

GB1 TEMPERATURE CONTROLLER INSTRUCTION MANUAL

Digitry Company, Inc.

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Dear Customer,

Welcome to the growing family of Digitry Controller users. Digitry is proud of its record of delivering "user friendly" Programmable Temperature Controllers for ovens, kilns, lehrs and furnaces since 1980. The GB1 is in use for controlling processes associated with heating ceramics and glass in both factories and studios around the world. These processes include annealing, fusing, slumping, fire polishing, kiln casting, pâte de verre, crystalline glazing, bisque firing, and batch melting.

In the following pages, you will find complete information on the use and installation of your GB1. As you will quickly learn, ease of operation and programming flexibility are the trademarks of your Digitry Programmable Temperature Controller.

We appreciate hearing from owners of the GB1. Please contact us with any questions, suggestions, or application stories you would like to discuss. Our telephone number and email address are listed in Chapter 6 of this manual under "Sales and Service."

Many of the features and design elements of Digitry's controllers were suggested to us by our users. This is one of the reasons Digitry controllers continue to be the easiest to use and most intuitive temperature controllers available today.

Congratulations on your decision to increase efficiency and productivity in your workplace with Digitry's GB1 Programmable Temperature Controller.

Sincerely,

Richard L. Tenney
President

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Chapter 1

Introduction

This manual introduces you to your GB1 Programmable Temperature Controller. It details how to operate and install it. You do not need prior experience with temperature controllers or computers. Just read and follow the simple instructions for programming and installing your GB1.

In this manual, we will refer to the unit you are controlling with the GB1 as an “oven”, regardless of whether it is a lehr, annealer, furnace, or what-have-you.

This manual is divided into six chapters and a Glossary. It is best to read Chapters 1 through 5 in succession. Chapter 6 and the Glossary are handy reference sections to be used whenever needed.

Chapter 2 introduces you to the features and benefits of your GB1. The function of each operating mode, indicator light, LED display and keyboard button on the face of the GB1 is explained.

Chapter 3 teaches you how to program your GB1. The GB1 is easy to program once you are familiar with the layout of its controls, explained in Chapter 2. The chapter contains a sample profile that you may want to enter to become comfortable programming the unit. There are some pre-printed forms at the end of the manual to facilitate your working with profiles.

Chapter 4 explains the special features of the GB1, including how it behaves when power failures occur. It also contains some helpful hints on programming your GB1.

Chapter 5 details the steps for installing your GB1. Read all the sections pertaining to your version of the GB1 before beginning to install it.

Chapter 2

Overview of the GB1

2.1 Features and Benefits

Versatility is a key advantage of your GB1 Programmable Temperature Controller. The following features are incorporated into your GB1 to maximize user benefits.

- Defining up to 15 set-points per profile broadens creative boundaries through a nearly limitless number of temperature profile options.
- Independent time-temperature control lets you set your own work schedule. No need to be on-site for set-point changes or to fire up during costly peak energy times.
- Ease of operation lets you program the GB1 in a natural way. With the push of a few keys, you can program almost 100 hours of automatic control per step, for a total of just shy of 1500 hours (almost nine weeks); very much longer if you link profiles.
- Automatic calculation and monitoring of slope between set-points eliminates time consuming and awkward manual temperature adjustments while achieving smooth ramping.
- Temperature and ramping accuracy controls oven temperature to expand product range and creativity. Auto-hold feature ensures preset temperature is reached.
- Manual overrides:
 - Skip-step capability increases programming flexibility by jumping to the following step with the push of a few buttons. This is particularly useful when fusing and slumping.
 - Keyboard hold extends the current step beyond its specified time and allows the temperature to be altered — instant setpoint control.
- Profile linking greatly enhances flexibility and total time and number of steps.
- Delayed start allows oven to start ramping up, so it will be ready when needed.
- Automatic memory back-up retains your profile if electricity fails, resuming operation, if appropriate, and holding at temperature in other cases, thus helping to protect your product from damage.

- Large LED display clearly indicates profile number, current step and time remaining for that step, temperature, mode, and status throughout a profile.
- Built-in connection for alarm that warns of abnormal conditions such as thermocouple burn-out.
- Key lock prevents accidental or unauthorized profile changes (optional).
- Voltage transient protection to help protect from malfunction caused by electrical disturbances.
- Standard features include solid-state circuitry, durable construction, direct connection for Type K thermocouple, automatic cold junction compensation, readings in Fahrenheit (Celsius, optional), product warranty and full corporate technical support.
- System options include programmable auxiliary relay, external GB5-type Sending Unit for either chromel-alumel (Type K), platinum-rhodium (Type R and Type S) thermocouples, key lock security, proportional output, chart recorder-like output for PCs, graphing software for Windows PCs, and customized hardware and software.
- Digitry also sells Type K and Type S thermocouples, specialized plug-boxes for instant installation of commonly available kilns, and both solid-state and mercury relays (“contactors”) of various sizes.

A diagram of the face of the GB1 is shown in figure 2.1. Refer to this drawing as you read through Chapter 2 to learn the system layout.

2.2 Modes

There are two modes of operation for your GB1: MONITOR and PROGRAM. During standard operations, you will usually keep your GB1 in MONITOR MODE. When entering, changing or examining temperature profiles, the GB1 must be in PROGRAM MODE.

For those GB1s that have proportional output, the MONITOR mode has two display choices: remaining time and power level. Added to the PROGRAM mode, these two MONITOR displays may give the user the impression that there are three modes. If this includes you, don't worry; it's OK.

2.3 Status Indicator Lights

There are two sets of indicator lights on the face of the GB1. The two mode lights are above and below the STEP display. The four system status indicator lights are directly beneath the HOURS/MINUTES display.

MONITOR MODE: When the green MONITOR light is on, the GB1 displays the time and temperature. (Your oven is constantly monitored by the GB1, even when the MONITOR light is not lit.)

PROGRAM MODE: When the red PROGRAM light is on, the GB1 is ready to receive, examine, or change temperature profiles. Note that if a profile has already been started, it will continue to execute.

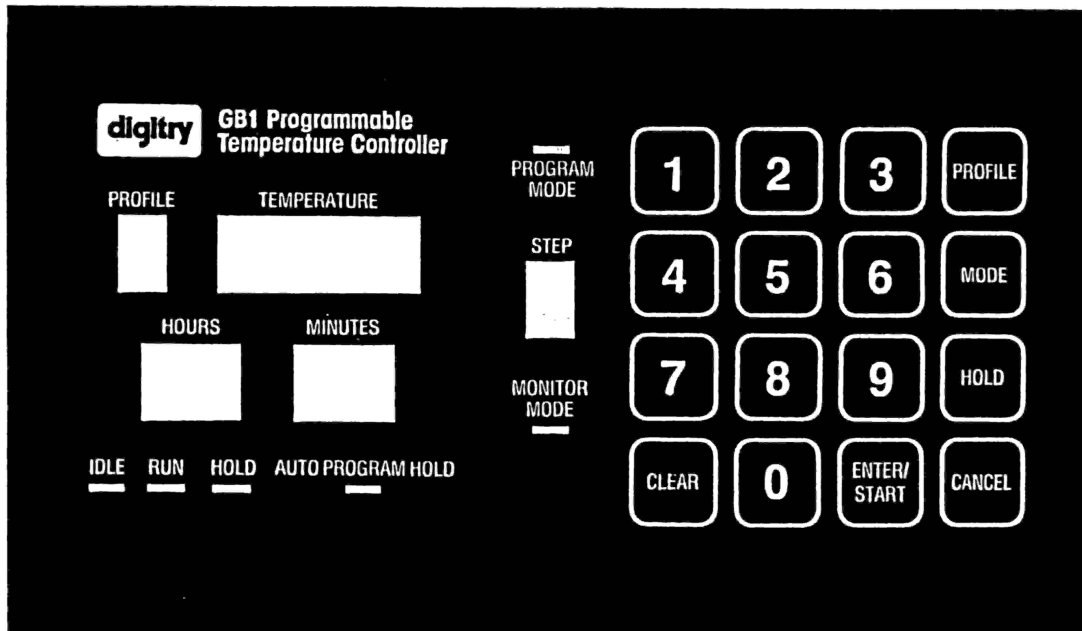


Figure 2.1: GB1 Face

The MODE button on the keyboard (see page 9) is used to switch between MONITOR and PROGRAM MODE.

IDLE: The red IDLE light indicates that the control power is off and the timer is not running. Therefore, your oven is ready to begin STEP #1 of your profile. Once the profile has completed its cycle, the GB1 automatically returns to IDLE. Resetting your oven using the CANCEL button (see page 11) also forces the GB1 into IDLE.

RUN: The green RUN light indicates that your oven has been activated. This means that the timer is running and the oven is following your profile.

HOLD: The yellow HOLD light indicates that your profile has reached an indefinite, programmed hold or that the HOLD Button has been pushed (also placing your oven in an indefinite hold or soak). In either case, the timer stops running and your oven maintains the preset temperature.

AUTO-HOLD: The yellow AUTO-HOLD light indicates that the actual temperature is far below or above the calculated profile temperature. This situation occurs when the programmed slope (calculated automatically according to the time and temperature set-points you entered into your profile) is too steep to be achieved by your oven's capability to heat up or cool down. When this light appears, the timer stops and will remain stopped until the actual temperature comes within the required range.

2.4 Numerical Displays

There are four LED displays on the face of the GB1: one digit each for the UNIT and the STEP, four digits for the TEMPERATURE, and four digits for the TIME. Under most circumstances, each indicates information either about a profile being entered or about an oven being controlled. At other times, power level or error messages may appear in the TIME and TEMPERATURE displays. These are described in other sections of this manual.

PROFILE: This display indicates the profile number that currently is being executed or programmed.

TEMPERATURE: This display indicates temperature in Fahrenheit (or Celsius, if your GB1 was ordered with this option). In MONITOR MODE, this is the reading from your thermocouple; in PROGRAM MODE, it is the final temperature of a given step.

TIME: This display shows the time in the current step. The time indicated when the GB1 is in PROGRAM MODE denotes the length the step. When programming, the letter "H" will be displayed to indicate a programmed hold or soak of indefinite length, and the letter "L" will be displayed to indicate a link to another profile.

In MONITOR MODE, the display shows the remaining time of the current step, and diminishes as the step nears completion. The timer is running whenever the green RUN light is on. The timer stops when your oven is in IDLE, HOLD or AUTO-HOLD. When the GB1 is in any of these hold conditions, the displayed time does not change. However, since a programmed hold has no time associated with it, the display shows "HHHH".

With proportional control versions of the GB1, the MONITOR MODE supports two different display modes, which differ only in what is shown in the bottom display. The first display

mode is the normal one described above. The second one replaces the time with a power level display. The letters “PL” show, followed by a 2 digit number representing the percentage of power called for. Because of the limitation of the display, 99% is the highest power shown, even when the level is really 100%.

STEP: In MONITOR MODE, the number displayed directly above the keyboard indicates the current step of the profile you are executing. When a profile has just finished running, the GB1 will go into the IDLE MODE and, to indicate that the profile has finished, the STEP display will show the last step of your profile, with zero time remaining. As soon as you switch modes or profiles, this display will change to show a STEP of “1”, with the TIME replaced by dashes “- - -”.

In PROGRAM MODE, this display indicates the step you are entering or reviewing. The steps are indicated by the numbers “1” through “9”, and then “A” for the tenth step, “b” for the eleventh step, and so forth, up to “F” for the fifteenth step (the maximum number that can be programmed for any one profile)¹. Dashes will appear in the TIME and TEMPERATURE displays if you try to enter more than 15 steps per profile or if you try to view a step after a Link “LL LL”.

2.5 Keyboard

The keyboard on the face of the GB1 consists of 16 buttons. There are 10 numerals, 0-9; and six special function buttons, labelled PROFILE, MODE, HOLD, CANCEL, CLEAR, and ENTER/START. The chart in Figure 2.2 summarizes the functions performed in each operating mode.

PROFILE is used to choose the profile you want to run or program. Simply push PROFILE and then push the number of the profile you wish to display. This will automatically select PROGRAM MODE and display step 1 of the profile. Press ENTER/START repeatedly to display the entire profile, step by step. To return to the beginning, reselect the profile. A useful short-cut to review a profile while in PROGRAM MODE is to press PROFILE twice. You may also back up to the previous step by pressing PROFILE followed by ENTER/START.

The number of the profile you select appears in the upper left hand corner of the GB1, below the word PROFILE. The step being displayed appears to the left of the keyboard.

MODE is used for switching between MONITOR MODE and PROGRAM MODE. The mode you select is indicated by a light directly above the keyboard: red for PROGRAM MODE, green for MONITOR MODE. With proportional output GB1s, this key cycles through the following sequence: time monitor mode, power level monitor mode, program mode, then back to time monitor mode.

MONITOR MODE is used for observing the status of your oven including the temperature and the remaining time of the current profile, if one is running. In MONITOR MODE you can perform any of the following functions:

- Start a profile (see “ENTER/START”).
- Initiate a non-programmed hold (see “HOLD”).

¹Some of these letters are uppercase and some are lowercase, because of the limitations of their 7-segment display format.

| Button | In PROGRAM MODE ¹ | In MONITOR MODE |
|---|---|---|
| PROFILE (pushed once followed by digit) | Selects profile for viewing or changing | Selects profile for viewing or changing (also changes mode to PROGRAM MODE) |
| (pushed once followed by ENTER) | Backs up to previous step | |
| (pushed twice) | Returns to beginning of profile for review | |
| MODE ² | Selects MONITOR MODE | Selects PROGRAM MODE |
| CLEAR | Clears entries so changes can be made | Clears errors; temporarily disables BAD1 and BAD2 |
| HOLD (pushed once) | Denotes a hold, or soak, at a specified temperature | Holds oven at current temperature |
| (pushed twice followed by digit) | Designates link to another profile | |
| (pushed three or more times) | Toggles Auxiliary Relay ³ on and off | |
| ENTER/START | Completes a profile entry | Starts, restarts or skips steps in a profile |
| CANCEL | Erases the entire profile | Cancels a profile and returns to IDLE |

NOTES:

1. A profile may continue to execute even while another profile is displayed or altered.
2. Proportioning GB1s have two monitor modes, one that displays power level and one that displays time. Pressing MODE advances along the cycle PROGRAM MODE → MONITOR TIME MODE → MONITOR POWER LEVEL MODE → PROGRAM MODE →
3. This action is available only on those GB1s that have the optional Auxiliary Relay (described in section 3.6).

Figure 2.2: Keyboard Functions

- Skip a step in a profile which is running (see “ENTER/START”).
- Cancel the cycle (see “CANCEL”).
- Select a profile for examination (see “PROFILE”).

When the GB1 is in PROGRAM MODE, you can enter, review or change the times and temperatures (which constitute your temperature profile) for the currently selected profile. As you enter times and temperatures into the profile, the step you are modifying is displayed in the STEP LED. To review any profile, reselect the profile by pressing PROFILE followed by the number of the profile to be reviewed. To back up to the previous step, press PROFILE followed by ENTER/START. See section 3.2 for details on changing time and temperature settings.

You may review or change a profile even while it is running.

IMPORTANT NOTE: Do not attempt to change the step that currently is being executed as this may cause your oven to return to IDLE.

ANOTHER NOTE: The behavior of MODE depends on whether or not a profile is currently running. If a profile is currently running, changing from PROGRAM MODE to MONITOR MODE automatically changes the selected profile to the one that is running. If your oven is idle, changing from PROGRAM MODE to MONITOR MODE does not change the selected profile.

CLEAR is most commonly used when the GB1 is in PROGRAM MODE to allow entries to be changed. In MONITOR MODE, CLEAR is used to clear various error indications.

