000 chooses the upper maid temperature to be the lower of the two setup switches and the setback switch becomes the lower maid temperature; (2) one switch in setup and two in setback range - the setup and upper of the setback switches become maid temperatures.

)TE: Do not use *maid control* if office personnel routinely or even occasionally work overtime. ɔffice workers may find the intermediate temperatures uncomfortable.

4.3 ADAPTIVE FREEZE PROTECTION

Adaptive freeze protection functions as needed with selection of either the 48 or 54°F setback temperatures. This feature checks for excessive heat loss (or very cold outside temperatures). The CS 2000 does this by measuring the rate at which temperature falls during the heating unit's off cycle.

Excessive heat loss triggers CS 2000 to temporarily select the next higher setback temperature (up to 58°F). This feature protects pipes from freezing in excessively cold weather. The temperature returns to its prior setback temperature when the rate of fall returns to normal. No seasonal changes to the temperature switches are needed because of the *adaptive freeze protection* feature. The CS 2000 automatically operates through summer and winter without changing setup and setback temperatures.

4.4 TEMPERATURE CLAMP

The CS 2000 employs a temperature limiting algorithm that prevents wasteful energy use and mis-operation of HVAC equipment. This waste occurs when personnel set the room thermostat too hot in winter or too cold in summer. The *temperature clamp* feature operates only when the area is occupied and the room temperature exceeds 79°F (in winter) or falls below 67°F (in summer). Under normal circumstances, the limit action never engages.

Temperature clamp is automatic and is not switch selectable. CS 2000's software automatically determines the climatic season during unoccupied periods by measuring room temperature fall (or rise). This measurement occurs whenever the CS 2000 turns off the HVAC unit. The season test determines whether the upper or lower temperature clamp functions. CS 2000 cancels the limit feature when the season determination may be uncertain. This uncertainty occurs during mild weather conditions. Room temperatures above 79°F (or below 67°F) enable the limit action. When the limit operates, HVAC operation stops. This allows room temperature to drift freely. CS 2000 calculates the direction and magnitude of the drift and verifies the season. The temperature limit remains in effect once the proper season is confirmed.

5. INSTALLATION

5.1 OVERVIEW

The CS 2000 system consists of a CS 2000 energy management controller plus other support parts as needed. Typical parts include door switches (for limited access operation) and a wall transformer (for installations in which low voltage power to operate CS 2000 is otherwise unavailable). Substitute a battery-backed power source for the wall transformer to retain learned schedule during loss of power. Also battery-backed power may be needed when CS 2000 is part of a security system. Additional parts include remote occupancy sensors (for additional area coverage) and power relays (for control of voltages greater than 24 VAC or currents greater than one ampere).

Wiring should be 18 gauge between the CS 2000 and the room thermostat (to interrupt the thermostat wire). Use 18 to 22 gauge wire between CS 2000 and other parts. Use Table 11 to choose the proper wire sizes for the total length of run.

Table 11 Minimum Wiring Gauge for CS 2000 Installation

Connection	Total Wire Length (ft.)		
	0 to 200	200 to 600	600 to 1000
Cs 2000 Power 12-18 Volts	22 AWG	20 AWG	18 AWG
Cs 2000 Power 18-24 Volts	22 AWG	22 AWG	20 AWG
Thermostat and Other Relays	18 AWG	16 AWG	14 AWG
Door and Other Signal	22 AWG	22 AWG	20 AWG

Installation and setup of a CS 2000 energy management controller requires no unusual tools or equipment. A partial list of tools necessary for proper installation appears in Table 12.

Table 12 CS 2000 System Installation Tools

Tool	Use
Multimeter	to measure AC & DC voltage & resistance
Screwdrivers	1/8" flat blade and #2 Phillips
Long-nose pliers	(small) for bending wire
Wire cutters and strippers	for #18 to #24 AWG
Drill and Bits	for mounting Model 3302 and door switches
Fish tape	for running wires through walls
Hammer	(small) for removing and replacing trim

tall the system by mounting the CS 2000 and other parts as required. Then connect these parts ıogether and wire to the thermostat. After installation, set the function and temperature switches to meet the facility requirements. Test the system for proper operation.

5.2 PRECAUTIONS

HVAC units contain hazardous and lethal voltages. Before removing any HVAC access panels or wiring to high-voltage, be sure to turn power off. Turn off and tape the HVAC circuit breaker to the off position. Be sure to label the breaker properly. Before proceeding, measure the voltage with a meter to be sure that power is off to the unit. Coordinate this installation with your supervisor and other personnel, and let them know that you are working with high voltages.

DANGER: Remove power from the HVAC system and CS 2000 while making connections. This prevents possible damage to the HVAC system as well as eliminating any danger to personnel. Use acceptable materials when making connections to the 24 VAC wiring. Materials and workmanship should meet the appropriate codes in your area. All connections should be tight and well insulated. Wire and wire nuts should be of the proper size.

WARNING: Connect the CS 2000 to the HVAC system through the 24 VAC wiring of the room thermostat. Use a power relay if the thermostat voltage is greater than 24 VAC. See special instructions in the appendices for use of power relays.

CAUTION: The CS 2000 contains sensitive electronic components. There are no serviceable parts in the unit. Use caution when working near CS 2000 with a screwdriver. Treat the switches delicately. use your finger or a small screwdriver to move them from one position to another.

DO NOT APPLY POWER TO THE CS 2000 UNTIL YOU ARE INSTRUCTED TO DO SO!

5.3 SELECTING A LOCATION

Mount CS 2000 about seven feet (7 ft.) from the floor in a high-traffic location which permits detection of a person conducting normal activity in the area. Typical high-traffic locations are entrance foyers, main hallways, and kitchens. Judgment is required to select a suitable location.

The CS 2000's PIR motion sensor has a long narrow detection pattern incorporating dual-detection zones to reduce false trips due to environmental temperature effects. The zones tilt downward at a 10-degree angle. The PIR sensitivity is preset for room lengths up to 60 ft. The approximate detector characteristics appear below in Table 13 and in Figs. 7 and 8.

Table 13 Passive Infrared Detector Characteristics.

PIR Parameter	CS 2000 Characteristics
Number of Detection zones	2 (opposed polarity)
Downard Beam Angle	10 degrees
Intersection of Zone Centerline with Floor	40 ft. (with Model 3302 mounted 7 ft. from floor)
Closest Coverage	5 ft. for 5 ft. person (depends on mounting height)
Width of Coverage	8 ft. at 20 ft. (approx. 2.8:1 distance-to-width ratio)
Maximum Distance	60 ft. or greater

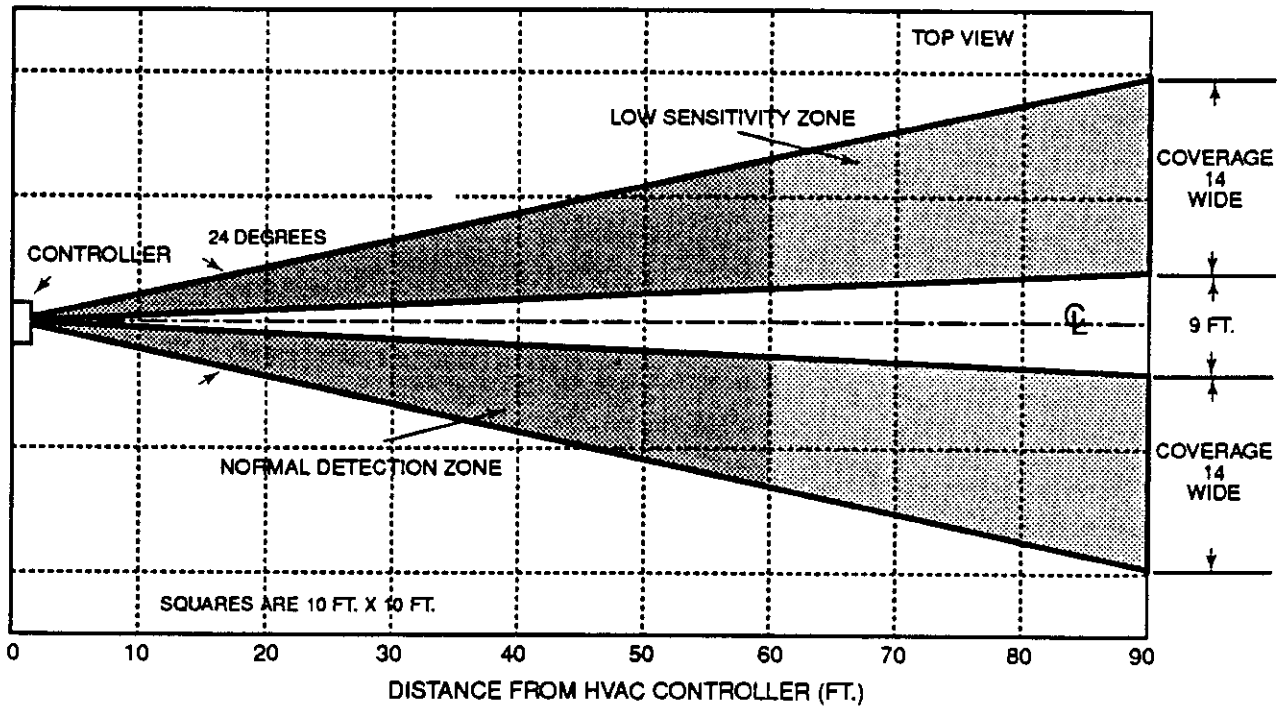


Figure 7 Top View of CS 2000's Passive Infrared Coverage*

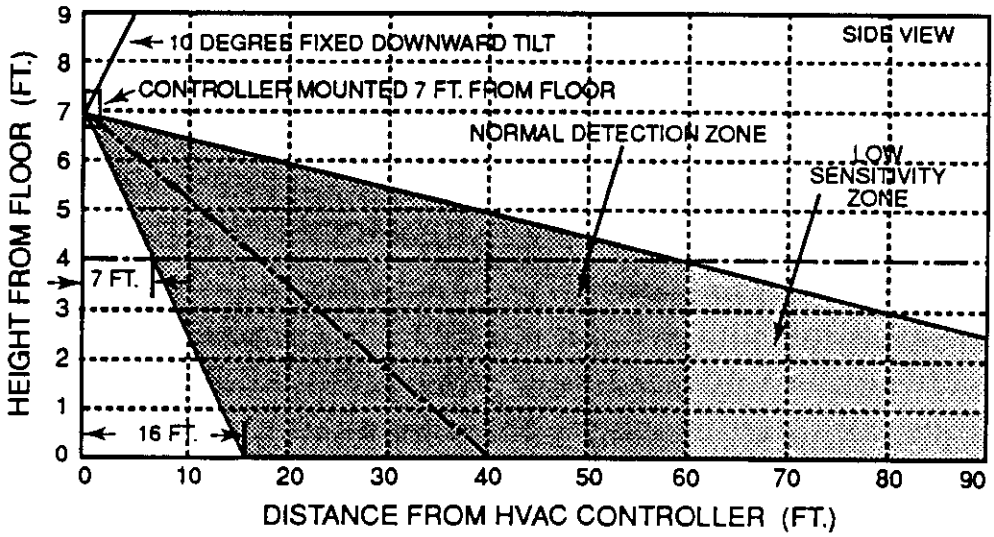


Figure 8 Side View of CS 2000's Passive Infrared Coverage*

**Ranges are approximate and assume that wall is plumb and floor is level.*

Please observe the precautions given in Table 14 when selecting a mounting location:

Table 14 Suggestions for Mounting CS 2000

DO	DON'T
Do mount CS 2000 in the vertical position (sensor window down) about seven feet from the floor pointing along the main traffic path where people travel. Point detection zones down a hallway when possible.	Don't mount flat on the wall in a corner. The adjacent wall blocks part of the sensor's field-of-view. Don't mount in a location that allows a person to enter then pass out of the field-of-view before the door closes and the three-second PIR blank ends. (For example, slow closing doors and field-of-view perpendicular to hallway).
Do make certain that the optical path remains unobstructed	Don't mount in a location in which the field-of-view may later become blocked (for example, doors, curtains, or furniture). Don't touch the lens or the protective sheet over the window in the cover.
Do locate CS 2000 as you would a thermostat, out of air currents and direct sunlight.	Don't mount over or in the direct draft of HVAC vents. Don't mount in a location that can receive direct sunlight. Don't face the sensor towards any object that may change temperature rapidly (for example, radiant heater, fireplace, etc.).
Do locate CS 2000 to conceal its wiring behind molding, in corners, or in the walls.	Don't locate so wiring is visible, thus exposed to vandalism.

5.4 MOUNTING AND WIRING

Remove the cover and mount the CS 2000 to the wall in the selected location with the mounting screws included. An exploded view showing CS 2000's parts appears in Fig. 9.

Run wiring through the hole in the base near the terminal strip. Connect the wiring to the terminal strips according to the wiring diagrams shown on pages 19 and 20. Read carefully the input/output terminal descriptions. All wiring should be done neatly and professionally. **Do not** run any wires behind the circuit board; keep wiring at the top. Wires close to and directly behind the circuit board may interfere with operation causing false detections in some instances.

NOTE: Be sure to position the cover on the base so the window in the case is over the passive infrared sensor.