In PROGRAM MODE, CLEAR is used to clear entries that you need to change. If only a time has been entered, then pushing CLEAR clears it. If both a time and a temperature have been entered in a step, pushing CLEAR once will clear only the temperature. If you do not want to change the time, you then can enter a new temperature setting. If you do want to clear both the existing time and temperature setting, push CLEAR twice; the first time to clear the temperature, the second to clear the time. You then can enter your new settings. While altering a profile during review, there is no way to clear the time without first clearing the temperature.

NOTE: If your display reads all “E”s (error in entry), you must push CLEAR in order to proceed. (See section 3.2 for a further explanation.)

In MONITOR MODE, pressing CLEAR when an error is present simply clears the error. However, pressing CLEAR when no error is present disables abnormal temperature warnings (BAD1, BAD2) for 45 minutes from the last time it was pushed. This allows you to open your oven and insert a piece or “crash cool” without unnecessarily triggering an alarm. This is discussed in more detail in section 4.4. When you press the CLEAR key in MONITOR MODE, both the TIME and TEMPERATURE displays momentarily show “- - -” to acknowledge the button press.

HOLD causes the GB1 to keep the oven at the chosen temperature. Pushing HOLD when the GB1 is in the MONITOR MODE immediately initiates a hold (also known as a “soak”) at the existing temperature of the oven. This means that the internal timer stops, and your oven will be maintained indefinitely at the temperature that the oven was at when you started the hold. In other words, the GB1 now acts like a setpoint controller. We call this a “keyboard hold” to distinguish it from the programmed hold described below.

When a keyboard hold is started, the yellow HOLD light will come on. To resume normal operation, push ENTER/START and then press the number of the profile being run.

While in keyboard hold mode, you may temporarily change the setpoint temperature. To do so, press the MODE key once or twice (if your GB1 is configured for PID and shows the Power Level) until PROGRAM MODE lights. At this point, the TIME display will become blank and the TEMPERATURE display will display the setpoint target temperature. If you wish to change the target temperature, you must first clear it with the CLEAR key and then enter the desired setpoint target temperature. Digit keys pressed before the temperature is cleared are simply ignored. Once you have entered the desired temperature, press the ENTER/START key to select that temperature. The MONITOR MODE will light, and the kiln will use the selected temperature as its target. Until you actually select the new temperature with the ENTER/START key, the GB1 will continue to use the original setpoint as its target temperature.

Before you press the CLEAR key, you can return to monitoring the keyboard hold by pressing the MODE key. However, once you have cleared the temperature, you must press the ENTER/START key to return to MONITOR MODE, and in doing so, you will cause the displayed temperature to become the target temperature. If this is not what you want, exit the keyboard hold (press ENTER/START key followed by the number of the profile being run) and restart the keyboard hold mode (press HOLD) to hold at the then current temperature.

To resume normal operation, i.e., to leave keyboard hold's setpoint operation and return to running the profile, press the ENTER/START key followed by the number of the profile being run.

While in PROGRAM MODE, the HOLD button is used to designate a hold, or untimed soak, at a determined temperature. Once the button is pushed, the hold is indicated by "H"s in the TIME display. The temperature is specified in the normal manner (see section 3.2). When the hold is reached while the profile is running, your oven will continue to hold at the indicated temperature forever or until you release it by pushing the enter sequence (whichever comes first!) Do not use this button for a timed soak (see section 3.1). To continue to the next step after the hold, press the ENTER/START button followed by the profile number.

You can start a profile with HOLD. You then can attend to other business while your oven reaches working temperature. Once you load the oven, push the ENTER/START button followed by the profile number, and the GB1 continues with the rest of the curing cycle.

HOLD pressed twice is used to program the special profile linking feature. See section 3.4 for a complete discussion of the profile linking feature.

Confirmation Sequence

The keys described below, ENTER/START and CANCEL, are used to start your oven, skip steps in your profile, erase your profiles or reset your oven to STEP #1. Because of the importance of these functions, the GB1 requires that you enter a special sequence, as a safety mechanism to avoid accidental use. After pressing ENTER/START or CANCEL, you must push the number of the currently selected profile. Pushing any other button after ENTER/START or CANCEL will disable the prior ENTER/START or CANCEL. For ENTER/START, this feature is active only when the GB1 is in MONITOR MODE. For CANCEL, it is always in effect whether the GB1 is in MONITOR or PROGRAM MODE.

ENTER/START serves a different function depending on the mode of the GB1: in MONITOR MODE, ENTER/START is the start/reset/skip-step button; in PROGRAM MODE, it serves as the enter button.

To start your oven, first be sure that no profile is currently running (*i.e.* that the red IDLE light is on).² Then pick your profile and change to MONITOR MODE (the green MONITOR MODE light will come on). Push ENTER/START and press the number of the profile displayed in the upper left corner (PROFILE). The red IDLE light will go out and the green RUN light will come on, showing that your program has started.

Thus, there are four steps to starting your oven:

1. Make sure that no profile is already running.
2. Pick your profile.
3. Change to MONITOR MODE.
4. Press ENTER/START, followed by the number of the profile.

At any time during the cycle you may terminate a given step and go on to the next step (this is called the “skip-step” capability). Push ENTER/START and then press the number of the running profile (as displayed). The GB1 will skip to the next programmed step. Once you have skipped a step, there is no direct way to back up. However, you can always cancel the whole cycle (CANCEL), restart the profile and skip to the beginning of any step.

ENTER/START also is used to continue your profile from HOLD. Leaving a programmed HOLD is, after all, nothing more than skipping to the next step.

When the GB1 is in PROGRAM MODE, ENTER/START is used to enter the times and temperatures you select for your profile. The Confirmation Sequence feature is not in effect in this mode. After selecting any time or temperature, you must press ENTER/START to record your entry into the GB1’s memory. Then, proceed to your next entry. If the GB1 detects an incorrect entry, “E”s appear in the TIME or TEMPERATURE, as appropriate, and you must press CLEAR to proceed (see 3.2).

ENTER/START is also used to review your profile. Each time you push ENTER/START, the next time and temperature set-point appears in the LED displays. You may back up to the previous step by pressing PROFILE followed by ENTER/START; you may go to the beginning of the profile by pushing PROFILE twice.

CANCEL is active in both MONITOR and PROGRAM MODE. In MONITOR MODE, it is used to cancel a profile and return the GB1 to IDLE. This does not erase your profile; it shuts your oven off and returns the profile to STEP #1.

In PROGRAM MODE, CANCEL erases your entire profile. Once you press CANCEL, remember that you must then enter the number of the profile. Failure to do this will trigger the Confirmation Sequence feature described above (see page 10) and the CANCEL function will be cancelled.

²If a profile is running, you must first cancel it before you can start a new profile.

Chapter 3

Programming

3.1 Introduction

A profile for the GB1 may be thought of as a series of points, with each point consisting of a time and a temperature. When these points are connected by straight lines, they form a continuous graph. This graph represents the temperature profile you want your oven to follow. You program your GB1 by entering these time-temperature points. The time you enter is always the length of the step; the temperature is in Fahrenheit or Celsius, depending on your GB1. Your GB1 automatically calculates the rate (“ramp”) at which the temperature rises or falls between successive time-temperature points.

Some people are used to being forced to describe temperature profiles in terms ramp rates up and down, expressed as degrees per minute, and in terms of timed soaks. The GB1 relieves you of the calculations required to specify profiles in this arcane manner.

For example, your oven is at 100°. In 2 hours, you want it to reach 500°. Then, in 3 more hours you want your oven to be at 650°. The only information you must enter is the two time-temperature points: 2 hours, 500°; and 3 hours, 650°. The GB1 then calculates and executes the ramp up between 100° and 500° in 2 hours, as well as a different ramp rate up from 500° to 650° in 3 hours.

A profile may consist of up to 15 such points, each of which is called a *step*. If you wish to hold a specific temperature for an indefinite period of time, you can use HOLD (see page 9). The HOLD acts as a substitute for a time setting. During a HOLD, the timer does not run, so there is no remaining time period to display. Instead, the GB1 displays “HHHH”. When you are ready to continue with the program, you have to advance the GB1 to the next step manually (see page 11). A programmed HOLD counts as one step.

If you wish to maintain a certain temperature for a specific time (a “timed soak”), you simply program it in the standard manner, using the same temperature for two consecutive set-points. For example, the following program ramps up to 950° over an eight hour period and then soaks at 950° for two hours before shutting off.

```
800  ENTER/START  (eight hours)
950  ENTER/START  (950°)

200  ENTER/START  (two hours)
950  ENTER/START  (950°)
```

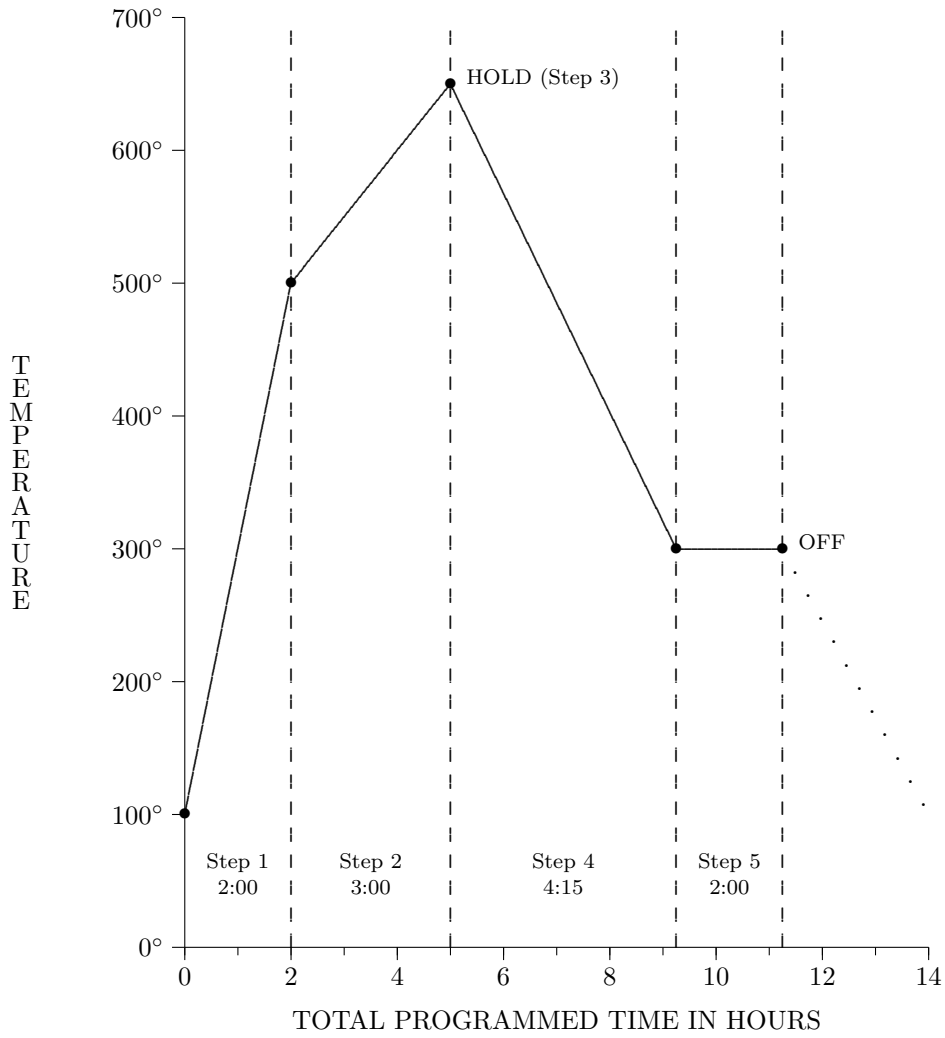


Figure 3.1: Simple Profile

As you can see, you should not use the HOLD button for a timed soak.

Now that you are familiar with the HOLD function, let's add three more steps to the previous example. Your third step is to HOLD at 650° for an indefinite amount of time. Then, cool off to 300° in 4 hours and 15 minutes. Finally, hold at 300° for 2 hours. The third step would then have "H" for time and 650° for temperature. The fourth step would have 4 hours and 15 minutes for time, and 300° for temperature. The last step would have 2 hours for time and 300° for temperature.

The graph in Figure 3.1 illustrates the profile corresponding to this simple program.

A second sample profile is shown in the graph of Figure 3.2. Figure 3.3 shows you just how easy it is to program your GB1 to follow this profile.

3.2 Entering a Profile

First, select the profile to be programmed by pressing PROFILE and the program number (from 0–9) on the keyboard. The GB1 will automatically switch into PROGRAM MODE.¹

Now the STEP display will read "1" and the TIME display will read "0". Punch in the time (in hours and minutes) on the keyboard. Then press ENTER/START to enter the time. At this point, "0" will appear in the TEMPERATURE display. If you wish to change the time, or if you have made an error, press the CLEAR Button. The TEMPERATURE will become blank and the TIME will read "0". You can now enter a new time. Then, punch in a temperature, and press ENTER/START, to enter the temperature.²

After pushing ENTER/START, the TIME will read "0" and the TEMPERATURE will be blank. The STEP will read "2". You now are ready to enter the second point in your profile.

This process is repeated until you have entered your entire profile. Remember, you have as many as 15 steps to work with for each profile. If you enter fewer than 15 steps, your profile will terminate upon reaching the first unfilled step (zero time).

NOTE: When your profile has finished running, the GB1 will go into IDLE MODE and, to indicate that the profile has finished, the STEP display will show one more than the last step of your profile, and the TIME display will show zero time remaining. For example, when a profile with 5 steps has completed, the IDLE light goes on, the STEP display shows "6", and the TIME display shows "0". Similarly, when a profile with ten steps has completed, the IDLE light goes on, the STEP display shows "b" (which looks similar to a "6"), and the TIME display shows "0". As soon as you switch modes, this display will change to show a STEP of "1", with the TIME replaced by dashes.

3.3 Reviewing a Profile

The preferred way to review a profile while in PROGRAM MODE is to press the PROFILE key twice. This automatically sets the STEP display to Step "1". The time and temperature settings you selected for the first step now will be displayed. Pushing the ENTER/START button advances you through the succeeding steps of your program. You may back up to the previous step by pressing PROFILE followed by ENTER/START. At any time during your review, you may make changes to your program by first clearing and then reentering new times and temperatures.

¹If your oven is idle, you may also select program mode for the current profile by pushing the MODE button.

²The maximum temperature for Type K thermocouples is set to 2400°F (1300°C); for Type R and Type S thermocouples, the maximum temperature is set to 3200°F (1800°C). Attempting to enter a temperature above the maximum causes E's to appear, indicating an error. If this happens, push CLEAR to proceed.