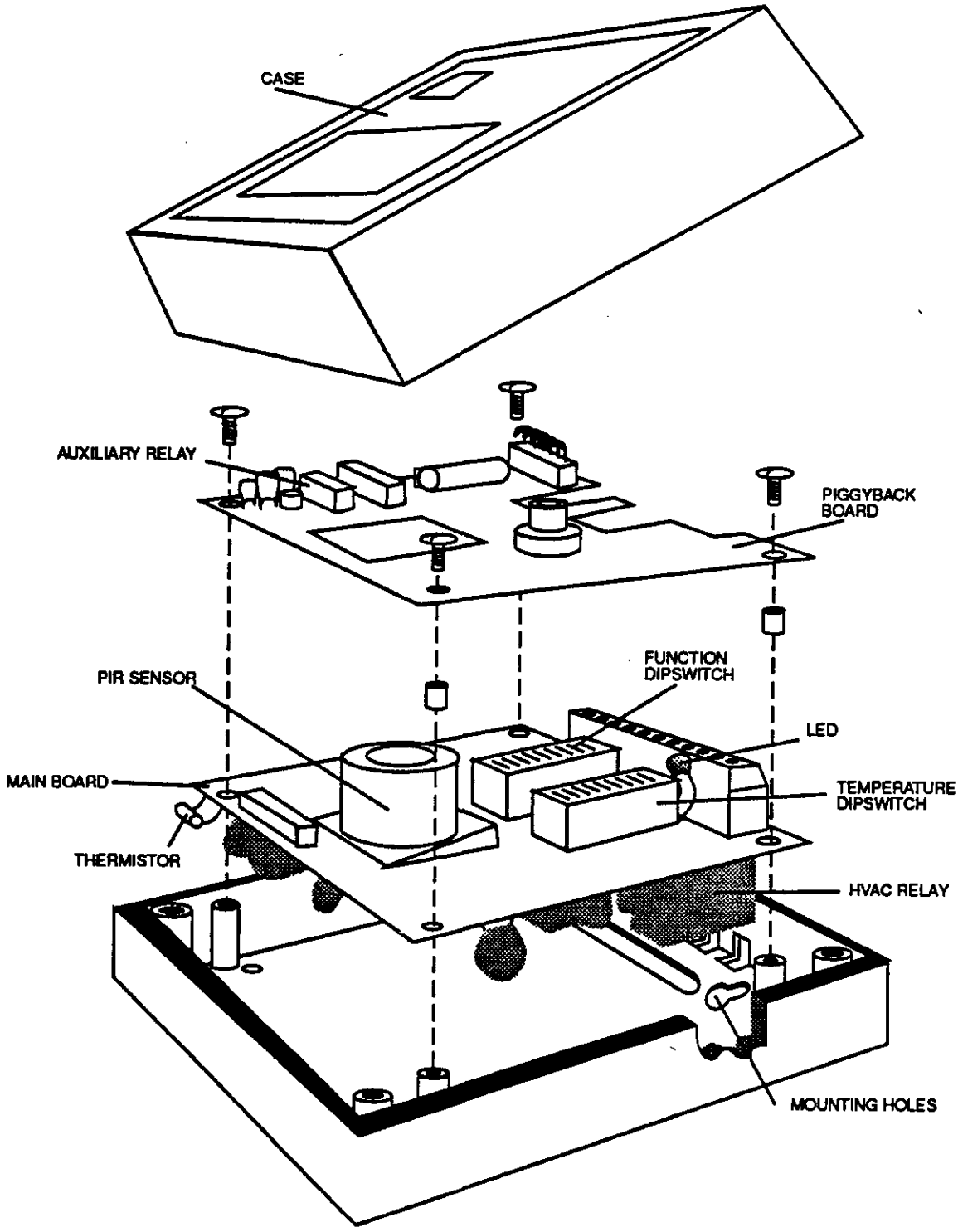


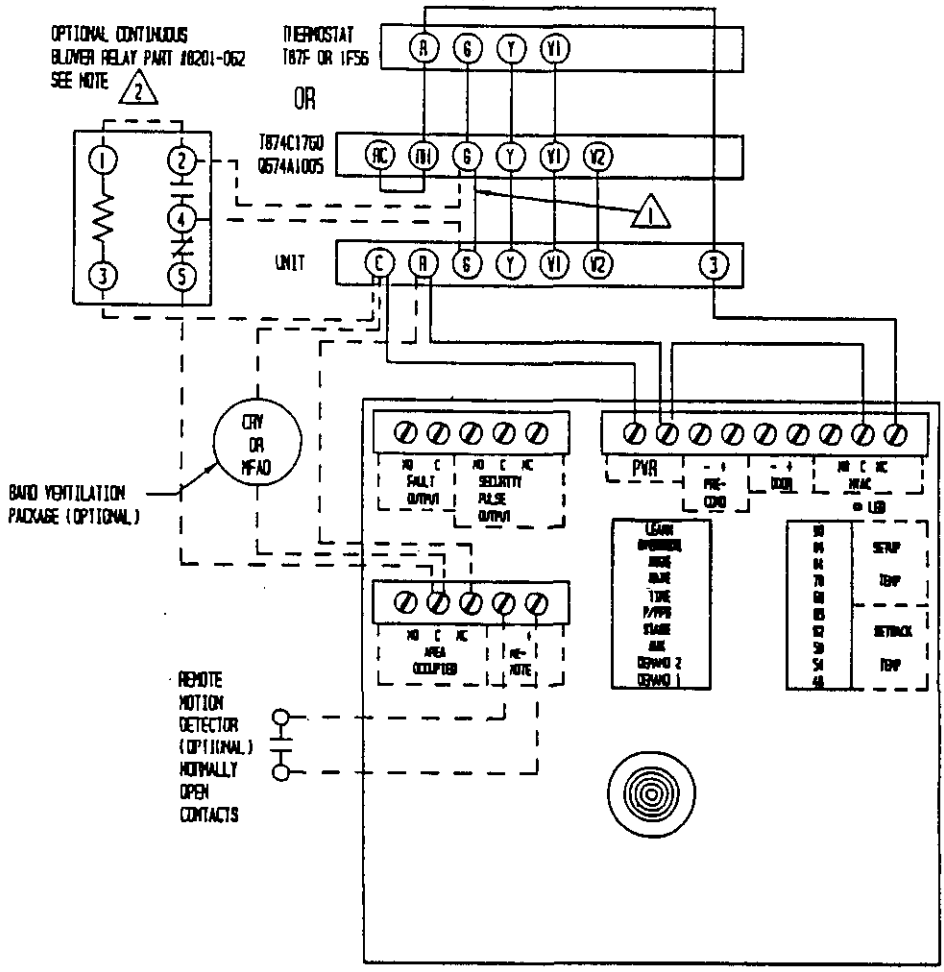
Figure 9 Exploded View of CS 2000

5.5 INPUT AND OUTPUT TERMINALS

ut and output terminals are located on the CS 2000's main and piggy-back circuit boards.

Be sure to mark and code installation wiring for future reference. This practice is crucial for later upgrading and troubleshooting of the system, especially when wiring to existing HVAC or other equipment.

AIR CONDITIONER CONNECTION DIAGRAM

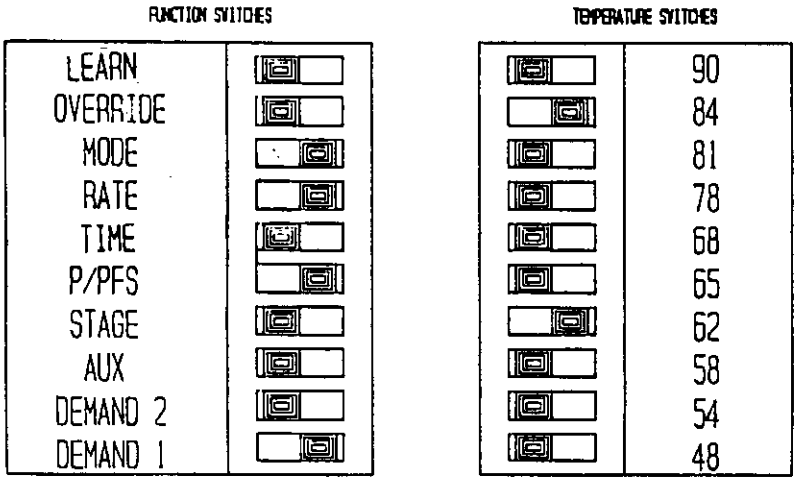


1 REMOVE THIS WIRE WHEN EMPLOYING OPTIONAL CONTINUOUS BLOWER RELAY.

2 THIS RELAY ENERGIZES THE INDOOR BLOWER RELAY WHEN THE ROOM IS OCCUPIED TO PROVIDE CONTINUOUS FRESH AIR THROUGH THE BARD VENTILATION PACKAGE.

RECOMMENDED SWITCH SETTINGS SHOWN BELOW

THIS SYSTEM MAY BE CUSTOMIZED TO INDIVIDUAL INSTALLATIONS. REFER TO CS2000 TECHNICAL REFERENCE MANUAL FOR CUSTOMIZATION OPTIONS.



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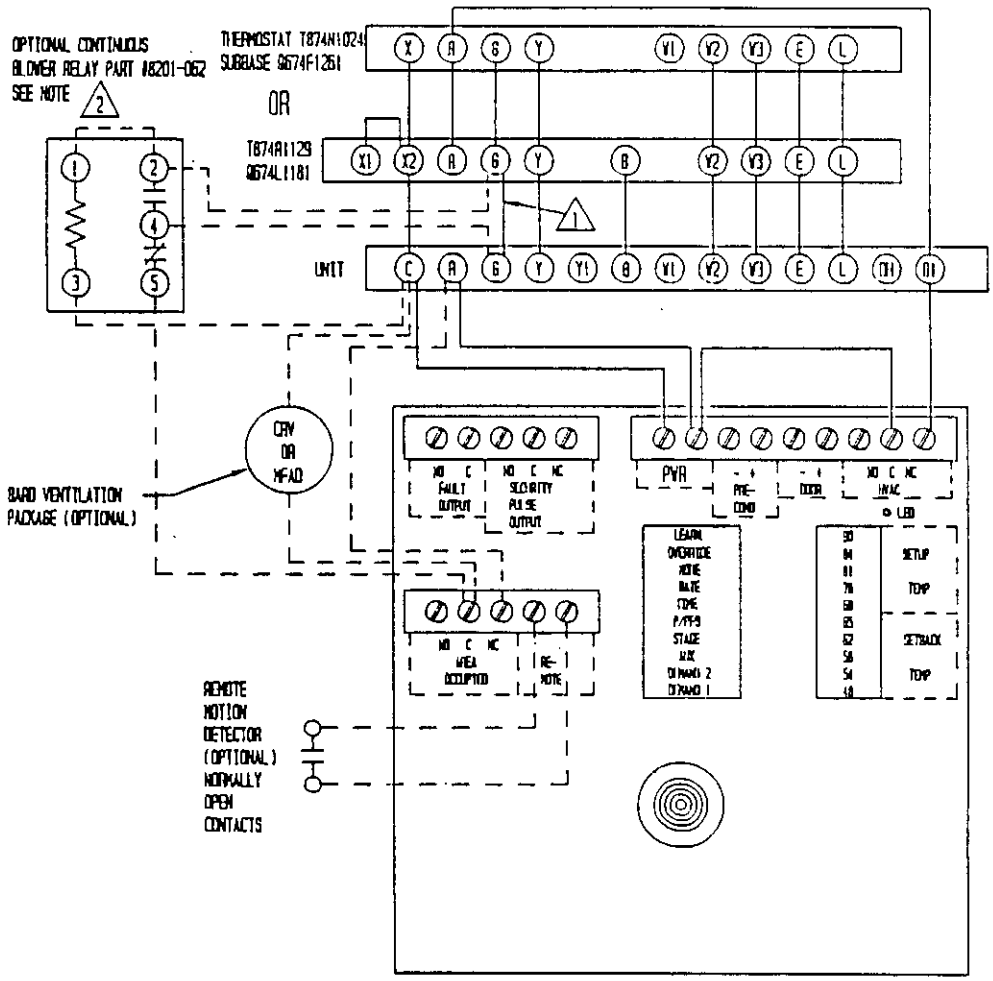
HEAT PUMP CONNECTION DIAGRAM



1 REMOVE THIS WIRE WHEN EMPLOYING OPTIONAL CONTINUOUS BLOWER RELAY.

2 THIS RELAY ENERGIZES THE INDOOR BLOWER RELAY WHEN THE ROOM IS OCCUPIED TO PROVIDE CONTINUOUS FRESH AIR THROUGH THE BARD VENTILATION PACKAGE.

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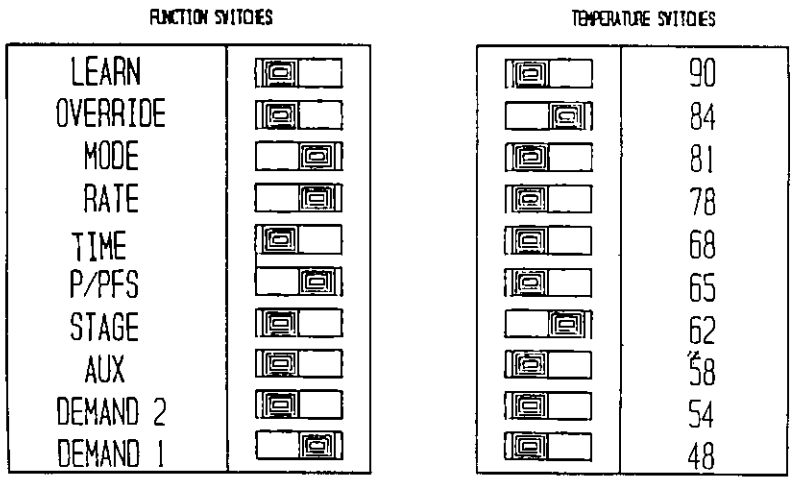
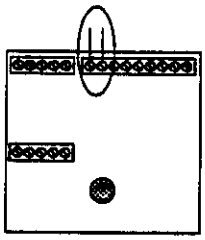


4093-113



POWER INPUT: The CS 2000 accepts a wide range of input voltages - 12 to 24 VAC or 12 to 30 VDC. Current draw varies inversely with applied voltage. At 24 VAC, current is about 100 ma (0.1 Amp). The current draw is shown in Fig. 11. The power supply is fuse protected. Supply power by a Class II transformer to prevent shock and fire hazard. A 10 volt-amp (VA) transformer is adequate. However, when choosing a transformer, also consider the current draw of other relays that connect into the transformer circuit.

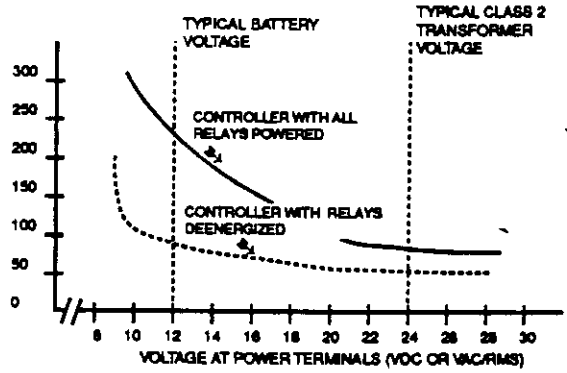
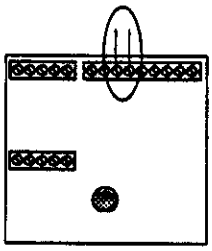


Figure 11 CS 2000's Current Draw Varies with Applied Voltage



PRECONDITION (POWER-FAIL-SENSE) INPUT: This is a dual-purpose input. As explained in Section 3.6, its use depends on the setting of *precondition/power-fail-sense* switch. With CS 2000 in *precondition* mode, a momentary contact closure to the input starts the preconditioning process. This action returns control to the room thermostat for three hours to begin heating or cooling an area for later occupancy. Continuous closure causes CS 2000 to remain in precondition until contact closure is released. See Appendix A for further discussion.

The *power-fail-sense* input signals power status to the HVAC system. The *power-fail-sense* mode is necessary when the CS 2000 is powered from a continuous power source and the start-up functions are needed. With CS 2000 in *power-fail-sense* mode, any change in state of the input contacts (open-to-close or close-to-open) triggers HVAC start-up functions such as three-minute lock-out and demand duty-cycling. The *power-fail-sense* input accepts a dry relay contact. Use a relay that changes state either from open-to-close or close-to-open when power returns after an outage. Power the coil of a Form *A* or *C* relay from the same AC line that powers the HVAC system. Connect either the N/O or N/C relay contacts to the *power-fail-sense* input (Fig. 12). In some cases, the nearest AC line or a contact from the UPS is acceptable. Use only contact closure. Do not apply external voltage to these terminals.

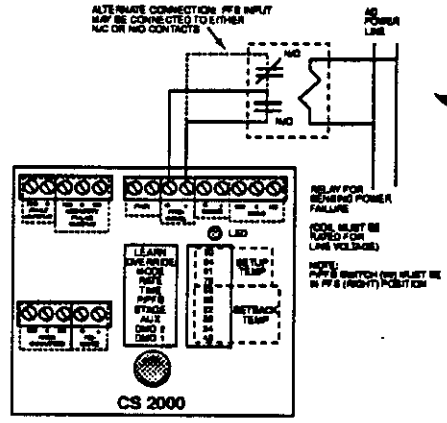
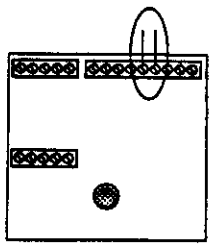


Figure 12 Connect the power-fail-sense input to either N/C or N/O contacts of a line powered relay.



DOOR SWITCH INPUT: Connect the contacts of a normally-open (N/O) door switch to these terminals. Check Fig. 13 for proper switch logic.

NOTE: N/O contacts remain closed when the door is closed and open when the door is open.

When sensing many doors, wire door switch contacts in series. Use contact closure only. Do not apply voltage to these terminals.

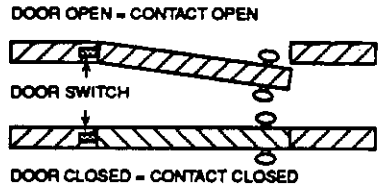
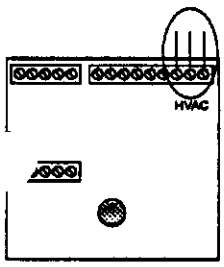


Figure 13 Required Door Switch Logic



HVAC CONTROL OUTPUT: The HVAC control output is a Form C, pilot current (1 amp) relay designed to interrupt thermostat operation. Contacts are paralleled by transient suppression devices. The relay de-energizes and the N/C contacts *close* with the area occupied. This state gives control to the thermostat. When the area becomes unoccupied, the N/C relay contacts open and close as needed to maintain setback or setup temperature. These contacts also open when the area exceeds 122°F to prevent spread of smoke by the HVAC. The HVAC relay contacts return to a closed state with power removed.

NOTE: Do not use a programmable setback thermostat in conjunction with a CS 2000 controller. The programmable thermostat requires *trickle* voltage to maintain internal battery charge. Also their programming may clash.

To connect CS 2000's control relay to the thermostat, cut the red wire (or wire connected to the terminal marked *R*) to the thermostat. Place the N/C contacts in series with it. The object is to place CS 2000's control relay contacts in series with the thermostat's common power connection. Thermostat connections are shown in Fig. 10. CS 2000's contacts are rated for 24 volt pilot current only.

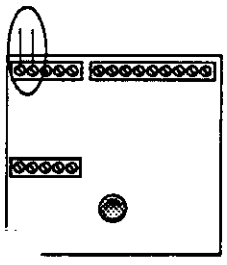
NOTE: Be careful <u>not</u> to splice into the fan control wire (usually the green wire). This can cause CS 2000 to stop the fan while the thermostat continues heater operation, which causes burnout of electric heater elements.

LED INDICATOR: The LED indicates several conditions about the CS 2000 and the environment.

lotion. The LED shows motion as the infrared sensor detects it. The LED lights *momentarily* about a second after each detection. Use this for checking the field-of-view. Be sure to close doors before checking motion detection.

- **Improper Temperature Switch Setting.** The LED *slow flashes* if the temperature switches are improperly set. See Section 4 on setting temperature switches.
- **Manual Override.** The LED *fast flashes* to show that manual override is in effect.
- **Out-of-Range Temperature Condition.** The LED lights *continuously* if room temperature is out of the range of values selected by the temperature switches. The LED lights also if room temperature exceeds 122°F.
- **Door Open.** The LED lights *continuously* when the door is open (only in limited access installations). Be sure to close all doors before trying to check PIR response.

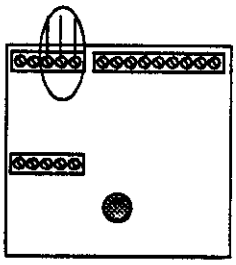
5.5.2 Piggy-Back Circuit Board



FAULT SIGNAL OUTPUT: The fault output is a Form A, low-current (0.1 amp dry circuit) relay contact. Connect the fault output to a digital communicator to report HVAC malfunction to a central station or a supervisory system. The fault output contacts close under the following conditions:

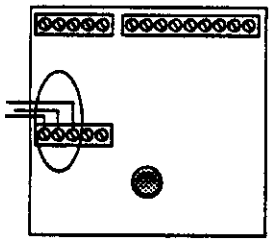
- **HVAC Failure.** HVAC unit fails to meet setup or setback temperatures (room temperature 3.5°F higher than setup or 3.5°F lower than setback temperatures).
- **Incorrect Switch Setting.** Temperature switches on CS 2000 are improperly set. (See Section 4 for correct settings.)

• **Possible Fire Condition.** Area temperature exceeds 122°F.