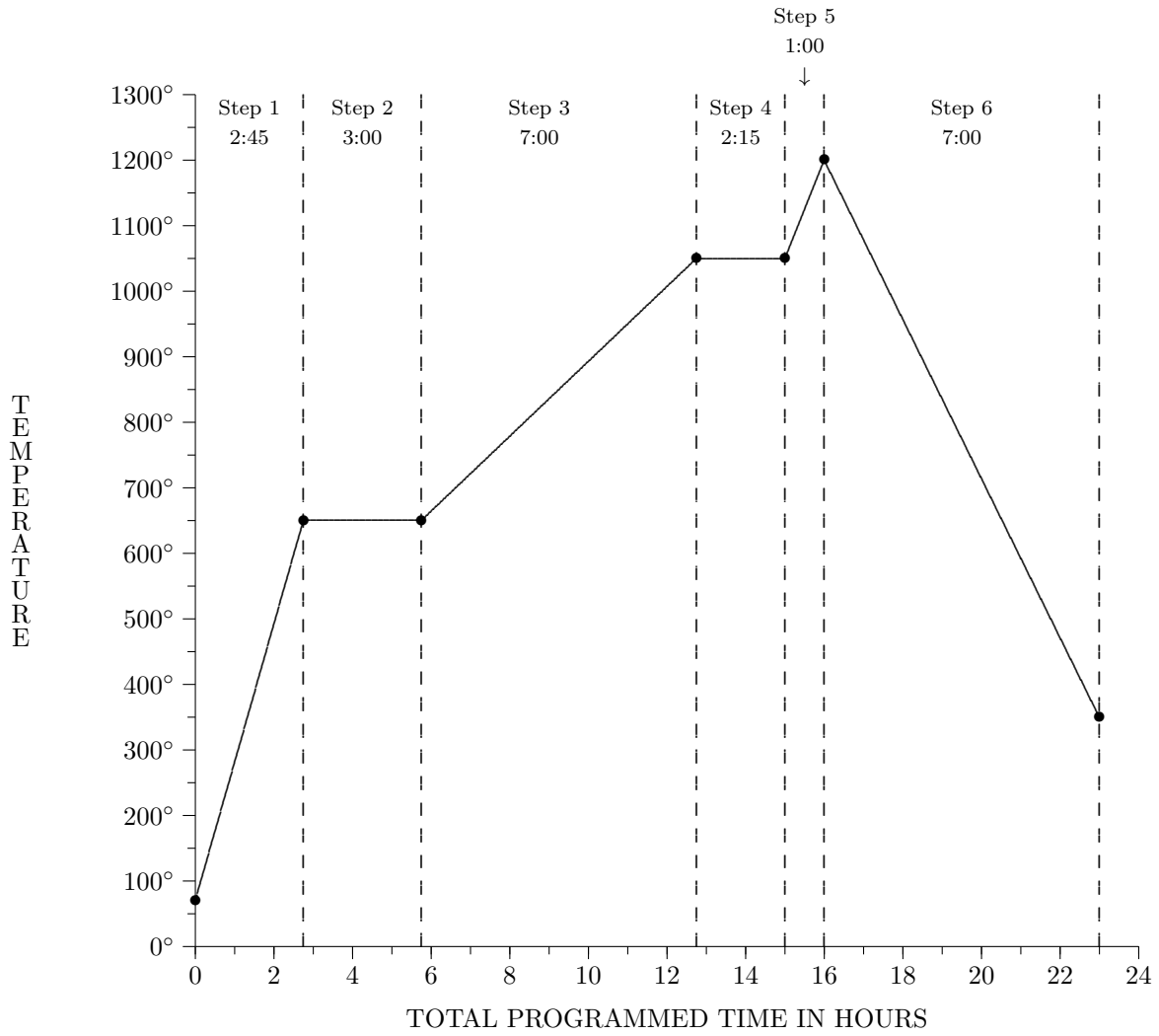


Figure 3.2: Sample Profile Graph

| Press: | To: |
|-------------------------|---|
| PROFILE 5 | Let the GB1 know you want to program profile #5. |
| MODE | Put the GB1 into PROGRAM MODE. |
| 245 ENTER 650 ENTER | Program oven to ramp up evenly to 650°F in 2 hours and 45 minutes. This is Step #1. |
| 300 ENTER 650 ENTER | Soak at 650°F for 3 hours. This is Step #2. |
| 700 ENTER 1050 ENTER | Ramp up to 1050°F in 7 hours. This is Step #3. |
| 215 ENTER 1050 ENTER | Soak at 1050°F for 2 hours and 15 minutes. This is Step #4. |
| 100 ENTER 1200 ENTER | Ramp up to 1200°F in 1 hour. This is Step #5. |
| 700 ENTER 350 ENTER | Ramp down to 350°F in 7 hours. This is Step #6. |
| | The profile is now entered. |
| MODE | Return to MONITOR MODE. |
| ENTER 5 | Start profile #5 running. |

Figure 3.3: Sample Profile

Recall that pressing CLEAR while in PROGRAM MODE clears the current entry. If you want to start fresh, you can press CANCEL, followed by the profile number, to erase all times and temperatures of the current profile in one fell swoop.

NOTE: To change the time setting in your program, you first must clear the temperature by pressing the CLEAR button once. Then you can clear the time by pressing the CLEAR button again. This step of your program now is ready to receive a new time and temperature. If you want to change only the temperature, just push CLEAR once and the time will remain unchanged.

You may review your program, even while it is running. In general, however, it is not advisable to change the profile that is actively running. However, if you choose to do so, be sure you do not change the time of the step that is currently being executed. This is because changing a time entails returning the time to zero which, in turn, will terminate your program, put the GB1 into IDLE, and shut off your oven. You may change non-active profiles without encountering any difficulties.³

3.4 Linking

The GB1 has the ability to link one profile to another. This is not something everybody needs, and you may wish to ignore this facility. However, there are several reasons you might want to use linking. Here are a few:

- to make a profile of more than 15 steps, or
- to make a profile that lasts longer than 1500 hours, or
- to make a program that does the same thing at the same time every day (*e.g.* turning up a furnace in time for the day's work, and turning it down every evening), by linking a 24-hour-long cycle to itself.

Specifically when the GB1 is running a profile and comes to a link step, it automatically ends the current profile and begins running the linked profile. This profile in turn may be linked to a profile. Any profile may be linked to any other profile, or even to itself. Thus, the GB1 can be made to run forever.

The link command can be used only once in each profile, and it cannot be the first step in the profile (nor is there any reason you should want the first step to be a link).

A link is entered into a profile while in PROGRAM MODE by pushing the HOLD twice in succession. The "H"s in the TIME display will turn to "L"s, which designate the link feature, and a dash ("-") will appear in the TEMPERATURE display.⁴ The dash is to remind you that you must now enter the number of the profile to which you wish to link. This may be any profile, including the current one.

After entering the profile number, press ENTER. (Failure to do this will result in an error. You then must clear the step by pressing CLEAR and start this step over again.)

When ENTER is pushed, the display will show all horizontal bars indicating that no further program steps may be entered, regardless of what the STEP display reads. This is because by definition link is always the last thing the profile does. Pushing ENTER at this point will have no effect.⁵

³GB4 and GB5 users who are used to pressing MODE twice to review a profile may become confused if a profile is running, because pressing MODE twice will result in reviewing the active program, which is generally not the one being modified.

⁴Since a link cannot be the first step of a profile, pushing HOLD a second time in the first step has no effect.

⁵You can gain access to the remaining program segments by clearing the "L"s (press CLEAR).

If you push ENTER after pushing HOLD just once, the GB1 will of course assume that it is a hold. In this case, a subsequent push of HOLD will result in an error, not in the appearance of the “L”s. This is because the next thing after a hold is the holding temperature. In short, the sequence of buttons to be pressed is:

To HOLD: Press HOLD, ENTER, (holding temperature), ENTER
 To LINK: Press HOLD, HOLD, (profile number), ENTER

You may set your linked profiles to run on a fixed length cycle, say a 24-hour cycle for daily repetition. The times may appear to stretch over a period of days. An oven set to come on at 8:00 a.m. every day may come on later in the day. Recall that there are several ways that the timer of the GB1 may have stopped:

- you may have pressed the HOLD button;
- the GB1 may have entered AUTO-HOLD if your oven was not able to follow its profile at some moment; and finally,
- power may have failed (which may well have gone unnoticed because of the GB1’s memory back-up feature).

OBSCURE NOTE: If you use the linking feature to create a loop, you should understand that, if the profile returns to its beginning, the ramp to the first point depends on the temperature at the start of the step. Thus, if your temperature is hotter during the second run of the cycle, there will be a different ramp from the first time, even perhaps ramping down instead of up. For example, assume your first step is to raise the temperature to 700° in one hour, then go to 1100° in 3 hours before entering the looping feature. The second time around, your oven will start out at 1100°, and the GB1 will take it down evenly to 700° in one hour. This may or may not be what you intended.

If you want the cycle to start from some cool point, you must specifically put that into your program. For example, if you want your cycle always to ramp up to 700° from a maximum of 300°, you must enter a cooling off segment in the program before the loop. If this segment is too short for the oven to cool down within the allotted time, then AUTO-HOLD will come on, changing your total cycle time.

3.5 Delayed Start

The GB1 has a *delayed start* feature.

The main use of this is to have your oven waiting for you at working temperature when you arrive at your studio in the morning. With the GB1, you do not have to leave the oven on all night to accomplish this, thus saving on your fuel bill and your time. All you have to do is set the first step of your profile to zero temperature and set the time to indicate the amount of time that should elapse before the oven should begin to heat.⁶ Then set the second step to HOLD at the desired morning temperature. Be sure to start the HOLD soon enough to allow the oven to attain desired temperature before you need to use it.

For example, assume it is 5:00 p.m. and you want your oven, which is currently at room temperature, to be at 850° by 9:00 the next morning. Estimating that it takes 40 to 50 minutes for the oven to reach 850° from a cold start, you should program the GB1 to begin heating the oven at 8:00 a.m. (15 hours from the present time). The first two steps of your profile then would be:

1. 15 hours at 0°, and
2. HOLD at 850°.

⁶Whenever the temperature is set to zero, the GB1 will run its clock without turning on the oven and without engaging AUTO-HOLD.

3.6 Auxiliary Relay

The GB1 may be ordered with an optional auxiliary relay. This relay may be programmed to turn on or turn off at any time. It may be used to control auxiliary heating coils, to actuate a pneumatic cylinder or small motor to open an oven door for crash cooling, to turn on an auxiliary fan or any other auxiliary equipment. You can use the auxiliary relay to control an external device that uses up to 120 volts at 8 amps, AC or DC. If you need to control something that requires more power than that, you can always control it through a secondary, external relay and control the secondary relay through the built-in auxiliary relay.

Any step in the profile may be used to turn the relay on or off. The state of the auxiliary relay is preserved even after the profile ends. If you want the relay to be off when the profile ends, the last step in the profile should explicitly turn the relay off. This method of controlling the auxiliary relay gives great flexibility in the criteria for its activation. It may be based on time, temperature, or both, depending on the previous and subsequent steps.

Even though each use of the auxiliary relay occupies a step in the profile, this is not a serious limitation, because profiles may contain up to 15 steps, and by linking to another profile (section 3.4), you can add additional steps.

The auxiliary relay function is programmed by pushing the HOLD key 3 times when entering the time. The first push causes the programmed HOLD function to appear; the second push causes the program LINKING function to appear, and the third push causes the Auxiliary Relay function to appear. This is indicated by the symbol -88- in the time display, and either a 0 or a 1 in the temperature display. Of course, 0 means the relay is off and 1 means that it is on. Any subsequent push of the hold key will toggle between on and off. If you get to the Auxiliary Relay function by mistake, just push clear and start that step again.

Examples

Preamble and disclaimer: These examples may be incorrect or foolish insofar as proper glass technique is concerned. They are merely for study purposes to show how one can program the Auxiliary Relay in various situations.

1. The auxiliary relay controls auxiliary high power heating elements on the top door of a slumping oven to heat work rapidly.

It is desired to ramp from a hold at 900° to 1100° in one hour and then rapidly heat the work to 1500°, hold at 1500° for 5 minutes and the ramp down to 1000° in 30 minutes.

| Step | Temperature | Time |
|------|-------------|------|
| 1 | 900 | Hold |
| 2 | 1100 | 1:00 |
| 3 | AUX | ON |
| 4 | 1500 | 0:01 |
| 5 | AUX | OFF |
| 6 | 1500 | 0:05 |
| 7 | 1000 | 0:30 |

2. The relay controls the crash cooling of a *pâte de verre* kiln by means of an auxiliary venting fan. After soaking at 1300° for 20 minutes we want to crash cool to 900° and then soak for 1 hour. Let's assume that the first 3 steps of the program have used 2 hours as we start the soak cycle.

| Step | Temperature | Time |
|------|-------------|------|
| 4 | 1300 | 0:20 |
| 5 | AUX | ON |
| 6 | 900 | 0:01 |
| 7 | AUX | OFF |
| 8 | 900 | 1:00 |

3. We have a high temperature auxiliary fan in an annealing oven to insure even temperatures throughout the oven. Assume that the kiln is to rise to 900° over the course of one hour. Then, starting at step 2, it begins a 2 hour soak during which we want the fan to come on for 5 minutes after half-an-hour, and again after a whole hour and finally for the last 15 minutes of the soak.

| Step | Temperature | Time |
|------|-------------|------|
| 1 | 900 | 1:00 |
| 2 | 900 | 0:30 |
| 3 | AUX | ON |
| 4 | 900 | 0:05 |
| 5 | AUX | OFF |
| 6 | 900 | 0:25 |
| 7 | AUX | ON |
| 8 | 900 | 0:05 |
| 9 | AUX | OFF |
| 10 | 900 | 0:45 |
| 11 | AUX | ON |
| 12 | 900 | 0:15 |
| 13 | AUX | OFF |

4. You are annealing a casting. You want it to cool down to 500° in 15 hours, at which point you must examine the mold before proceeding. Since this is a long procedure, you visit some friends in a nearby town while waiting. Because your kiln and mold are well insulated the cooling process may be retarded as you approach the 500° point, causing the auto-hold to come on, which in turn increases the time beyond 15 hours. If you arrive at your studio in 15 hours you may have quite a wait until the 500° point is reached. So, you connect the auxiliary relay to a phone dialer that has been programmed to call your cell phone. Just in case the call didn't go through, you want it to call twice more at 10 minute intervals. In addition, you want the kiln to hold at 500° until you have checked the mold. To actuate the phone dialer, the relay acts somewhat like a push button: you simply turn it on and then off again.

| Step | Temperature | Time |
|------|-------------|-------|
| 1 | 500 | 15:00 |
| 2 | AUX | ON |
| 3 | AUX | OFF |
| 4 | 500 | 0:10 |
| 5 | AUX | ON |
| 6 | AUX | OFF |
| 7 | 500 | 0:10 |
| 8 | AUX | ON |
| 9 | AUX | OFF |
| 10 | 500 | HOLD |

5. This example is a variation on the one above. The main difference is that you want to have the dialer activated every twenty minutes until you arrive to turn off the kiln. The annoyance of having your cell phone activate every twenty minutes can be finessed by turning it off. Here we make use of the profile linking capability of the GB1.

First, put the following program into profile 9 to trigger the phone dialer every twenty minutes while holding the kiln at 500°.

| Step | Temperature | Time | Comment |
|------|-------------|------|----------------------------|
| 1 | AUX | ON | |
| 2 | AUX | OFF | |
| 3 | 500 | 0:20 | |
| 4 | LINK | 9 | loop back to the beginning |

And now, into any other profile, put the following:

| Step | Temperature | Time | Comment |
|------|-------------|-------|-----------------------------|
| 1 | 500 | 15:00 | |
| 2 | LINK | 9 | go to dial-and-hold profile |

When you arrive at your studio, you simply cancel profile 9 (and remember to turn your cell phone back on).

Chapter 4

Special Features of the GB1

The GB1 is designed with several special features to enhance its ease of use and reliability. These include

- the ability to adapt a program to the capabilities of your oven using automatic holds,
- warnings of common external failures (thermocouple burn-out, contactor failures, etc.),
- protecting your programs (and consequently your work) in the event of a power failure, and
- continual internal validation of memory accuracy.

4.1 Automatic Hold

Using the profile you entered, the GB1 calculates a temperature for each minute of the cycle. It bases its decision about automatic holding on this temperature. Essentially, if your oven is not able to keep up with the temperature changes you requested, the GB1 clock will be stopped until the oven catches up.

On heating steps (ramping up), the AUTO-HOLD light will come on if the oven temperature is more than 40°F (20°C) below the calculated temperature for the current minute. On cooling or soak steps, the AUTO-HOLD light will come on whenever the oven temperature exceeds the calculated temperature for the current minute by more than 40°F (20°C).

Once the AUTO-HOLD is engaged, it keeps the clock stopped until the temperature calculated for the current minute is actually achieved.