SECURITY PULSE OUTPUT: The security output is a Form C, low current (0.1 amp dry circuit) relay contact that changes state for 0.8 sec to signal motion detection. This security signal results from either an event detected by CS 2000's internal sensor or by a closure at the remote sensor input. This output can signal motion to other CS 2000s or to a security system. A short pulse also results from loss of power.

NOTE: Power CS 2000 from a battery-backed supply if using this output for security alarm. This prevents false alarms and loss of coverage during an outage.

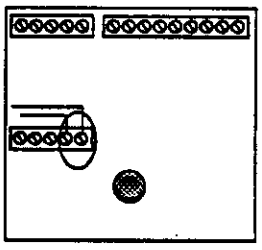


AREA-OCCUPIED OUTPUT: The area-occupied output is a Form C, pilot current (1 amp) relay. Contacts are paralleled by transient suppression devices. One of four different functions may be chosen for this output. These functions and the required switch settings appear in Tables 7 and 8 of Section 3.7. The relay contacts are rated for 24 volt pilot current only. Output modes are summarized below:

•**Area Occupied.** The N/C contacts close with the area occupied and open when unoccupied. Use these contacts to control lighting, office equipment, appliances, or signal occupied status to another location. If power fails, the output goes to the occupied state.
•**Water Heater.** The N/C contacts close to operate an electric water heater. A power relay must control 240 VAC power to the heater. Appendix B illustrates application of a power relay.
•**Second Stage Heat.** This output is primarily used for heat pump applications. The CS 2000 closes the N/C contacts to permit thermostat control of strip heat and opens them to inhibit strip-heat operation. The N/C contacts fail to a closed state if power fails.

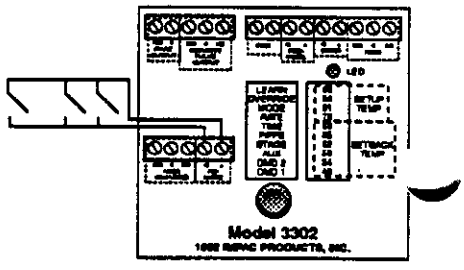
To connect these contacts to a thermostat, cut the *white* wire (or wire connected to the *W* or *W1* terminal) that runs from the HVAC unit to the thermostat. Place the N/C area-occupied relay contacts in series with it. Be sure the function switches are set for second stage heat. Appendix C illustrates application of second stage heat.
•**Second HVAC system.** The CS 2000 controls a second (slave) HVAC system using this output mode. The N/C contacts close to operate the system. The advantage of this output mode is that one CS 2000 can control two HVAC systems. This saves the cost of an additional CS 2000. The disadvantage is imprecise control of the second system's temperature since CS 2000 measures temperature only for the area of the main system.

NOTE: Because the CS 2000 contains only one auxiliary relay, only one function of the four above can be selected for the installation.



EXTERNAL SENSOR INPUT: Connect the N/O contacts of a motion sensor to these terminals for coverage of additional rooms or areas.

NOTE: The contacts of the remote sensor must remain open until motion occurs. Then they should momentarily close.



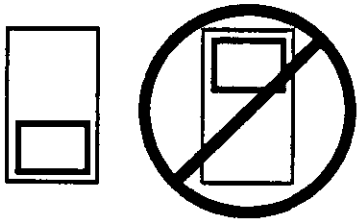
Connect motion sensor contacts in parallel for multiple sensors (Fig. 14). Passive infrared, ultrasonic, and microwave types of motion sensors are acceptable. Floor mats may also be used. Use contact closures only. Do not apply an external voltage to these terminals.

5. TESTING

Be sure that the HVAC unit under the CS 2000's control is properly functioning before beginning the CS 2000 installation. Have the HVAC system checked by a specialist if you suspect a problem. With the HVAC working properly, proceed with the CS 2000 installation. Test the completed installation as described in Table 15 below. Appendix E contains form #IPC/9011, *CS 2000 Installation quality Assurance Form.* Use this form to document the installation details and as a testing checklist. Be sure to leave a copy at the installation site for the owner's records, keep a copy for your organization, and return a copy to your factory representative.

Table 15 CS 2000 System Test Procedure

Test Step	Action	Comment
	Before Installation of CS 2000	
TEST HVAC UNIT	Check HVAC unit for proper functioning prior to CS 2000 installation. Check both heating and cooling modes if possible.	Have HVAC system checked by reputable professional before proceeding if problem is suspected.
	After Installation of CS 2000	
/ERIFY ALL WIRING CONNECTIONS AND SWITCH SETTINGS	• Be sure that the wiring is correct after installing CS 2000 and other accessories. • Be sure that the Function and Temperature switches are properly set. • Be sure that all controls for the HVAC system and other devices are properly set.	The HVAC system's wiring may not conform to the color docing conventions described in this manual or you may suspect an unusual wiring strategy. In these cases, yhou must positively verify the system's connections by consulting its wiring diagram and tracing the wiring if necessary.
APPLY POWER	• Remove CS 2000s cover. • Apply power to the system. • Measure the power input connections to CS 2000 to be sure that proper voltage is present.	• A flashing LED indicates improper temperature switch setting. • The HVAC unit should lock out for about three minutes. Also, there is a 30-second warmup after applying power before the PIR sensor operates.
CHECK DOORS	Check door-switch operation if you are installing a *limited access system.* Opening an entry-exit door should light the LED. The LED should go out with all doors closed. Check each door by opening each separately and watching that the LED lights.	Leave doors closed for the next test. This allows the LED to respond to motion detected by the intrared sensor.

Test Step	Action	Comment
WALK-TEST INFRARED DETECTOR	• Check the field-of-view of the infrared sensor with all doors closed. Perform this check by walking around the room and watching the response of the LED. the LED should light momentarily about a second after each detection. • The response of additional motion detectors connected to the remote input should be checked in the same manner.	After door closes, the sensor waits 2.5 seconds before looking for motion. CS 2000's field-of-view should cover an area in the zone of the controlled HVAC system. A person should not be able to pass undetected through the zone. Use the *do's* and *don'ts* of Table 15 as guidelines for CS 2000 placement and orientation.
REPLACE COVER	Replace the cover on CS 2000 after being sure that the system is functioning properly. Be sure to correctly orient the window in the cover over the passive infrared sensor.  YES NO	During testing, installer may place CS 2000's cover in the inverted position to block detection of local motion. This blockage simulates an unoccupied area without having to leave. ***However, the cover must be returned to normal position before leaving the site.***
CHECK OPERATION OF CONTROLLED EQUIPMENT	Check for proper operation of HVAC system. After three minute lockout timer elapses, either motion or opening a door should return control to the HVAC. Be sure to turn on the thermostat. Set it to the correct temperature(s), and proper operating mode.	Beware of *electronic setback* thermostats. They usually require constant trickle current. Replace with conventional type thermostat for reliable service.
LEAVE SYSTEM IN PROPER WORKING ORDER	Set thermostat(s) to correct temperature, and season position. Lock thermostat's tamper-proof case if present. Be sure all wires and access panels are secured.	• Fill out Installation QA form (IPC/9011) and distribute. • Leave copy of Customer Survey (IPC/9013) for site manager OR homeowner to fill out and return.
FUNCTIONAL CHECK	• Perform a complete functional check of the entire system. Allow a full cycle to complete. • The installer must be sure that the HVAC system is properly operating before leaving. If a problem is suspected, use *manual override* to return control to the thermostat. Remember *manual override* operates for 24 hours from the moment the switch is thrown to the right.	With CS 2000 in the *anticipation* mode, testing may be performed for up to one hour from the time power is applied. After the hour elapses, the CS 2000 returns complete control to the HVAC unit until synchronization occurs the nest morning. (See Section 2.2.1.) This limitation does not apply to CS 2000 installations operating in the *non-anticipation* mode.

APPENDIX A

USING THE PRECONDITION FEATURE

The CS 2000's precondition feature allows an HVAC system to *preheat* or *precool* an area for later occupancy while presently unoccupied. (Whether in heating or cooling depends on the room thermostat's switch position.) Several applications for preconditioning exist. (1) Areas with a predominate occupancy schedule may sometimes be used with advance notice outside of their normal schedule. (2) Some areas have no regular schedule but their usage may be known in advance. (3) Some areas must be strictly controlled by a supervisor. Summer cottages, winter resorts, and some condominiums fit this application.

Any source that provides a contact closure can send a command to CS 2000's precondition input. Once activated, the precondition state lasts for three hours. With the demand duty-cycle option set, CS 2000 cycles the HVAC at the selected duty cycle during the precondition period. A continuous closure of the precondition input enables the HVAC unit for as long as the input remains shorted. This keeps the area in extended precondition. The three-hour timer starts once the contact reopens. The precondition input terminals accept commands from remote devices such as a manual pushbutton, a timer, a master energy control system, or a telephone control device.

> **NOTE: Be sure *function switch #6* is set to *precondition mode* before using this input to start preconditioning.**

TIMER MODULE

A mechanical or electronic timer may be used to start preconditioning. Preferably, the timer should run on a battery-backed power supply so loss of electrical power does not disturb its programming. Set the timer to turn on at a specific time each day or on specific days depending on the capabilities of the timer selected.