Under normal circumstances, AUTO-HOLD is usually thought of as something that compensates for unusual demands placed on your oven's ability to follow a profile. However a creative use of AUTO-HOLD allows you to program your oven to ramp up to a given temperature as quickly as possible. Simply program the time for the step to be one minute. The GB1 then will go into AUTO-HOLD until the desired temperature is reached and then go on to the next step.

4.2 Guaranteed Temperatures

Sometimes it is very important that the final temperature of a ramp be attained before going on to the next step of the profile, and it can never hurt, so the GB1 guarantees that the oven actually

reaches the temperature specified at each point in the profile before allowing it to go on to the next step. When necessary, the clock will be stopped during the last minute of a step to allow the oven to reach this temperature. The auto-hold light will come on while the clock is stopped.

4.3 Warnings and Alarms

There are certain serious problems that could cause improper temperature readings or overheating of the oven. When this happens the alarm will be activated and an error code of the form “BAD?” will appear in the display to identify the problem. Except in the case of BAD8, the GB1 will attempt to shut down the oven by turning off the contactor. At this point, the only key that is active is the CLEAR key. It will clear the BAD message, shut off the alarm and allow the GB1 to continue. However, if the condition has not been corrected, the alarm and error message will be reactivated as soon as the condition is again detected. This can take anywhere from one second to twenty minutes, depending on the cause of the problem. Of course if the alarms have been disabled, as discussed below, then BAD1 and BAD2 are prevented from occurring for at least 45 minutes. As a special option, GB1s may be ordered with BAD1 and BAD2 both disabled.

The “BAD?” display is made up of unusual-looking characters: a lower-case **b**, an upper-case **A**, a lower-case **d**, and then a single digit between 1 and 7. Thus, BAD6 looks a little like **bAd6**; in the actual display, the **b** and the **6** look almost identical. We mention all this because it can be very confusing when first seen, and we hope you see them seldom enough that you never get used to them!

These are the various error messages and their interpretations.

BAD1: The temperature does not appear to be increasing, even though the GB1 is calling for heat. This alarm latches on until the CLEAR key is pushed. Likely causes of BAD1 are

1. The thermocouple has come out of the oven.
2. There is a bad fuse in GB1 output module circuit.
3. The contactor is bad (its coil has probably burned out).
4. There is a fault in the oven itself that prevents it from heating.
5. There is an internal problem in the GB1.

BAD2: There has been a significant temperature increase even though the GB1 is not calling for heat. This alarm latches on until the CLEAR key is pushed. Likely causes of BAD2 are

1. The contactor is bad (it has become stuck or shorted).
2. There is a short circuit in the wiring between the GB1 and the contactor.
3. There is an internal problem in the GB1.

BAD3: There is a problem with the thermocouple. This alarm remains active only so long as the problem is detected; once the problem disappears, the alarm goes off by itself. This warning is not active in controllers with an external Sending Unit. Likely causes of BAD3 are

1. The thermocouple itself is broken (“open” or burned out).
2. There is no thermocouple attached to the GB1.
3. A wire connecting the thermocouple to the GB1 has become loose.
4. There is an internal problem in the GB1.

5. Leakage of electrical current from heating elements to thermocouple¹.

It is normal for thermocouples to burn out after a certain amount of use. When this happens, the BAD3 message will appear. To be sure that the problem is indeed external to the GB1, try the following: connect a plain piece of wire from the red to the yellow terminals where the thermocouple attaches. Don't forget to turn off all power, including the power to the contactor, before opening the GB1. When you turn power back on, the GB1 should display ambient room temperature when in MONITOR MODE. If it does, the GB1 is functioning correctly, and you should replace your old thermocouple.

BAD4: The thermocouple is connected backwards. Once the thermocouple is correctly installed, this should not ever happen. Watch for this warning the first time you heat your oven after changing thermocouples. This alarm remains active only so long as the problem is detected; once the problem disappears, the alarm goes off by itself. Only certain versions of the GB1 have this feature.

BAD5: Internal problem with the analog to digital converter. This can also be caused if the temperature appears to be over the maximum the GB1 is capable of reading (approximately 2550°F for Type K). This alarm remains active only so long as the problem is detected; once the problem disappears, the alarm goes off by itself.

BAD6: Internal problem in the GB1.

BAD7: GB1 continuous self-diagnostics have discovered a problem, possibly caused by electrical noise or cosmic particles. If the built-in recovery procedures are likely to have resolved the problem, the GB1 will continue operation with no other disruptions — except the BAD7 alarm, which you clear in the usual way, by pressing the CLEAR key. If the problem appears to have corrupted the GB1's working memory, the GB1 will shut off the oven.

In other words, while displaying BAD7, if it appears that the GB1 can continue safely, it does so; otherwise it shuts down.

If BAD7 occurs repeatedly, you either have a problem with the electrical power being supplied to the GB1, or your GB1 needs to be repaired. If the problem is due to poor electrical power, a power conditioner is likely to cure it. If it does not, you should arrange to return your GB1 for repair.

BAD8: The GB1 has detected an internal timing error. The GB1 will reset itself and continue to control your oven, but it will display BAD8 until you clear it with the CLEAR key. If the BAD8 recurs immediately after clearing it, then there is a serious problem with your controller. Holding a key down for over eight seconds will generate this error.

All of the alarms except BAD3 “latch on” and will reset only when CLEAR is pressed. The BAD3 alarm is self-clearing. If it is caused by an intermittent condition and if you have attached an external alarm to the GB1 (see section 5.5), then this alarm will sound intermittently also.

¹This tends to happen mainly at very high temperatures, when refractory materials become electrical conductors instead of insulators, and thus this appears to be an intermittent problem. Typically this is an installation problem and may sometimes be cured by changing the placement of the thermocouple or by using a better thermocouple.

4.4 Disabling Alarms

BAD1 and BAD2 detect temperature changes not initiated by the GB1. Under normal circumstances these work as expected. However whenever an external event causes abrupt temperature changes, these alarms may falsely trigger. This could happen when you place a large, hot casting into the oven; it might raise the temperature without the GB1's calling for heat, thus triggering a BAD2. Similarly, opening the oven door to place a piece into the kiln or keeping it open to "crash cool" a piece could trigger a BAD1. Under these circumstances, it is desirable to be able to disable the alarms before they trigger. Assuming the GB1 is in MONITOR MODE and not already displaying a BAD message, you can do this by pressing the CLEAR key. This disables BAD1 and BAD2 alarms for 45 minutes. Each time CLEAR is pushed, the 45 minute delay begins afresh; pushing it twice does not give 90 minutes — just 45 minutes from the second push. The key is acknowledged by momentarily displaying a horizontal bar "—" in both the TIME and TEMPERATURE displays. In general, there is no way to cancel this delay but the passage of time. However, starting a profile or skipping a step nullifies any time left in such a 45 minute delay.

4.5 Behavior During Power Failures

Special components and circuitry are used within the GB1 to preserve its memory during power failures. The GB1 will remember:

- whether your oven was running or idle when the power failed,
- the profile step and time when the outage occurred, and
- the last temperature reading at the time of the power failure.

When the GB1 detects low power, it indicates this by displaying "LO" "P—" instead of TEMPERATURE and TIME. This may be the result of a "brown out" or the prelude to total loss of power. The actual power loss may be so short that your only indication is this "LO P—" display.² So that it may be seen, the "LO P—" display stays on for a couple of seconds even if full power returns more quickly.

During the power failure, the face of the GB1 will look blank.

When power is restored, "8"s will appear in the TIME and TEMPERATURE displays while the GB1 takes new, reliable temperature readings. Concurrently, the PROFILE display counts down from 3 to 1. The GB1 then evaluates the temperature loss of your oven from the time the power failed to the time it was restored. If the actual temperature loss is less than 200°F (or 100°C for Celsius models), the profile will continue as if the power failure had not occurred. Since the vast majority of power failures are quite short (under one minute), the temperature drop will be insignificant and the oven thus will continue running according to your original profile.

If your oven cools more than 200°F during a power failure, the temperature of the oven when power is restored will be maintained. The TIME and TEMPERATURE displays will read "Cold". If you have connected an alarm, it will sound. This procedure should protect your oven and its contents from reheating rapidly without your knowledge. When you check the oven and notice this condition, you then have the opportunity to decide the most appropriate course of action from this point (as described in the following section).

²It is important to realize that many power failures are extremely short, so short that you may not even notice them. As a consequence, from time-to-time your GB1 may appear to begin the count down cycle spontaneously. This is invariably a result of power difficulties of some sort.

4.6 'Cold' Readings

As noted above, if a power failure has lasted long enough that your oven has cooled more than 200°F (100°C) during the outage, its TIME and TEMPERATURE displays will read "Cold". If you have connected an alarm, it will sound. The current temperature will be maintained.

When this occurs, push the CLEAR button to clear the "Cold" display. The last step and time reading before the power failure will be displayed along with the CURRENT temperature.

If you choose to continue with the profile at this point, push ENTER/START and the profile number. As the oven lost more than 200°F during the power failure, the oven will begin heating.

ANOTHER OBSCURE NOTE: If the oven was ramping up or holding when the power failed, AUTO-HOLD will go into effect until the oven reaches the programmed temperature. If it was ramping down, AUTO-HOLD will not come on, because the temperature is lower than required, and the GB1 assumes that the temperature is thus simply ahead of schedule. See section 4.1 for more details.

If you want to cancel your profile and restart it, push CANCEL and the profile number. The GB1 will then be in IDLE.

When "COLD" is displayed and the GB1 is in MONITOR MODE, you can examine or change any profile by putting the GB1 into PROGRAM MODE. Remember, it is best not to reprogram a profile that is running.

4.7 Voltage Protection

Considerable design effort has been devoted to protecting your GB1 against line voltage transients and transients at the thermocouple connections. At the power input, transient spike protection is wired internally into the GB1. Any abnormally high voltage spikes are automatically shorted to ground by the internal solid-state circuitry.

In spite of all this protection, contact between a thermocouple and a live heating element is likely to damage the GB1. The GB1 is not guaranteed against damage of this type. The thermocouple should be fastened securely within the oven to prevent contact with the heating elements.

Under no circumstances should you adjust the position of the thermocouple when the oven is heating. Not only do you risk damage to your equipment, you also risk a **DANGEROUS ELECTRICAL SHOCK**. Remember, the heating elements typically contain voltages as high as 240 volts, depending on exactly where they are touched. Thermocouples are made of metal. Metal conducts electricity. Even if your elements and thermocouples are encased in porcelain, care still must be used. Porcelain and other refractory materials become conductive at high temperatures and consequently do not give as much protection as you might assume.

4.8 Memory Failure

Your GB1 continually checks its internal memory for accuracy. In case of a memory failure, the green and red MODE lights alternately will light about every one-half second and "P"s (for "Problem") will flash across the TIME and TEMPERATURE displays. If you have hooked an alarm to the alarm relay, it will sound.

The flashing "P"s indicate a corruption of the GB1's memory. This may be a temporary condition, one that may never recur.

In the event of a memory failure, the GB1 is designed to protect your work and ovens by running the following sequence. First, it will turn off your oven for about one minute to allow the temperature readings to stabilize. Then, it will read the current temperature and hold at that temperature until you reprogram the GB1.

When the GB1 signals a memory failure, push any key to reset it, and it will stop flashing. The GB1 will then check to see if the profiles have been corrupted. If they have been, then all profiles will be cleared, your oven will be set to IDLE, and the GB1 will display PROFILE #0. If you do not reprogram the GB1, your oven will begin to cool down.

On the other hand, if the profiles have not been corrupted, then when you push a key the GB1 will go on as though nothing had happened. However, the flashing indicates that something was corrupted, so you should be sure to check the profile number, step number, time, *etc.* It may be necessary to restart the profile and manually skip steps to an appropriate step to resume work (see page 11). In some cases, you may have to program a special rescue profile to recover.

Fortunately, memory failure is quite unusual. It can usually be traced to one of two causes:

- A voltage transient so fast and so powerful that it swamps the GB1's protective circuitry and modifies profile memory. Digistry's memory assurance scheme is so sensitive that it will detect the alteration of even a single digit.
- Power failure while you are entering a profile. In this case, the memory assurance scheme may detect inconsistent information.

In rare cases, electronic failure of the memory will appear as a memory failure, one that you cannot clear using the procedure above. In this case, you will have to return your GB1 for repair.

Chapter 5

Installation

Safety Considerations

Before installing your GB1, please consider the following important safety issues. Your Digitry temperature controller is a device to facilitate the processes involved in ceramic and glass production. Any electronic device can fail for a myriad of reasons — both obvious and obscure. One should never rely on any temperature controller to ensure fire safety. Any kiln or annealing oven should be installed so that there is no fire danger, even if the kiln is on full all of the time (although this might cause damage to the kiln itself). Be sure there is adequate clearance from all walls and flammable materials. In particular, floors under kilns should be fireproof. Additionally, your installation should conform to all applicable fire and building codes.

The electrical circuits powering your kiln involve very high currents and dangerous voltages. Apart from dangers posed by potentially lethal electric shock, there is also a danger of fire arising from inadequate or improper wiring. Accordingly, it is strongly advised that all electrical work involving the powering of your kiln and installation of power relays (mercury or solid-state) be done by a qualified electrician, in compliance with all applicable electrical codes.

5.1 Orientation

There are two required aspects and one optional aspect to the installation of your GB1:

- connecting the thermocouple that measures the temperature of the oven,
- connecting the relay or solenoid that controls the heating of the oven, and
- [optional] connecting an alarm to the GB1.

The Digitry GB1 is available in several variants, each designed to give the best match for its intended use. Installation details vary with each of them.

Input Variants:

The standard GB1 is designed for use with a Type K thermocouple that connects directly to the GB1. For cases where it is desirable to mount the GB1 some distance from the kiln or oven, a remote, GB5-type Sending Unit may be used. This requires a special version of the GB1. For these GB1s, you cannot connect the thermocouple directly to the GB1; you must use the Sending Unit.

For high temperatures, a platinum thermocouple is needed. Variants of the GB1 are calibrated for Type R or Type S platinum thermocouples. A special Sending Unit is required in this case; it is the same for Type R and Type S thermocouples.

Those GB1s that use an external Sending Unit do not use BAD3 to indicate that the thermocouple has failed. Type K Sending Units have an internal buzzer to warn you about this condition.

Output Variants:

The standard GB1 has an on/off output optimized to control magnetically activated devices such as mercury contactors, mechanical relays or contactors, or gas solenoid valves.

GB1s are also available with proportional control instead of on/off control. In this case there are 2 possible variants.

1. “pulse averaging” using a solid-state power relay.
2. 4–20 milliamp current loop for phase angle triggered SCRs or motorized valves on gas furnaces.

Figure 5.1 shows a GB1 that has the Sending Unit built in, so it connects directly to a Type K Thermocouple. Figure 5.2 shows a GB1 with connections for an external Sending Unit. Review the appropriate figure to familiarize yourself with the layout of the interior of your GB1. Then read all the following instructions before installing your GB1. As you will see, the entire procedure is relatively easy.

5.2 Opening the GB1

It is necessary to remove the faceplate of the GB1 in order to gain access to the terminal strips to which the thermocouple and relays are to be connected. It is a good idea to do this work at a table or desk.

Before opening the GB1, always be sure that all power is off, including especially power to the contactor and the optional alarm relay.

Once you have checked that power is off, remove the six screws on the faceplate. If you now tilt the GB1, the faceplate and its attached circuit board will fall away from the box. Be ready to catch the faceplate so that it doesn’t get damaged and no strain is put on the cables that connect it to the main circuit board in the bottom of the case. These cables are long enough so that you can lay the faceplate on the table out of your way.

The GB1 should be oriented so that if the faceplate were in its normal place, all lettering would be right-side-up. Given this orientation, the red and yellow terminals for the connection of the thermocouple are found at the lower left corner. The terminal strip for the connection of the contactor control and alarm is in the upper right corner. This strip has four terminals on it. The top two terminals are for connection of the contactor control, and the bottom two are for connection of the optional external alarm.

The wires are to be passed through the rubber grommets before connecting to the terminals, so that the cover can be replaced afterwards. Wires being lead into any enclosure through an opening should have a *strain relief* to prevent a tug on the wires from disconnecting them. This is particularly important for wires that carry power like the relay wires. A strain relief is formed by having something attached to the wires that is bigger than the opening or by forming the wires into a knot. This enlargement must be far enough from the ends of the wires that when it is snug against the opening, there is no tension on the wire ends.

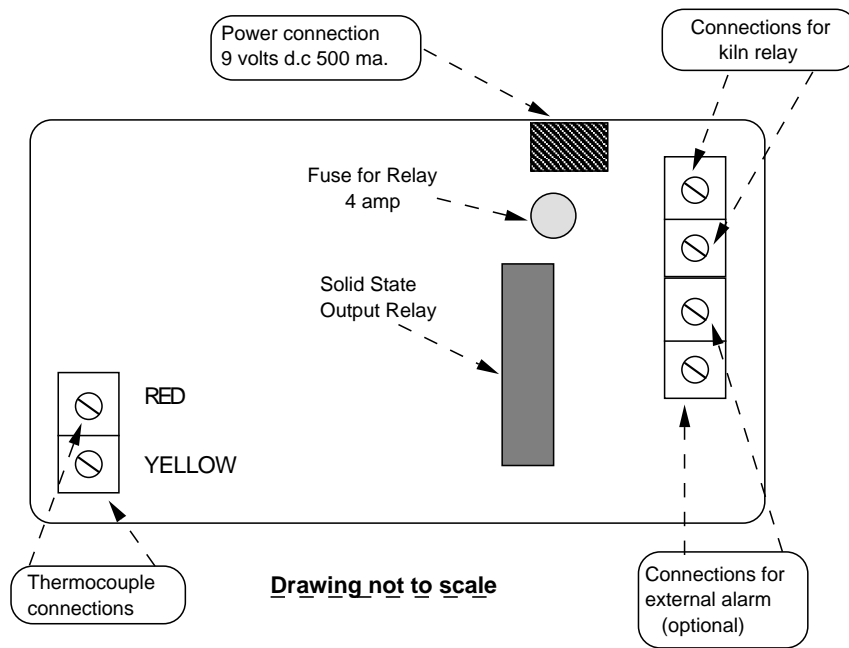


Figure 5.1: Interior of GB1 — No External Sending Unit

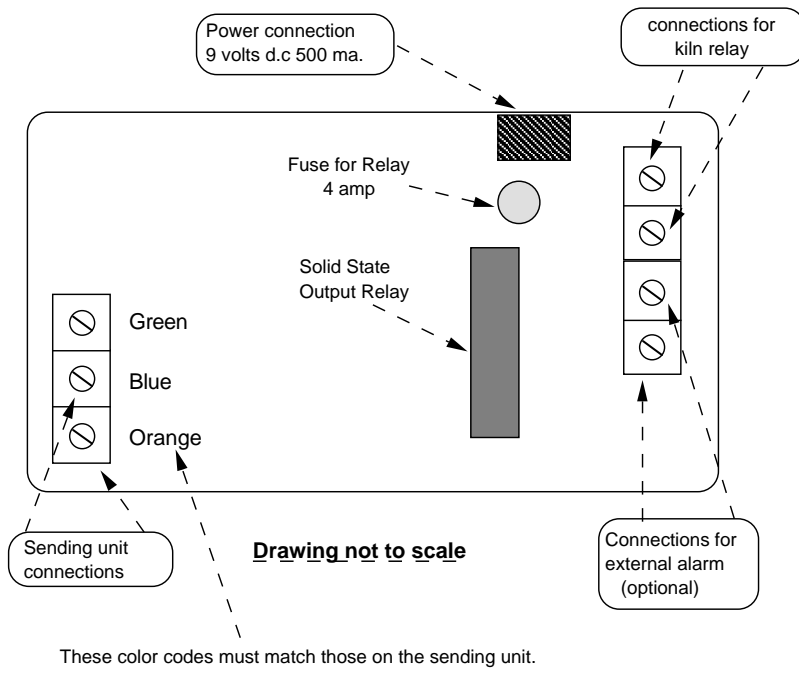


Figure 5.2: Interior of GB1 — For External Sending Unit

You can form a strain relief using some of the supplied plastic tie wraps. Wrap a tie wrap around the wires a couple of times and pull it as tight as possible with pliers. Alternatively, if your relay wires are flexible enough, you can tie a knot in them before connecting them to the terminals.

After all connections are made according to the directions in the following sections, replace the cover, making sure the cables between the circuit boards lie fair and are not forced over towards the terminal strip. Put in the six screws and hand tighten moderately. Do not over-tighten these: you may need to remove the cover again some day.

5.3 Thermocouples

There are various types of thermocouples in common use. For temperatures typical of most glass and ceramic techniques, the Type K (chromel-alumel) thermocouple is almost universally used. For the higher temperatures encountered in certain processes such as crystalline glazing of ceramics and for melting glass in furnaces, a platinum thermocouple is required. Digitry's standard GB1 is designed for use with Type K thermocouples, which connect directly to a terminal strip inside the GB1. For Type R and Type S (platinum-rhodium) thermocouples an external Sending Unit is required, as described below. Because of differences in calibration, a GB1 that has been designated as Type R or Type S should not be used with a Type K thermocouple and so forth. The type of thermocouple must be matched with the type of GB1. A mismatch between the thermocouple and the GB1 will result in erroneous temperature readings but will not damage the GB1.

For the standard GB1, with a Type K thermocouple, the installation is as follows.

We assume you have removed the faceplate of the GB1 as described above. The first step is to attach the thermocouple to the GB1. Unless your unit was equipped with a thermocouple at the factory, then it was shipped with a jumper wire across these two terminals. This wire must be removed before proceeding.

A thermocouple is a polarized device, and it is important to attach it correctly. The leads to the thermocouple should be marked red (negative) and yellow (positive), and these are to go to the red and yellow terminals, respectively, within the GB1¹.

If the thermocouple lead wires are not long enough to reach from your oven to the GB1, you must use extension leads. These leads should be made of thermocouple extension wire and should be relatively short. Ordinary copper wire can be used instead of extension wire, but this generally introduces small errors into the temperature readings. This error is known as cold-junction error and is an offset error that depends only on the ambient room temperature.²

The suggested length of the thermocouple leads or extension is up to approximately eight feet [2.4 meters], but there is no hard-and-fast rule about this. Depending on your situation, you might be able to use leads considerably longer than this, but you will have to make a few experiments to find out. If you observe unreliable or erratic temperature readings, especially when heavy electrical equipment or motors turn on and off, you should be suspicious of long thermocouple leads³. If you find that your thermocouple leads are too long, you should probably be using a GB1 with the external Sending Unit option.

¹This may be confusing to those of us who associate red with positive and black with negative. However, we must accept this inscrutable convention of the thermocouple world.

²An offset error does not increase as the measured temperature gets higher.

³A thermocouple generates extremely small voltages, on the order of a few thousandths of a volt, reaching a maximum of about 50 millivolts. The longer the wires, the more they act like antennas, picking up electrical noise that makes it harder to get correct temperature readings.

The thermocouple itself should be situated within the oven so that it is certain to measure an even temperature. For example, if placed too near the heating element, it may read a temperature that is higher than the ambient temperature.

If you hook up the thermocouple with the leads interchanged, no damage will occur, but the readings will be wrong. On some models the GB1 will activate the BAD4 message and the alarm (if connected) as soon as the thermocouple is heated approximately 30° or 40°. If your thermocouple is not marked as described above, you must determine which wire is positive and which is negative. Try one way. If it is wrong you will soon see the BAD4 message, as described just above, and will thus know to reverse the leads.

There is no way that the GB1 can distinguish between a thermocouple that has burned out and the situation where no thermocouple is attached. In either case, it will activate the BAD3 message and alarm. When a functioning thermocouple is reconnected, normal operation will resume as soon as you press the CLEAR button or restore power.

5.4 Sending Units

For simplicity the standard GB1 has the thermocouple conditioning circuitry integrated into the unit itself. Unless your GB1 has an optional external sending unit, you should ignore this section: it does not apply to your GB1.

Since the signal from the thermocouple is very weak (in the few thousandths of a volt range), a long wire connection for the thermocouple to the GB1 presents great possibilities for electrical interference from motors, fluorescent lights, *etc.*, to adversely affect the temperature readings. So for those cases where we need to have the thermocouple far from the GB1, a version of the GB1 with external conditioning circuitry is available. This circuitry is contained in a small aluminium box called a “Sending Unit”. This Sending Unit should be located near the thermocouple and then be connected to the GB1 with 3 ordinary, light gauge wires. There are two types of Sending Units — one for Type K thermocouples and one for Type R and Type S thermocouples — and three different calibrations — Type K, Type R, and Type S. Make sure you use the correct thermocouple and correct Sending Unit for your GB1. If you do not, you will not damage your GB1, but it will read temperatures incorrectly.

As far as installation is concerned, the only difference between the two types of Sending Unit is in the color coding: Type K units use Red (for negative) and Yellow (for positive), while Type R/Type S units use Red (for negative) and Black (for positive)⁴. These directions are written as though you were installing a Type K thermocouple, with the Type R/Type S color in parentheses where it differs.

The Sending Unit has two terminal strips, one at each end (see Figure 5.3). The one with two terminals coded red and yellow (black) is for connecting the thermocouple leads. These leads should be of thermocouple wire or thermocouple extension wire of the appropriate type (K, R, or S) and should be relatively short. We suggest keeping the length of the thermocouple leads to under eight feet (2.4 meters) — even less for Type R and Type S thermocouples — but this is not a hard-and-fast rule. Also, the Sending Unit should not be exposed to excessive heat [anything greater than 170°F (75°C)].

To prevent damage from static electricity during shipping, the Sending Unit terminals are shorted together with small jumper wires. Generally, these should be removed prior to installing the Sending Unit. However, if you want to test your connections to the GB1 before connecting the thermocouple, leave the jumper between the red and yellow (black — positive) terminals on, but

⁴These colors are used in the United States; other color schemes are used in some other countries.

remove the others. Then, when the sending unit is correctly connected, the GB1 should display room temperature. If the thermocouple jumper wire is removed but no thermocouple is connected, the Sending Unit will think there is a burned-out thermocouple. (The Sending Unit cannot tell the difference between a burned-out thermocouple and the fact that there simply is none connected.) In this case, with a Type K Sending Unit, the audio alarm will buzz; there is no audio alarm for a Type R/Type S Sending Unit. In case of thermocouple burn-out, the temperature will drift to a very high number that has nothing to do with the actual temperature, and, if a program is running, your oven will turn off. This will not damage your GB1, and when a functioning thermocouple is reconnected, normal operation will resume. Of course, when a thermocouple is connected, any jumper wire used in testing must be removed.

The other end of the Sending Unit has three terminals, coded orange, blue, and green. These are for connections to the GB1 itself. The connections between the Sending Unit and the GB1 are made with common wire (between 22 and 18 gauge hook-up wire is recommended). When making the connections from the GB1 to the Sending Unit, it is very important that the colors match (*i.e.*, orange to orange, blue to blue, and green to green). The order of the colors on your Sending Unit may not match the order shown in Figure 5.3, but the color is all that is important. For reference purposes we note that the orange coded wire carries 15 volts DC to power the Sending Unit, the blue is common, and the green carries the temperature signal.

When connecting the wires between the Sending Unit and the GB1, try to avoid (as much as possible) running them parallel to heavy current-carrying wires (such as the main power lines in your heating elements or relay control power lines). If these lines run parallel, they can form an electro-magnetic coupling, which causes 60 cycle noise to be picked-up on the temperature input. Frequently, problems involving erratic temperature readings can be traced to a situation such as this.

5.5 Connecting a Control Relay

There are three different output versions of the GB1, one for on/off control, one for proportional control using a solid-state power relay, and one for proportional control using a 4–20 milliamp current loop. Each has a different installation scheme, so please consult the section appropriate for your version.

All GB1s have two pairs of relay outputs.⁵ One is the main control relay, which controls your oven via a contactor, a solid-state power relay, or a current loop; the other is the alarm relay, which is activated whenever an abnormal situation requiring your attention occurs. As described in section 5.2, the top two terminals are for the main control relay, and the bottom two are for the alarm.

Standard GB1 — On/Off Control

The control relay output of the GB1 is an AC solid-state relay capable of handling up to 3 amps, 24–240 volts AC. This voltage is not supplied by the GB1, but must be provided as part of the installation. Whether 24, 110, or 240 volts, *etc.*, is used depends on the requirements of the relay or solenoid. The minimum load, necessary to actuate the output relay is about 20 to 30 milliamps. Note that a typical two-pole mercury contactor draws about 100 milliamps, which is very comfortably within the range of the GB1's specifications.

⁵Those GB1s that have an Auxiliary Relay have three pairs of relay outputs.

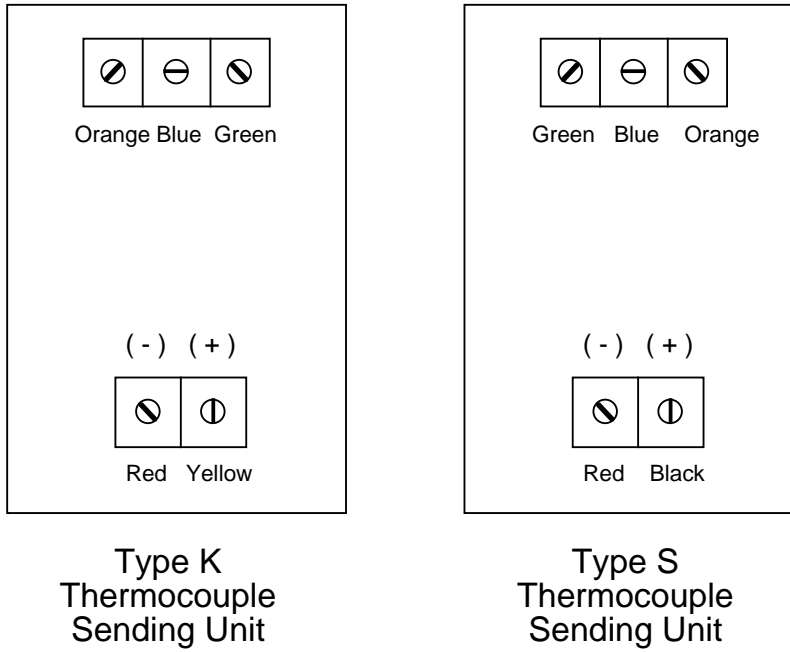


Figure 5.3: Thermocouple Sending Units

The GB1 control relay is optimized for reliable control of contactors, relays, and solenoids; it completely isolates the external voltage from the rest of the GB1 circuitry. Because the control voltage is AC, there is **no difference** between the two top terminals — they are symmetric. You should not think of one of them as “in” and the other as “out”.

THIS IS A CONTROL CIRCUIT ONLY: NO MAIN HEATING ELEMENT POWER SHOULD BE RUN THROUGH THIS RELAY!

It should be noted that in order to provide the utmost flexibility, the main control terminals do not supply any power or voltage. This means you can use, say, a 24 volt, a 36 volt, a 120 volt, or a 240 volt relay without having to make any changes whatsoever to the GB1. We repeat:

This is a passive switch and does not supply any power.
 This is a passive switch and does not supply any power.
 This is a passive switch and does not supply any power.