Remember the three-hour preconditioning period begins when the contact closure releases. To precondition, the timer should produce a short contact closure (no shorter than one second). A continuous closure to the precondition input causes CS 2000 continuously to enable the HVAC unit.

REMOTE TELEPHONE RELAY

Several types of modules are available to decode a Touch-Tone™ sequence over the telephone lines. The module can open or close signal-level contacts. Installation is similar to the timer module above. Connect the precondition terminals to the normally open contacts of the telephone module. With this method, a phone call (and the entry of a short code) from any location starts preheating a facility.

APPENDIX B

CONTROLLING LOADS GREATER THAN 24 VAC OR 1 AMP

Control of loads greater than 24 VAC or one Amp may be necessary in some installations. Either of these conditions exceeds the rating of CS 2000's control relays (HVAC and area occupied).

The CS 2000's relay contacts can operate a power relay to control larger loads. More than one power relay may be employed to control several separate, isolated loads. Use the contacts to energize the coils of larger power relays or contactors. Be sure that the power required by the extra relay coils does not exceed the VA rating of CS 2000's internal relay contacts.

The coils of external power relays need a voltage source. If possible, use the same power source supplying current to CS 2000 to power the external relay coils. However, be sure the source has an adequate rating. Usually, a 24 VAC wall transformer with at least 30 VA output is adequate. Also, 24 VAC from the HVAC system may be used if available.

A power relay or contactor may be supplied with either N/O or N/C contacts. Use N/C contacts where possible so system defaults to operating state with a failed coil. Make connections to CS 2000 according to Table B1.

Table B1 Wiring Sense for External Relay Connections

CS 2000 Connection	Contact Configuration of External Power Relay	
	Normally Closed (N/C)	Normally Open (N/O)
Control Relay	Wire to Cs 2000's *Normally-Open* (N/O) Contacts	Wire to CS 2000's *Normally-Closed* (N/C) Contacts
Area Occupied Relay	Same as above	Same as above

A Transformer/Relay package is available for up to 30 Amp, 277 VAC loads. Consult your Bard Manufacturing Company representative.

An example of connecting CS 2000 to a N/C power relay appears in Fig. B1. CS 2000's contacts open for normal thermostat operation and close to interrupt HVAC operation for energy savings. When CS 2000's contacts open, the power relays' contacts close. Figure B2 suggests other possible applications of CS 2000 controlling larger loads.

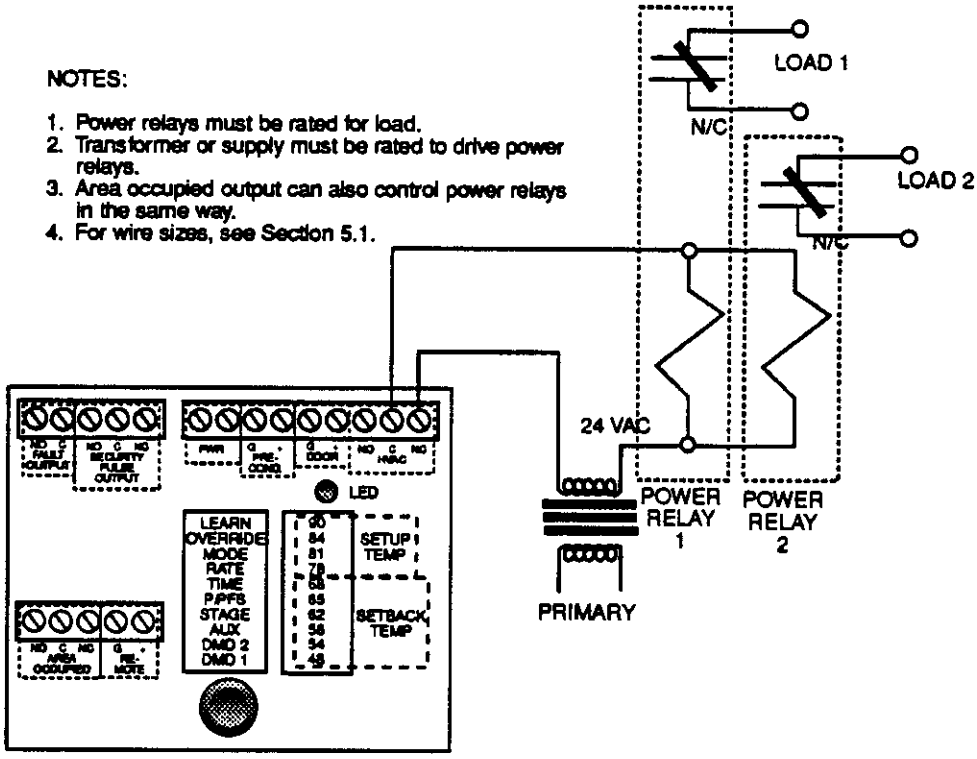


Figure B1 Typical Power Relay Wiring Diagram. External Relays Can Be Controlled from CS 2000's HVAC or Auxiliary Relays.

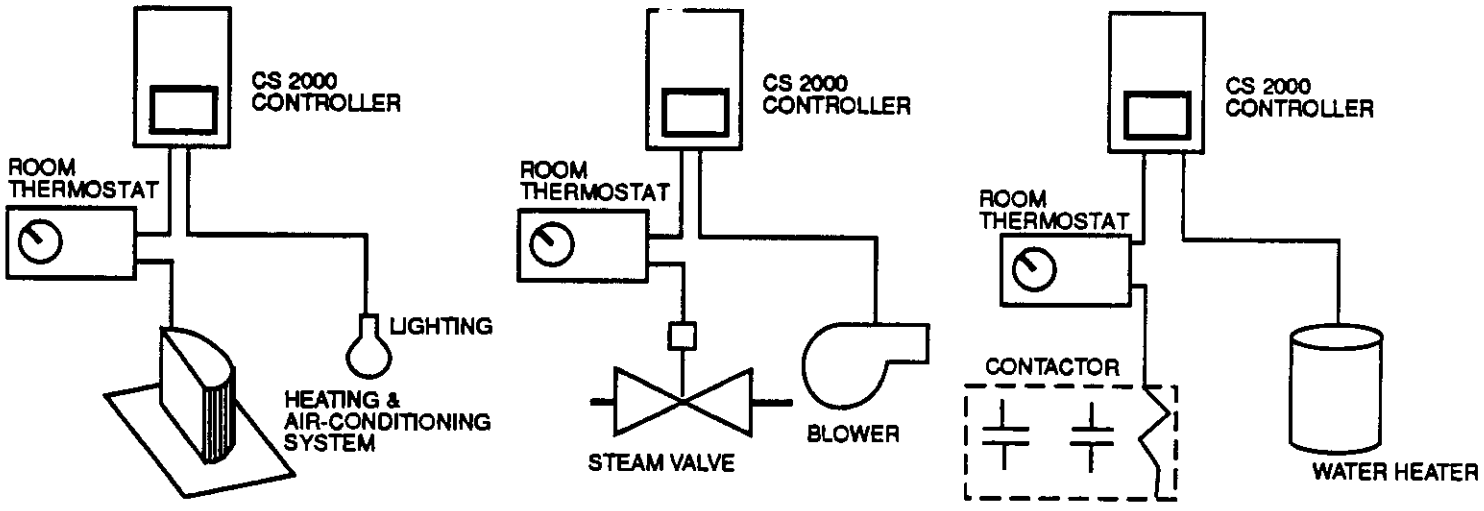


Figure B2 External power relays (contactors) allow CS 2000 to control a variety of energy consuming equipment.

APPENDIX C

CONTROLLING MULTI-STAGE HVAC SYSTEMS AND HEAT PUMPS

CONFIGURING CS 2000

The CS 2000 controls a two-stage heating system such as a heat pump by using the *area-occupied* terminals to interrupt operation of the supplemental electric heat. As in single-stage installations, CS 2000's HVAC control terminals operate first-stage heat. This would be the compressor on a heat-pump system. Be sure to set the *stage* and *aux* function switches according to Tables 3 and 4 of Section 3.7. Place *stage* to the right and *aux* to the left. The area-occupied is ready for second-stage heat control.

> **NOTE: CS 2000's auxiliary relay can control only one of four functions: area occupied, water heater, two-stage HVAC system, or slave HVAC.**

WIRING TO THE THERMOSTAT.

To install, cut the *red* thermostat wire and connect it in series with the N/C terminals of CS 2000's HVAC control contacts. This also would be done for single-stage systems. In addition, cut the *white* thermostat wire and connect it in series with the N/C terminals of CS 2000's area-occupied contacts. The white thermostat wire connects to the *W* or *W1* terminals of the room thermostat. This connection controls the second stage of heat.

> **NOTE: If the HVAC system does not conform to this color coding convention positively verify the connections by consulting the system's wiring diagram. Trac the wiring if necessary.**

OPTIMIZING SECOND STAGE USAGE.