We cannot stress this too strongly: it is the cause of much confusion during installation. These circuits will control any AC voltage from 24 to 240 volts. The voltage to be used will depend upon the type of coils in your contactors. If you are using contactors with less than 120 volt coils, you will probably need a step-down transformer to get the lower voltage. In new installations, a low voltage 24 or 36 volt control system may be preferable to a 120 volt system: such a system is safer and easier to install according to various electrical codes. For control of gas, a low voltage solenoid is generally specified.

As shown in figure 5.5, the control voltage should be connected in series between the GB1 terminal and the appropriate contactor or solenoid. It is important to realize that the control voltage is not necessarily the same as that used to heat the oven. A 24 volt relay may still control a 240 volt oven.

It is essential to have a switch or circuit breaker in circuit of the main heating element of the oven. This allows the independent shut down of the oven in case of a malfunction or stuck contactor. The output channel is fused internally. To check or replace this fuse, you must remove the front cover of the GB1.

Figure 5.4 shows what a typical mercury displacement contactor might look like. Figure 5.5 gives a schematic view of a typical installation of a GB1 controlling a contactor. The version shown in figure 5.6 gives a more pictorial view of the same thing. Note that there are three wires used to form the circuit involving the GB1 and the contactor:

- from the control voltage source to the GB1,
- from the GB1 to the contactor, and
- from the contactor to the control voltage source.

The GB1 power supply is shown in figure 5.5 for reference only; it does not provide any power for controlling the contactor, only for supplying the GB1.

The most frequent problem in installing a GB1 is to assume that it provides power and to install it as shown in Figure 5.7. Note that in this incorrect installation there is no source of power for the control circuit, and thus there is nothing that can activate the contactor. This installation will not work.

WARNING: TO PREVENT POSSIBLE DANGEROUS ELECTRIC SHOCK TO YOURSELF AND DAMAGE TO YOUR GB1, REMOVE THE COVER ONLY WHEN THE AC POWER IS TOTALLY DISCONNECTED FROM BOTH THE GB1 AND ALL CONTROL CIRCUITS.

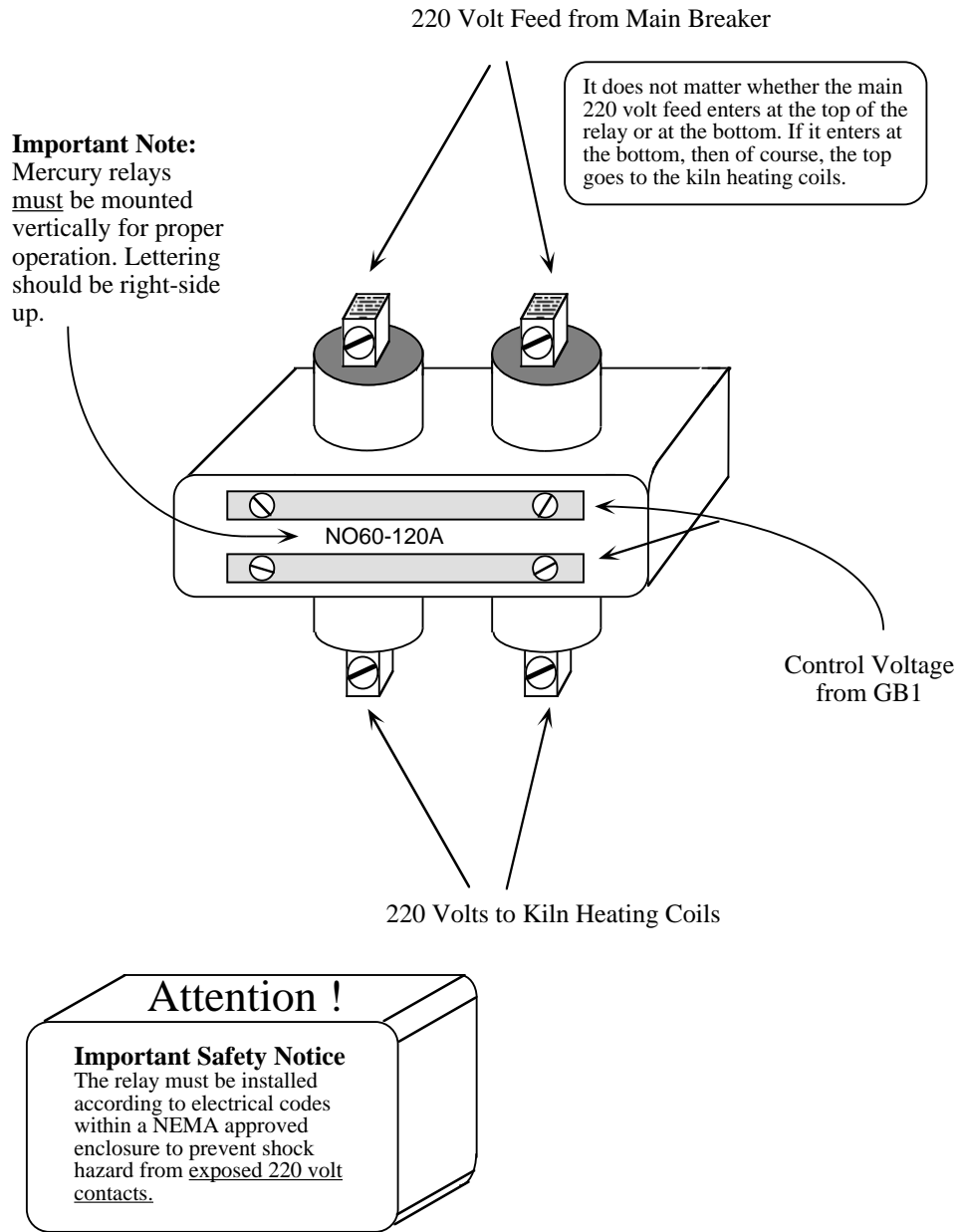


Figure 5.4: Typical Mercury Relay

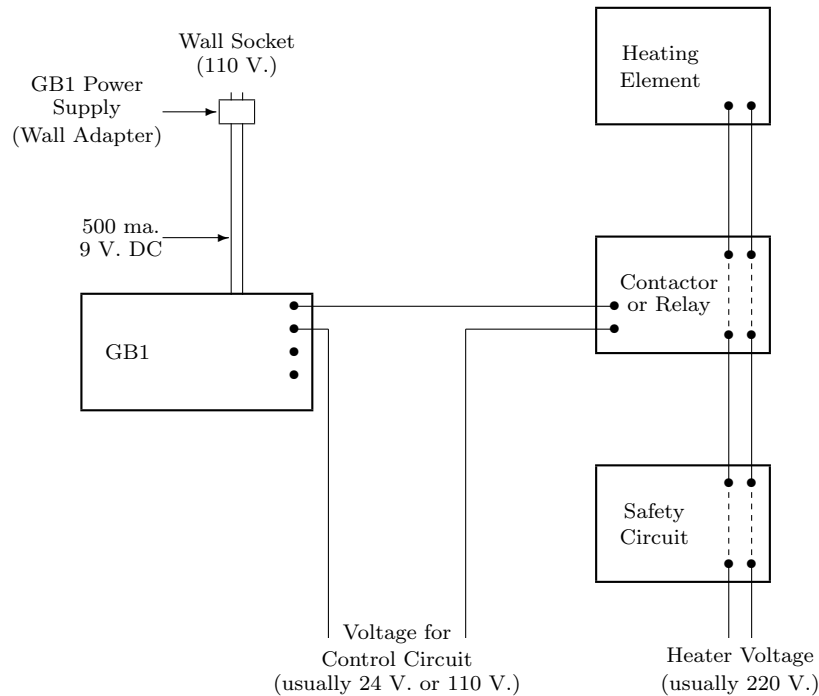


Figure 5.5: Typical Installation, Standard GB1 — Schematic

Note that even though a fuse is provided in the main control relay, it does not guarantee total protection for the solid-state output module inside the GB1. In the event of excess current's being drawn (from improper wiring, for example), this solid-state device may be damaged long before any fuse of a reasonable size could blow. Therefore, when installing your GB1, scrupulously review your wiring. Be certain there is no direct short across the output terminals before applying power to your relay control circuit, as this quite possibly may blow out the output module. Also, be certain that you have connected the relay wires to the correct terminal strips (on the right of the GB1, looking from the top).

WARNING: SERIOUS AND EXPENSIVE DAMAGE WILL OCCUR TO YOUR GB1 IF YOU APPLY 110 VOLTS, OR EVEN 24 VOLTS, TO THE THERMOCOUPLE INPUT TERMINALS. DO NOT BE CARELESS WHEN HOOKING UP THE RELAY POWER. YOUR UNIT IS NOT GUARANTEED AGAINST DAMAGE DUE TO INCORRECT WIRING.

When you attach the wires, remember, the top two terminals on the upper right hand side are for connection of the contactor control, and the bottom two are for connection of the optional external alarm. Don't forget the strain reliefs.

One final remark for those of you using mercury relays: these must be mounted vertically. They depend on gravity to control the position of a pool of mercury and if not properly oriented they will not work; they will either stay on or stay off continually. A typical mercury relay is shown in figure 5.4.

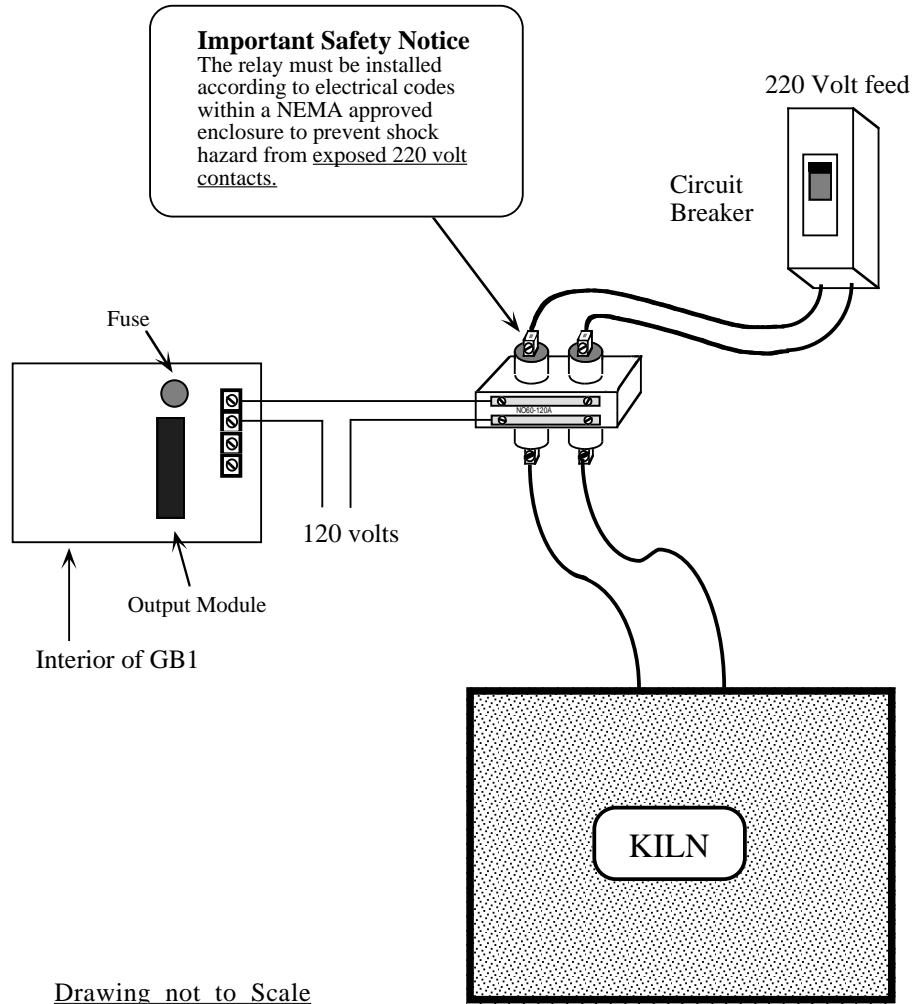
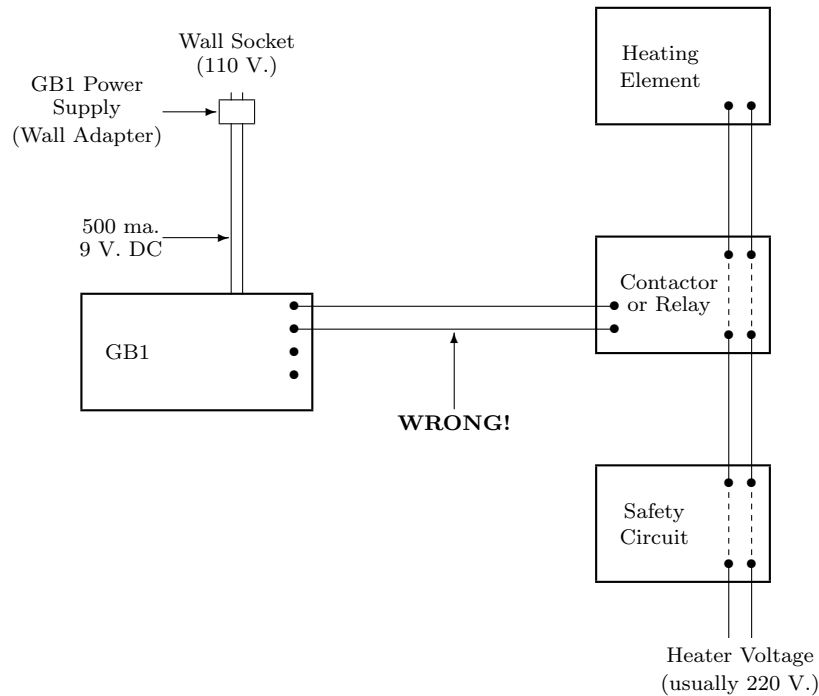


Figure 5.6: Typical Installation, Standard GB1 — Pictorial

Figure 5.7: **Incorrect** Installation for Standard GB1

Solid-State Power Relay

With “pulse averaging” proportional control, also known as “pulse width modulation” or “PWM”, the oven is controlled by a solid-state power relay, which is pulsed on and off very rapidly. To the oven it seems to be partially on all the time. The percentage of “on” is determined by the number of pulses in a given second.

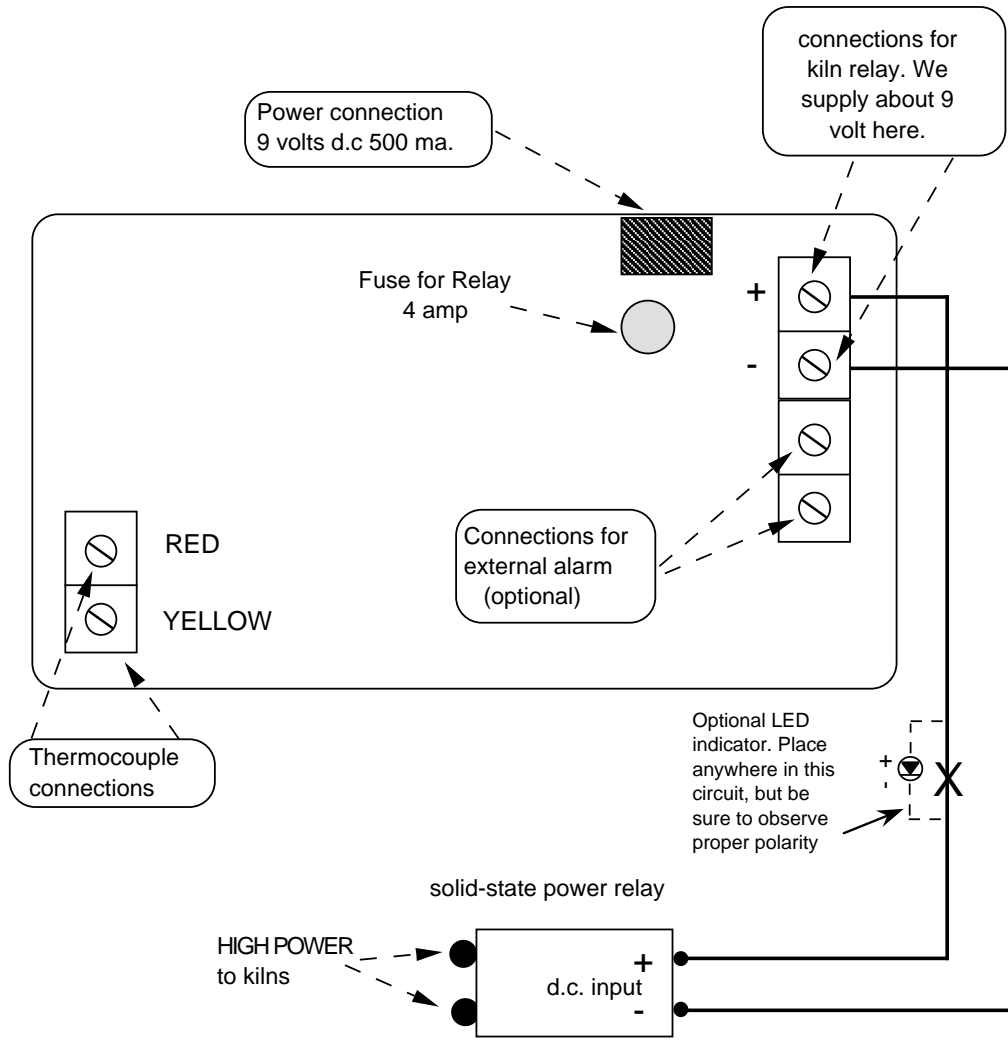
See figures 5.8 and 5.9 for installation diagrams.

A pulse averaging GB1 differs from that of the standard on/off version, since it is controlling a solid-state relay and not a magnetic device such as a contactor. In this case the GB1 provides about 9 volts DC drive for the solid-state relay. The relays used in this application should be of the type which have a DC input, usually 3–15 or 3–60 volts, and as with all solid-state power relays, they must be provided with adequate heat-sinks or they will quickly fail. If in doubt about this, check with the supplier of the solid-state relay to be sure that it is properly installed.

It is also possible to use solid-state power relays without proportional control. In this case we still use the same physical version of the GB1 and the same connections apply.

The connections for this variant differ from the standard GB1 in two very important ways.

1. External power is neither required nor allowed. In particular, connecting 110–120 volt external power will instantly blow the fuse in the output circuit, and even then may cause damage to the relays.
2. The connections are polarized. It matters which goes where. The top terminal is positive



Drawing not to scale

Figure 5.8: Solid-State Power Relay Connection

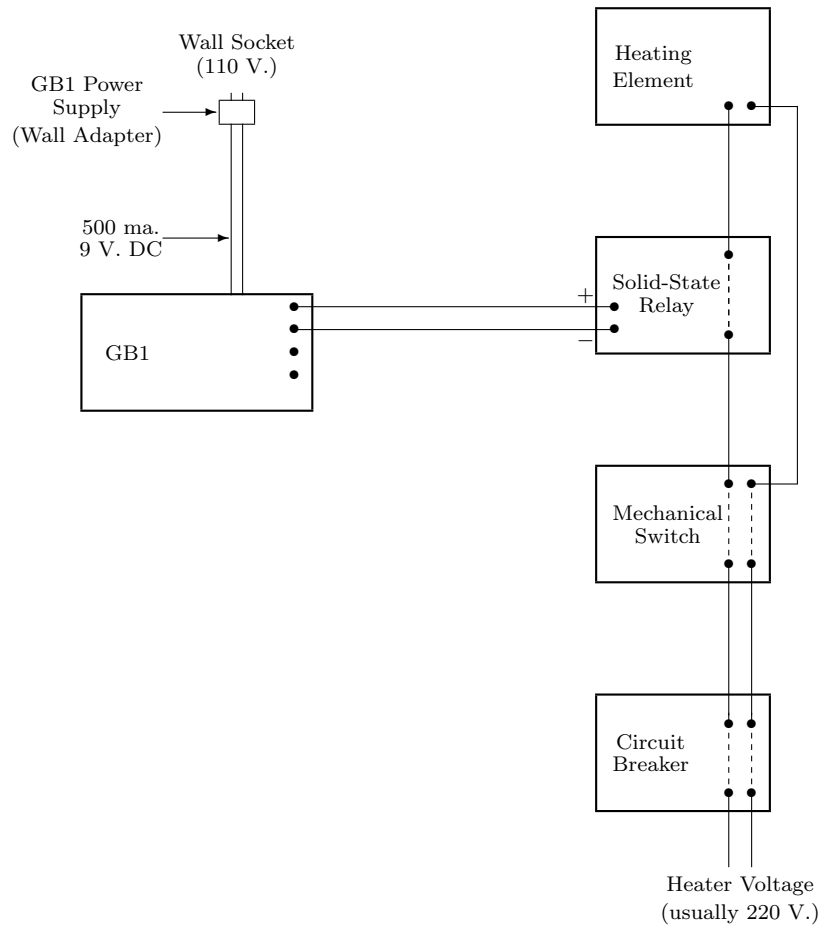


Figure 5.9: Recommended Solid-State Relay Installation

and the second one is negative. If the polarities are reversed no damage will result, but the power relays will not activate.

Important safety consideration: When using a mechanical or mercury relay to control a 220 volt line, it is normal practice to use a two-pole relay so that both sides of the line are switched. Therefore, when the relays are not actuated, there is no possibility of current flowing through the heating elements, so they are electrically safe to touch — though they may still be quite hot. With solid-state relays, this is **absolutely not true**. Solid-state relays are not open circuits when off; they are just high impedance circuits. Therefore, some current, possibly enough to shock a person, still flows. The only sure way to prevent shock is to mechanically disconnect the heating elements from the power source. One way to do this is to open the circuit breakers for the heating element circuit. If the breaker panel is not near the kiln, you can install a disconnect switch near the kiln.

WARNING: ALWAYS COMPLETELY DISCONNECT THE HEATING ELEMENTS FROM ELECTRICAL POWER BEFORE TOUCHING THEM.

And, of course, be sure they are cool.

4–20 Milliamp Current Loop

Some applications, such as a gas furnace using a Honeywell “Modutrol”⁶ motor or similar device, require a 4–20 milliamp “current loop” for control. These devices are proportional, where the proportion is encoded as the amount of current flowing in a circuit. The amount of current in the circuit is determined or “conveyed” by the GB1. It is interpreted or “read” by the Modutrol motor, whose shaft angle adjusts itself according to the current. A special “current loop” version of the GB1 must be used in such an application. Since these installations are frequently in harsh industrial environments, the GB1 uses an optically isolated output circuit to protect the computer circuitry from electrical spikes and transients.

Note that there is no fuse in the 4–20 milliamp output circuit. Since the current is intrinsically limited to 20 milliamps, there is no need of a fuse.

The connections are polarized. It matters which goes where. The top terminal is positive and the second one is negative. If the polarities are reversed no damage will result, but the external equipment will fail to actuate. The connections for a Honeywell series M72XX Modutrol motor are shown in figure 5.10. Connections to other brands of similar motors or phase-angle SCRs should be analogous. If the motor or SCR doesn’t actuate, make sure that all polarities are as shown in one or the other diagram.

5.6 Connecting an Alarm

If you choose to, you may connect an external alarm to the two terminals below the two you used to connect the oven relay. When the GB1 detects an abnormal situation, it not only indicates this with a “BAD” message in the display, but it can also activate an external alarm if you attach one. It does this by closing an internal alarm relay, which is a mechanical reed relay with a maximum capacity of two amps. Since the relay is not solid-state, there is no restriction concerning AC or DC current. For utmost flexibility, no power is supplied by these terminals

The use of an alarm is optional. It may be connected to a light, buzzer, bell, horn, siren, telephone dialer, *etc.* The details of installation depend on the nature of device used for an alarm.

⁶Modutrol is a brand name of Honeywell Corp.

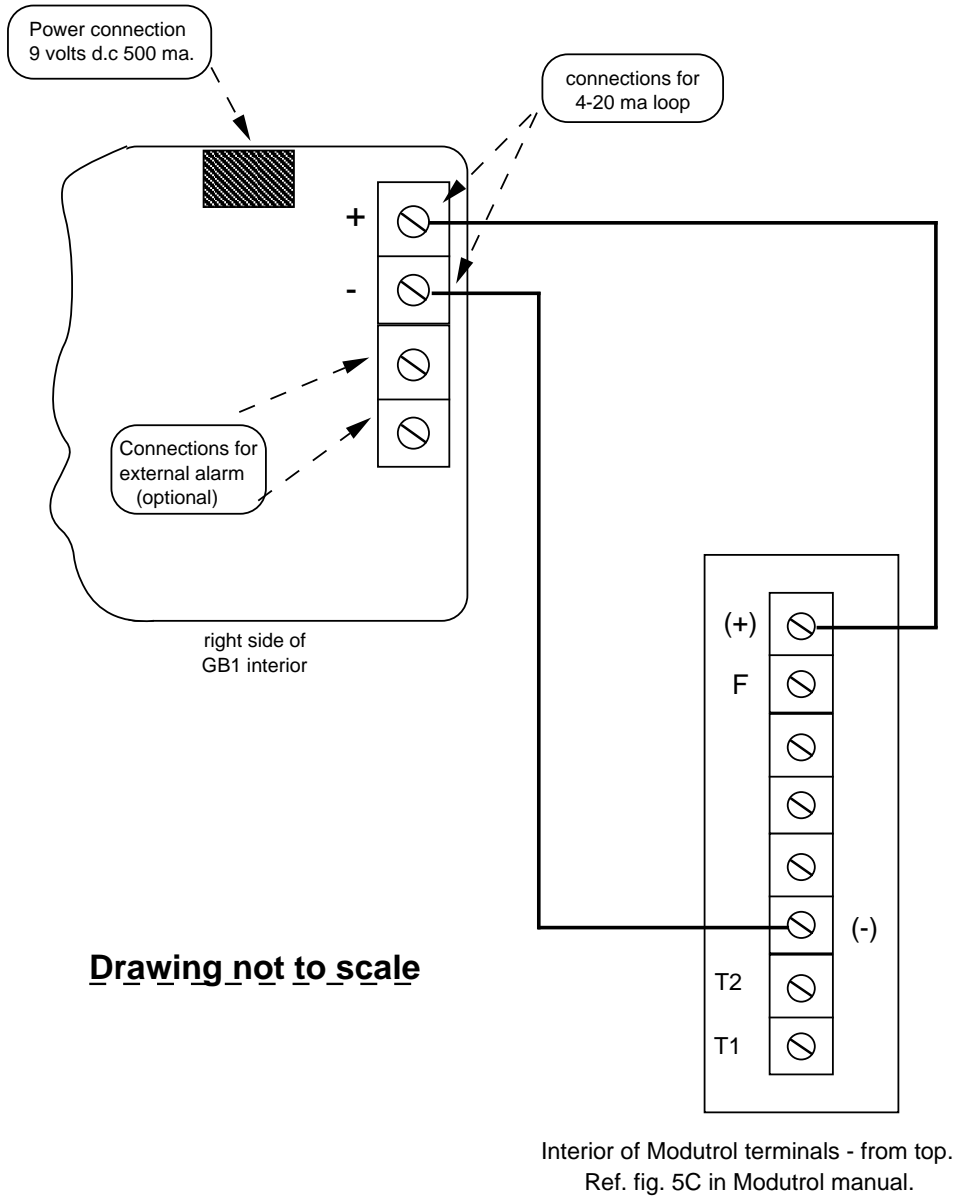


Figure 5.10: Modutrol Series M72XX Connection

The primary consideration — the most important thing that the installer must understand — is whether or not the connection to the alarm must supply power. For example, a phone dialer typically provides its own power and simply requires a switch be connected. Thus two wires from the dialer to the relay contacts on the GB1 suffice. This is shown in figure 5.11.

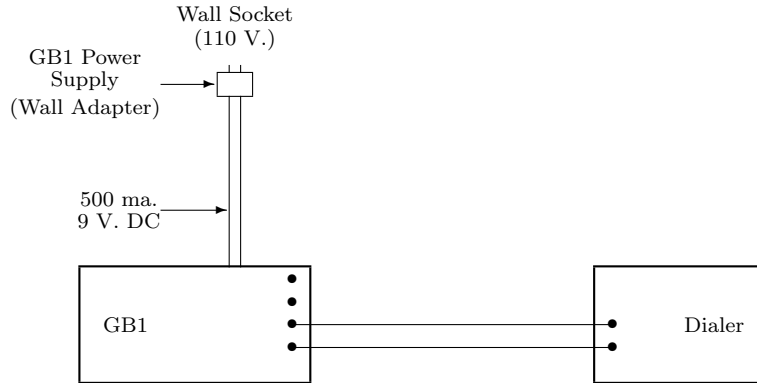


Figure 5.11: Typical Phone Dialer Installation

On the other hand, a bell or a siren or a horn typically requires power, and its installation will closely resemble the installation of the control relay of the standard GB1. Explicit directions are given below. The voltage required by the alarm device is determined the device itself. The GB1 can control any voltage up to 120 volts.

If a current of more than two Amps is necessary to drive your alarm, you must use an intermediate relay of appropriate size. Note that a 100 Watt light bulb draws in excess of two amps when it is first turned on, so it must be controlled through an intermediate relay, even though its eventual current is only about one amp. If your alarm draws too much current, it will probably weld the contacts of the reed relay together, and you alarm will not ever shut off! In this case the relay will need to be replaced.

The alarm relay is not fused internally, since it is too likely that a bad fuse will prevent an important alarm from sounding. If you want a fuse, include it in the external wiring to the alarm. The GB1 itself imposes no limit on how far away the alarm can be. This will be determined by the alarm device itself and how it is installed.

The circuit and the installation procedure for a bell-like alarm are virtually identical to those discussed in the section for the standard GB1 control relay. Three wires are required. One wire goes from one side of the power source for the alarm to the terminal on the GB1. The second wire goes from the other terminal on the GB1 to one connector on the alarm. The third wire goes from the other connector on the alarm to the other side of the power source. This is shown schematically in figure 5.12. Please observe the same cautions while installing the alarm as you did while installing the control relay.

To recapitulate: The alarm may use either AC or DC power, up to 120 volts. The maximum current that the alarm may draw is 2 amps. As is the case with the control relay, the GB1 alarm connection is to a passive switch. The GB1 does not supply any power for the alarm.

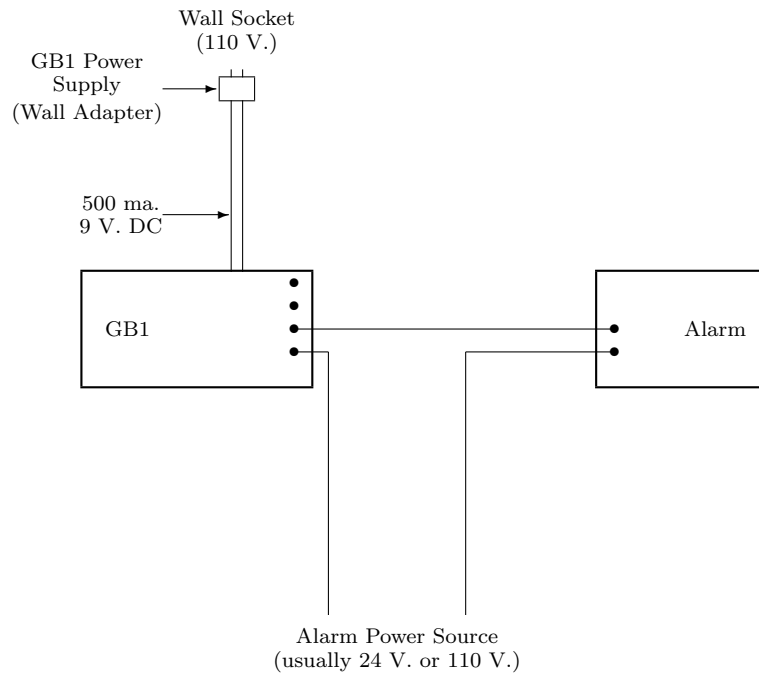


Figure 5.12: Typical Alarm Installation

5.7 Powering Your GB1

The “wall adapter” power module of the GB1 should be plugged into a 110–120 volt AC circuit (“wall adapter” power modules for 220 volt, 50 cycle available on special order). It is recommended that this circuit be used **ONLY** for the GB1. If no independent circuit is available, do not operate motors or large equipment on this same circuit.