Select from two second-stage usage rates using the rate function switch (#4). Set the *rate* function switch to *economy* for a gradual (7.5 degree/hour) warmup that lessens use of more costly second-stage heat. For a faster heatup (15 degree/hour), set the *rate* switch to *comfort*. This switch setting brings the area to comfort temperature more rapidly by allowing second-stage heat to operate more often. For either setting, second-stage heat operates only enough to maintain the prescribed warm-up rate when recovering from setback. No second-stage heat operates if first-stage heat (the compressor in a heat pump system) satisfies the prescribed heat rate. Control over first- and second-stage heat returns to the room thermostat on reaching normal room temperature.

The CS 2000 energizes second-stage heaters when room temperature falls 2.5 degrees below the selected setback temperature. This is a protection against first-stage heater failure and low compressor performance during extremely cold weather.

APPENDIX D

ABBREVIATIONS AND ACRONYMS USED IN THE MODEL CS 2000 INSTRUCTION MANUAL

Amp: Ampere, measure of current flow

AUX: Auxiliary, a function switch for selecting the area occupied relay's function

AWG: American Wire Gauge

DMD Demand, a function switch for randomly delaying operation

DIP: Dual In-line Package, a type of container for integrated circuits and small circuit board switches

EMS: Energy Management System

F: Degrees Fahrenheit

Form A: Single-Pole Single-throw Contact, Normally Open

Form C: Single-Pole Double-Throw Contact

ft.: Foot

HVAC: Heating, Ventilating, and Air Conditioning

kw: Kilowatt

LED: Light-Emitting Diode

LRN: Learn, a function switch for selecting anticipation of occupied state

ma: Milliamperes

MODE: Access mode function switch for selecting door switch or open area operation

N/C: Normally Closed - closed when de-energized

N/O: Normally Open - open when de-energized

OVR: Override, a function switch for returning control to the thermostat for service and troubleshooting purposes

P/PFS: A function switch for selecting whether the precondition terminals perform precondition or power-fail-sense operation

PIR: Passive infrared sensor

RATE: A function switch for selecting economy or comfort preferences

sec: Second

SPST: Single-Pole Single-Throw contact

STAGE: A function switch for selecting the auxiliary relay's function

TIME: Search time, a function switch for selecting the decision-making period before declaring unoccupied state

UPS: Uninterruptable power supply

VA: Volt Amperes, a measure of power capacity of contacts and transformers

VAC: Volts - Alternating Current

VDC: Volts - Direct Current

APPENDIX E

MODEL CS 2000 INSTALLATION FORMS

The following pages contain forms useful during installation. Copy them as needed for CS 2000 installations.

Form	Title	Description / Use
IPC/3311	CS 2000 Installation Quality Assurance Form	Form for documenting installation including all settings and wiring. Contains testing checklist.
IPC/3112	CS 2000 Installation Quick Reference	Condensation of installation guidelines from main body of CS 2000 manual.
IPC/3313	CS 2000 After Installation Customer Survey	Customer satisfaction survey form. Customer completes after job finished.

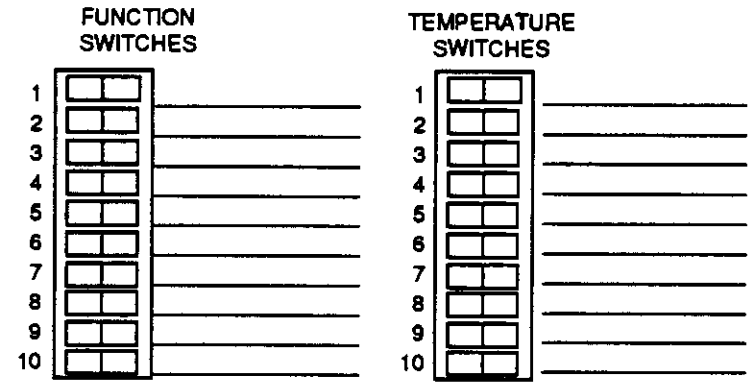
MODEL CS 2000 INSTALLATION QUALITY ASSURANCE FORM

Job Number Identification		
Date of Installation	Beginning	Finish
Installer Supervisor	Name	Phone
Installing Company	Name & Address	
Site Responsible Person	Name	Phone
Location of Installation	Address	

List Installation Components

Installation Wiring Diagram (Be sure to record wire colors for future use. Use Reverse Side or Separate Sheet if Required)

INSTALLED CS 2000 SWITCH SETTINGS (Indicate positions)



CHECKLIST

- ❑ HVAC OK prior to CS 2000 installation
- ❑ CS 2000 door response correct
- ❑ CS 2000 walk test successful
- ❑ All other CS 2000 inputs and outputs respond correctly
- ❑ CS 2000 switch settings correct
- ❑ Cover installed correctly
- ❑ Area thermostat set properly
- ❑ Final check of all systems successful

FORM DISTRIBUTION (ONE EACH): (1) Installation Site, (2) Installer Files, and (3) Factory Files

Installation Physical Location Diagram (Use Separate Sheet If Required)

BARD MANUFACTURING CO.
INSTALLATION QUICK REFERENCE

These basic installation guidelines have been condensed from the full CS2000 installation manual for field use. Access to the full manual may be needed for special situations. CS2000 installers should be factory trained and familiar with CS2000's features and capabilities. Installers should also have a working knowledge of the HVAC equipment connected to CS2000 controllers.

Operation Overview

CS 2000 is an energy management controllers that work in conjunction with the HVAC thermostat to optimize energy savings and occupant comfort. CS2000's learning capability, occupancy detection, and self-adjusting time-base provides effective control of HVAC systems without the need for user adjustments.

CS 2000 may also be used to control lighting, water heaters, and other appliances. The security output allows it to be used as a part of an intrusion alarm system.

Function Switch Settings

For most installations, place the function switches to the left position. Check below and in the full manual for exceptions.

Learn *Left* = Anticipate. CS2000 learns occupancy schedule for each day of seven.
Right - Non-anticipate. CS2000 operates on occupancy only.

Override *Left* - Normal. CS2000's normal working mode.
Right = Override. Relays D & E released to N/C position. Reverts to normal operation in 24 hours.

Mode *Left* = Limited. Usual mode for most installation. Requires door switches on all entry-exit doors.
Right = Unlimited. Control based on motion sense only. Use for restaurants and warehouses.

Rate *Left* = Economy. Maximum energy savings: no wait after recovery, low strip-heat usage.
Right = Comfort. Maximum comfort level: 30 min. wait after recovery, higher strip heat usage.

TIME *Left* = Short. 5 min. for limited access, 30 min. for unlimited access.
Right = Long. 30 min. for limited access, 60 min. for unlimited access.

P/PFS *Left* = Precondition. Precondition feature enabled by momentary closure at precondition input terminals.
Right = Power Fail Sensa. Change in status of closure at terminals sets power-up functions.

Stage & Aux Stage and Aux switches work together to determine the function of the auxiliary relay.

Function Switch Positions		Control Relay Operation	
Stage	**Aux**	**HVAC**	**Auxiliary**
Left	*Left*	Single Stage	Area Occupied
Left	*Right*	Single Stage	Water Heater
Right	*Left*	1st Stage HVAC	2nd Stage Heat
Right	*Right*	HVAC #1	HVAC #2

Demand2 Demand 1 Last two switches work together to determine the HVAC duty cycle during unoccupied periods.

Switch Positions		Duty Cycle (% on Time	On Time (Minutes)	Off Time (Minutes)
Upper Switch	Lower Switch			
Left	*Left*	100	—	—
Left	*Right*	80	15	4
Right	*Left*	60	15	10
Right	*Right*	40	15	22.5

Installation

Place a CS2000 in control of each HVAC system for the typical installation. Under some circumstances, a CS2000 can control two or more systems. This depends on location of zones and their occupancy schedules.

Mount the CS2000 controller about seven feet from floor level in a high traffic location such as a foyer or hallway. Avoid corners, blockage by curtains or furniture, and drafts by heating vents. To facilitate wiring, mount close to the existing thermostat if possible.

Temperature Switch Settings

Temperature switches determine the setup and setback temperatures that CS2000 controls during unoccupied periods. A minimum of two switches must be *on:* one setup and one setback. Suggested settings are 84 and 62 degrees.

Night Setback/Setup
Set one additional temperature switch in the setback range and/or one in the setup range to enable energy savings during sleep hours. The inner switch setting(s) are used as the sleep temperature values.

Adaptive Freeze Protection
The lowest two temperature switches (48 or 54 degrees) enable adaptive freeze protection when excessive heat loss is detected.

Temperature Clamp
Temperature clamp is automatic, not switch selectable. This feature prevents HVAC operatin above 79 degrees in winter and below 67 in summer. Clamp turns off during mild seasons.

Trouble Shooting Hints

- LED Indicator gives helpful status information:
  Motion - lights momentarily after motion detection. Door must be closed before testing for motion.
  Bad Switch Setting - slow flashes
  Manual Override - fas flashes
  Out-of-Range Temperature - lights continuously
  Door Open - lights continuously
- CS2000 loses schedule if power is removed. It must then relearn.
- One hour setup-setback operation for testing allowed after power-up. Normal operation begins only after morning synchronization .
- Manual override has 24-hour operation before self reset.
- Changing from non-anticipation to anticipation erases schedule.
- Lockout timer inhibits HVAC operation for three minutes.
- Night setback/setup may not engage in mild weather.
- CS2000 must be in location to sense temperature of its controlled area.
- Temperature clamp may infrequently inhibit operation while performing season check.
- Detector's field-of-view must cover key traffic pattern.
- Slow-closing doors may allow occupant to pass out of field-of-view before end of three-second PIR blanking period.
- Inverted CS2000 case blocks PIR view.
- Working on an older HVAC system may cause a borderline component to fail. Check for HVAC equipment malfunction.
- Door switches must provide closed contacts when door is closed.
- Imporper wiring may result if existing HVAC system does not conform to standard color-coding conventions.
- Contacts of external remote motion sensors must remain open until motion occurs.

Suggested Wiring (refer to diagram below)

A. *Power Supply:* Provide 12-24 VAC or 12-30 VDC. Current draw at 24 VAC is about 100 ma. Use power from existing HVAC system if accessible. Otherwise, supply separate 10 VA Class II transformer. Use 22 AWG wire for power. Use larger wire for runs over 200 ft.

B. *Precon./Power-Fail-Sense:* This input activates either *precondition* or *power-fail-sense* function, depending on position of function switch #6.

Precondition - a momentary or continuous closure gives control to thermostat for three hours. (Timing starts once contact reopens.) Function useful for preheating area from remote location.

Power-fail-sense - A change in state of input signals CS2000 to being HVAC start-up sequence. Use this function when powering CS2000 from battery-backed power supply (UPS). Connect input to contacts of relay held in by line power.

C. *Door Switch:* One or more normally-open (N/O) door switches may be connected in series to this input. (N/O) door switch contacts remain closed when door is closed and open when door is open.) Be sure to place CS2000 in *limited access mode.*

D. *HVAC Output:* N/C contact closes when area is occupied or CS2000 calls for HVAC operation. For most systems, cut *red* thermostat wire and connect in series with CS2000's N/C contact. Use 18 AWG wire for thermostat connections.

E. *Auxiliary Relay:* This relay permits several control options. (See switch descriptions.) Figure below shows auxiliary relay wired for second-stage HVAC control. For most systems, cut *white* wire at thermostat and connect in series with CS2000's N/C contact. Use 18 AWG wire for thermostat connections. Second-stage control is used for heat pumps.

F. *Remote Motion Detector:* This input accepts a closure from external motion sensor. Used to extend occupancy detection to an area isolated from CS2000's built-in detector.

G. *HVAC Fault Detection:* This contact closes when HVAC fails to meet the switch-selected temkperatures. Also closes when CS2000's switches are improperly set or if room temperature exceeds 122°F. This output may be connected to a digital communicator to report malfunction to remote location.

H. *Security System:* This contact closes when CS2000 detects motion through built-in PIR or by remote input. Output may be used as part of a security system or to signal motion to other CS2000s.

Model CS2000 General Specifications

Inputs

Power	10-24 VDC or VAC (< 100 ma)
Precondition (power fail)	Contact closure
Door	Contact closure
Remote (R only)	Contact closure

Outputs

HVAC Relay (pilot)	Form C, 24 VAC 1 Amp max
Auxiliary Relay (pilot) (R only)	Form C, 24 VAC 1 Amp max
Security Relay (reed) (R only)	Form C, 24 VAC 0.1 Amp max
Fault Relay (reed) (R only)	Form A, 24 VAC 0.1 Amp max

User Interface

Function Selection	10 PCB DIP switches
Temperature Set Points	10 PCB DIP switches
Indication	Single LED

Physical Characteristics

Operating Temperature	0 to 122 F (-20 to 50 C)
Case	2 piece, 4 x 7.25 x 2 in., High Impact ABS, U.L. listed
Color	Off White
Terminals	12-22 AWG, #3 Screw
Mounting	4 screws

5-MINUTE TEST PROCEDURE
Field Testing Procedure for the CS-2000 Control

STEP 1: Place the CS-2000 in the limited mode (th' dip switch) to the left, also search time (5th dip switch) to the le Set the attached thermostat to a setting in which it cannot be satisfied during the test period.

STEP 2: Before applying power to the CS-2000, connect the HVAC control wire as shown in the wiring diagram. The HVAC unit should continue to run demonstrating the fail-safe feature in the event the CS-2000 should fail. If the HVAC unit does not continue to run, verify the connections at the thermostat control wire by twisting the ends together. If the unit begins to run, then the control wires are correctly spliced and the problem exists with the HVAC control relay on the CS-2000 board. With a meter, verify the status of the relay. It should be closed as no power has been applied to the unit. If the relay reads open, then it is either faulty or sticking.

STEP 3: Apply power to the CS-2000 unit. The HVAC should cease to run when power is applied. The unit will be off for 3-5 minutes demonstrating the delayed startup in the event of a power failure. If the unit does not cease running when power is applied, verify that you have spliced into the correct control wires at the thermostat. These wires should have veen verified in step 2, but a second look doesn't hurt. If the splices are correct, verify with your meter that you do indeed have power coming through your line. Once these checks have been made and verified, then the problem is likely on the CS-2000 board.

STEP 4: After the units start up from the delay caused ' step three, take two pieces of wire and connect them to the do contact terminals located on the Cs-2000 board (if not using door switches with the original install). Make sure these wire pieces are long enough to extend from under the CS-2000 cover. Invert the cover on the CS-2000 unit such that the PIR window is at the top of the unit and the internal PIR is shielded. (The pieces of wire should be twisted together simulating a closed door). With cover inverted, untwist the wires then twist them back together (this simulates a door opening and closing). the HVAC unit should cease running in 5-6 minutes. If the unit continues to run, verify the control connections again. With a meter, verify the HVAC control relay, if it remains closed after the 5-6 minute period, then the problem is in the Cs-2000 board.

STEP 5: After the unit ceases running, remove the cover and the wire pieces from the unit. In approximately 3-5 minutes, the HVAC units should begin running again. Once these 5 steps have been successfully completed, the CS-2000 unit has been fully tested and should be deemed correctly installed. Remember to adjust the dip switches to whatever the intended mode of operation is to be and reset the thermostat at the desired setting of the customer.

Note

- If wiring must return to a central control panel, use 2-wire cable for single-stage thermostat, 4-wire cable for two-stage thermostat, and 10-wire cable for remaining wiring. Use color code shown in diagram.
- Check existing wiring of HVAC system to be sure of compatibility with CS2000 before connecting to **D** or **E**.

MODEL CS 2000 After-Installation Customer Survey

We are pleased that you have chosen CS 2000 for your energy management and environmental control system. Please help us improve our products and services by completing this questionnaire. Use the space on the back for further comments or suggestions. Return your completed form to the address shown at the bottom of this page.

Site Responsible Person	Name	Phone
Location of Installation		
Installing Company		
Salesman	Name	Phone
Installing Supervisor	Name	Phone
Dates	Date installation started Date installation finished	Date this form was completed
Job Number (if known)		

Equipment
How many CS 2000s are installed?
On what type of HVAC system(s) are the CS 2000s installed?
Are any of the CS 2000s connected to an intrusion alarm system?
What types of equipment, other than HVAC, are under control of the CS 2000?
Installation
Was the installing crew courteous and professional in their conduct?
Does the finished workmanship appear neat and orderly?
Did the installation begin and finish on schedule?
System
Were the CS 2000's features and operation explained to you?
Did you find the documentation adequate?
What features are most important to you?
Does the performance of the CS 2000 system meet your expectations?
Did you encounter any problems with your HVAC (or other equip.) as a result of the CS 2000?
Have all the initial problems been resolved?
General
Why did you select Model CS 2000 controllers?
Are you pleased with your CS 2000 system?
Do you have any additional applications for the CS 2000?
What improvements do you recommend for our product?
Please return this form to the following address:

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INDEX

FCC COMPLIANCE

This equipment generates and uses radio frequency energy and if not installed and used properly, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications of Subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against such interference in a business or institutional installation. However, there is not guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures.

1. Reorient the TV or radio antenna.

2. Relocate or move the unit away from the receiver.

3. Plug the transformer for the device into a different outlet so the receiver and the device are on different branch circuits.

4. If necessary, the user should consult the installing dealer for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful:

"How to Identify and Resolve Radio-TV Interference Problems,"
available from the U.S. Government Printing Office, Washington, DC 20402
stock #004-000-00345-4.

NOTES