WARNING: TO PREVENT POSSIBLE DANGEROUS ELECTRIC SHOCK TO YOURSELF AND DAMAGE TO YOUR GB1, REMOVE THE COVER ONLY WHEN THE POWER IS TOTALLY DISCONNECTED FROM BOTH THE GB1 AND ALL CONTROL CIRCUITS.

5.8 DOs and DON'Ts

Like any tool you work with, the GB1 abides by a prescribed set of operating principles. Follow precisely the installation instructions detailed in this chapter. And, keep in mind the following “do”s and “don’t”s when installing your GB1.

- Do not run power for heating elements through GB1 relays.
- Do remember that the standard GB1 controls your contactor or solenoid by a passive relay, which acts simply like a switch; it does not itself supply power.
- Do not run thermocouple extension wires to the GB1 in the same conduit or in close proximity to wires connected to heavy equipment or to power wires for relays or heating elements.

This practice would introduce “noise” into the readings and may very likely cause incorrect or erratic temperature readings.

- Do not reposition the thermocouple while the oven is running as it may touch a live heating element and put 110 (or 220) volts through the thermocouple input. This will cause expensive damage and possible shock.
- Do not remove the front cover of the GB1 until all AC power is removed from both the GB1 and all control circuits. This will prevent possible shock to you and damage to your GB1.
- Do not connect 110 (or 220) volts directly to the power connector mounted on the GB1 itself; use the “wall adapter” instead. The GB1 runs on 9 volts DC (unregulated); if you directly connect it to 110 volts, you will ruin it.

5.9 Additional Help

If you have any questions about installing your GB1 after reading this chapter, please call your supplier who will provide you with the information you need.

Chapter 6

Reference

6.1 GB1 Specifications

The GB1 Programmable Temperature Controller, basic model, is designed for use with a Type K (chromel-alumel) thermocouple. Type R and Type S capabilities, key lock security and customized hardware and software are optional.

Power Requirements: 500 ma. at 9 volts DC, unregulated, via a “wall adapter” power supply. Standard supply is for 110–120 volts AC, 50–60 cycle; 220 volt AC “wall adapter” power supply is available.

Temperature Range: 32°F to 2550°F (0°C to 1300°C) for Type K; 50°F to 3200°F (10°C to 1760°C) for Type R and Type S. Type K, Type R, and Type S have automatic cold junction compensation.

Resolution: 1 part in 4100.

Repeatability: 1°.

Common Mode Rejection Rate: at 50 and 60 Hz for Type K, 126 dB minimum; for Type R and Type S, 148 dB minimum.

Output: ON/OFF control via solid-state relay with zero crossing detection; 1.5 amps at 24–280 volts AC, fused. Minimum load current is 10 milliamperes. Options:

- 3 or 5 amps at 24–280 volts AC, fused; minimum load current 10 milliamperes.
- 3–60 volts DC.
- internally powered 9 volts DC (only for direct control of solid-state relays).
- 4–20 milliamp current loop (built-in, isolated power source.)

Alarm: ON/OFF control via dry contact, reed relay; 2 Amp AC or DC.

Programmable Auxiliary Relay (*optional*): Programmable ON/OFF control via dry contact relay; 8 Amp AC or DC.

Clock: Crystal controlled timer.

Programming: 10 profiles; 15 set-points per profile; maximum of 1,499 hours and 45 minutes in one minute increments per profile; maximum of 14,097 hours and 39 minutes (over a year-and-a-half), using linked profiles.

Dimensions (H × W × D): 7 × 3 × 2 inches.

Shipping Weight: 2.5 lbs.

Operator Interface: 1/2 inch, 7-segment, red LEDs; 16-button sealed keyboard (dust and moisture resistant).

All specifications are subject to change from time-to-time.

6.2 Accuracy

While the absolute accuracy of the GB1 is limited to about 1%, the resolution always is approximately 1/2°F. This yields more than 0.025% of full scale reading. With a given GB1 and fixed thermocouple location, your temperature profiles are repeatable to an extremely high degree of accuracy. More variation will be introduced by the way you load your oven than by the accuracy of your readings.

To help ensure this repeatability, all GB1s are equipped with automatic cold junction compensation to account for variations in room temperature. Such variations ordinarily would appear as an error in the temperature reading. This is because a thermocouple measures the difference in temperature between the hot end and the point where it attaches to the GB1; it does not measure absolute temperature.

It is important to realize that because of the resolution of the GB1 temperature measurement, you will note swings in the temperature of your oven that would go unnoticed with a standard, meter type pyrometer. These swings are to be expected. They were always there, you just could not see them. You should notice that the more material you place in your oven, the less severe the swings.

6.3 Sales and Service

Write or call the company that supplied your GB1 for sales, service, and technical information. If you need additional assistance, please contact Digitry directly. You can reach us at

Digitry Company, Inc.
449 Forest Avenue, Suite 9
Portland, ME 04101
USA

Phone: +1 207-774-0300
FAX: +1 617-484-5220

Email: service@digitry.com
Web: <http://www.digitry.com/>

6.4 Warranty Information

DIGITRY COMPANY, INC., (“SELLER”) WARRANTS THAT THE PROGRAMMABLE TEMPERATURE CONTROLLER (“PRODUCT”) SOLD TO PURCHASER SHALL BE OF STANDARD QUALITY OF SELLER. SELLER’S OBLIGATION AND LIABILITY UNDER THIS WARRANTY IS EXPRESSLY LIMITED TO REPAIRING OR REPLACING, AT SELLER’S OPTION, A PRODUCT NOT OF SELLER’S STANDARD QUALITY FOR A PERIOD OF NINETY (90) DAYS FROM THE DATE OF DELIVERY. SELLER MAKES NO OTHER WARRANTY, EXPRESS OR IMPLIED, AND MAKES NO WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR ANY PARTICULAR PURPOSE. SELLER’S OBLIGATION UNDER THIS WARRANTY SHALL NOT INCLUDE ANY TRANSPORTATION CHARGES OR COSTS OF INSTALLATION OR ANY LIABILITY FOR DIRECT, INDIRECT OR CONSEQUENTIAL DAMAGES, DELAY OR LOSS OF PROFITS, EVEN IF SELLER HAS BEEN INFORMED BY PURCHASER OF THE POSSIBILITY OF SUCH DAMAGES.

IF REQUESTED BY SELLER, A PRODUCT ON WHICH A WARRANTY CLAIM IS MADE SHALL BE RETURNED TRANSPORTATION PREPAID TO SELLER’S PRINCIPAL PLACE OF BUSINESS. ANY IMPROPER USE, OPERATION, SUBSTITUTION OF PARTS, OR ALTERATION OR REPAIR BY OTHERS IN SUCH A MANNER AS IN SELLER’S JUDGMENT AFFECTS A PRODUCT MATERIALLY AND ADVERSELY SHALL VOID THIS WARRANTY. NO EMPLOYEE OR REPRESENTATIVE OF SELLER IS AUTHORIZED TO CHANGE THIS WARRANTY IN ANY WAY OR TO GRANT ANY OTHER WARRANTY.

Chapter 7

GLOSSARY

Auto-hold

Automatic function that halts the GB1 timer if the actual temperature varies too far from its programmed temperature.

Cold Junction Compensation

Mechanism incorporated into GB1 thermocouple circuitry that adjusts for variations in room temperature.

Confirmation Sequence

A feature of the GB1 that requires you to enter a specific sequence of keys to prevent accidental starting, erasing, or resetting of programs.

Contactors

Another name for a relay (described below).

Current Loop

A way of encoding a power level as a small current running through a circuit. Usually 4 milliamps means no power, 20 milliamps means full power, and current levels between 4 and 20 milliamps represent the corresponding intermediate power levels. Many proportional control devices, such as servo-motors and SCRs, are controlled in this way. A special version of the GB1 is needed to control a current loop.

Heat-Sink

A large piece of metal, sometimes with fins, to absorb and dissipate heat generated by a solid-state power relay.

Hold

Function that stops the timer and maintains the programmed temperature for an indefinite period of time (also known as an indeterminate “soak”).

Idle

Condition in which the timer is off and control power to your oven is off and the GB1 is ready to start at the beginning of a profile.

Key Lock

Optional feature that prevents accidental or unauthorized profile changes.

Linking

Connecting one profile to another; when the first finishes, the second automatically commences.

Memory Back-up

Safety device to ensure profile retention in the event of power failure.

Mercury Displacement Relay

A special type of relay that uses liquid mercury to make electrical contact. This type of relay is quieter, more reliable, and more expensive than ordinary mechanical relays and is recommended for applications where currents in excess of 30 amps must be controlled.

Modutrol Motor

A type of servo-motor made by Honeywell which is used to control gas valves *etc.* The motor adjust its shaft angle according to a electrical signal, usually a current between 4 and 20 milliamps.

Monitor Mode

Operating mode used to display current time and temperature set-points for your oven. GB1 must be in this mode to start or stop your oven.

On/Off Control

A method of controlling an oven where the power is either full-on or full-off, depending on whether the oven temperature is below the set-point or above the set-point. This is the simplest and least costly form of control to implement and troubleshoot. It is particularly well suited for use with mechanical or mercury relays. Most GB1s use this method.

Output Module

A special electronic (“solid-state”) relay used within the GB1 by which it controls your contactor.

Oven

An oven, kiln, lehr or furnace.

Phase-Angle Triggered

A method of getting intermediate power levels from an SCR or similar device by turning off the power for a certain part of each cycle of AC electricity. While this method can theoretically give a very fine resolution of power levels, it is quite undesirable because it generates a large amount of electromagnetic interference. Phase-angle triggering “chops” up the individual cycles, whereas PWM uses a percentage of complete cycles to achieve the same result with almost no electromagnetic interference. Before the advent of digital electronics, phase-angle triggering was the only way to get intermediate power levels.

PID

Stands for “Proportional, Integral, Derivative”. This is a method which some GB1s use to decide how much power to give the oven.

Program Mode

Operating mode that permits the GB1 to receive, change or examine temperature profiles.

Proportional Control

A method of controlling an oven in which the power level is adjusted to an intermediate value. Certain GB1s are capable of Proportional Control.

PWM

Stands for “Pulse Width Modulation”. This is a method an on/off output can be made to simulate intermediate power levels. For example, if the power is on half of every second, this is an average power level of 50 %. If it’s on 750 milliseconds out of every second, it represents three-quarters power.

Pyrometer

Instrument for measuring high temperatures, commonly (but incorrectly) used to refer to a thermocouple probe.

Ramping

The uniform increase or decrease in oven temperature over a specific time.

Relay

A electromagnetically actuated switch controlled by a small amount of power that, in turn, controls a larger amount of power. Large relays are also referred to as contactors.

Run

State in which the timer is activated and the oven follows its programmed operations.

SCR

Stands for “Silicon Controlled Rectifier”. This is an earlier version of the solid-state power relay. It is not so integrated as a modern solid-state relay, but some of these devices can handle awesome amounts of power. They are frequently phase-angle triggered and controlled by means of a 4-20 milliamp current loop.

Sending Unit

A specially designed thermocouple amplifier that strengthens the very weak signal produced by a thermocouple and sends it to the GB1. It is required for Type S thermocouples but is optional for Type K. It is housed in a small, aluminum box and should be placed near the oven.

Set-Point

The target temperature of the oven at any given instant. During a soak, the set-point is the soak temperature. When your GB1 is ramping up or down, the set point can change as often as every minute. The GB1 automatically calculates the set-point based on elapsed time and the profile you have entered. This term is also used for the temperatures and times you punch in to define a program.

Single Phase Power

The normal type of electrical service. The power is delivered by means of two wires. The voltage may be 110–120 or 220–240. For 110–120 volt single phase power, a single pole relay is sufficient. For 220–240 volt single phase power a two pole relay is used.

Skip-step

Function that instructs the program to jump to the following programmed step.

Slope

The pitch, or rate of increase or decrease in temperature, determined by time and temperature set-points.

Soak

Function that holds a specific temperature setting for a designated period of time.

Solid-State Relay

A type of relay constructed entirely of semi-conducting materials. It has no moving parts to wear out, but is nevertheless subject to electrical and thermal failure. Large Solid-State Relays, called Power Relays, can control the main heating power for an oven. Because they have no moving parts they can be turned on and off very quickly. This makes them ideal for use with PWM proportional controllers. Solid-State Relays inherently waste a small amount of power when they are on, and require a heat-sink to remove the heat this generates. A Power Solid-State Relay which is not properly fitted with a heat-sink will destroy itself from overheating.

Step

A single set of time and temperature instructions to be executed in a profile, corresponding to a single ramp up, ramp down, soak or hold.

Thermocouple

Temperature sensing device placed inside an oven or kiln. The composition of the thermocouple determines its type. Type K is chromel-alumel; Type R and Type S, platinum rhodium.

Thermocouple extension wire

Wire that has the same characteristics as thermocouple wire at typical room temperatures but may have different ones at higher temperatures. It is used for extensions, especially of Type R and Type S thermocouple leads, because it is cheaper than thermocouple wire.

Three-Phase power

A type of electrical service where the power is delivered by means of 3 separate wires instead of just 2. The voltage between any two wires is usually 208 volts AC. Three-phase power is usually found only in industrial or ex-industrial environments. To control three-phase power you need a 3 pole relay.

Voltage transient

An electrical disturbance of very short duration, typically caused by lightning or by heavy electrical equipment; sometimes called a “voltage spike”.

Zero-Crossing Relay

Many AC solid-state relays have built in circuitry to detect when the load voltage is near zero, and they do not switch the load on or off until this occurs. This means that individual cycles of AC power are not “chopped” which in turn limits the generation of electromagnetic interference. The zero voltage switching also limits inductive “kickback” from relay coils, making for much more reliable operation of electronic equipment, including the GB1 itself.

Programming Forms

For your convenience, we include some blank Digitry programming forms that you can photocopy.



Copy Freely &
Use Genuine Digitry Controllers

Digitry GB1 Programming Form

Profile # _____

Date _____

Use _____

Author _____

| | Step 1 | Step 2 | Step 3 | Step 4 | Step 5 |
|------|--------|--------|--------|--------|--------|
| Temp | | | | | |
| Time | | | | | |

| | Step 6 | Step 7 | Step 8 | Step 9 | Step A |
|------|--------|--------|--------|--------|--------|
| Temp | | | | | |
| Time | | | | | |

| | Step B | Step C | Step D | Step E | Step F |
|------|--------|--------|--------|--------|--------|
| Temp | | | | | |
| Time | | | | | |

Notes:



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| | Step 6 | Step 7 | Step 8 | Step 9 | Step A |
|------|--------|--------|--------|--------|--------|
| Temp | | | | | |
| Time | | | | | |

| | Step B | Step C | Step D | Step E | Step F |
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| | Step 6 | Step 7 | Step 8 | Step 9 | Step A |
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| Temp | | | | | |
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| | Step B | Step C | Step D | Step E | Step F |
|------|--------|--------|--------|--------|--------|
| Temp | | | | | |
| Time | | | | | |

Notes:

