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Communications

A Low Cost Programmable Temperature Controller

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Accurate temperature control of a system is essential in many scientific experiments[1]. Maintaining a constant temperature, linear temperature ramp with variable heating rate, and temperature scanning with ramp and soak functions are the types of temperature control required in various experiments. Although, there are many commercially available temperature controllers, sometimes they are robust to use as a part of the instrument because they are not designed for that specific instrument. We designed a low cost temperature control circuit for accurate measurement and control of the system temperature, which can be used as a temperature control unit in various chemical instrumentations. The temperature controller designed can be used up to 1000℃ with ±0.15℃ accuracy and can be programmed by a personal computer to function in various modes.

The temperature controller designed is the type of proportional control[2]. The controller eliminates the temperature cycling by adjusting the ON/OFF time ratio depending on the temperature difference from the setpoint within the proportional band. The functional level schematic of the temperature controller is shown in Figure 1. The function generator IC1 gives sawtooth waveform (300 Hz) and the analog multiplier IC2 multiplies the sawtooth waveform with the reference temperature signal to produce the proportional band. The proportional bandwidth is automatically adjusted to a constant fraction of the programmed reference temperature signal. Automatic control of the proportional bandwidth is very important because with a fixed proportional bandwidth temperature control works only in a certain temperature range. The system temperature which is sensed by a thermocouple is summed with the scaled sawtooth signal by IC3 to generate the modulated temperature signal.

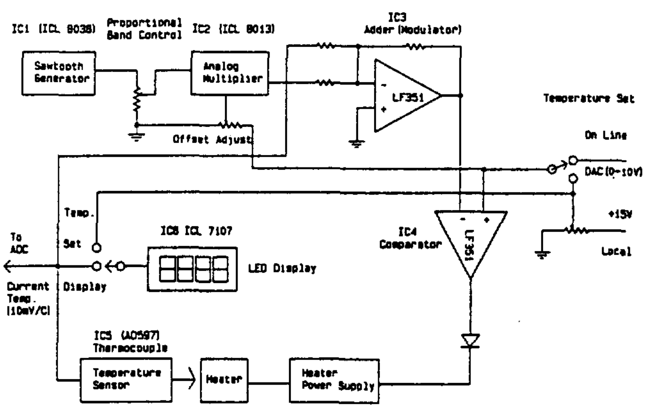

Figure 1. Functional level schematic diagram of the tempera ture controller.

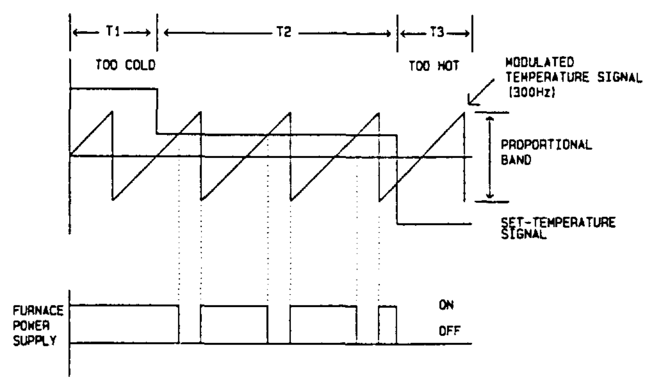

Figure 2. The operating principle of the temperature controller.

The comparator IC4 compares the modulated temperature signal with the reference temperature signal. The modulation of the temperature is necessary for fine regulation of the system temperature. The operating principle of the temperature controller is shown in Figure 2. When the system temperature is too cold compared to the set-point temperature, the comparator switches the furnace power supply fully on to increase the system temperature (time region T1). If the system temperature rises up to the proportional band region, the

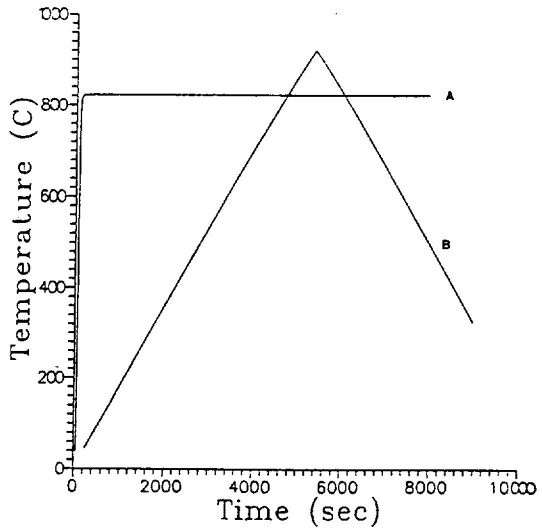

Figure 3. Temperature profiles of a DTA furnace programmed by an external 12-bit digital-to-analog converter using a personal computer. The curve A is a constant temperature regulation at 820℃ and the curve B is a linear ramp (105℃/10 min) up to 920℃ and back to 300℃.

comparator starts to generate pulses for fine regulation of the system temperature (time region T2). The pulse width will vary within the proportional band depending on the magnitude of the temperature differences between the modulated temperature signal and the set-point temperature signal. This enables the furnace power supply to operate in pulse switching mode instead of operating in either fully on or fully off mode. If the system temperature is too cold then the furnace power supply will be fully off to decrease the system temperature (time region T3). The switching of the furnace power supply was done by a transistor switch circuit using three NPN power transistors (one 2N3055 and two MJ802) to withstand repeated high loads of the furnace heater.

The temperature difference between the programmed temperature and the system temperature under control can be minimized by adjusting the offset of the multiplier. The reference temperature signal can be programmed in two ways. If only a fixed temperature is desired, one can supply a fixed voltage using a simple voltage divider. Also, the temperature controller can be programmed by an external source such as digital-to-alanlog converter (DAC). In this way, the system temperature can be programmed through a personal computer to function in various modes. The comparator generates pulses whose pulse width varies depending on the temperature differences between the reference and the system under control. These pulses are used to switch the furnace power supply ON or OFF.

The temperature profiles of a furnace controlled by the controller is shown in Figure 3. We used a home made differential thermal analysis furnace for system evaluation. A DAC output of a data acquisition board[3] is connected to the reference temperature signal input of the controller. The proportional bandwidth is adjusted to 20% of the reference temperature signal. However, the optimum bandwidth must be obtained by trial and error because different heat capacity of the furnace requires different bandwidth. The furnace temperature is programmed by software using a personal computer. The temperature regulation at a fixed temperature showed ±0.15℃ accuracy and the temperature ramp whose rate is programmable by software also showed reasonable linearity up to 600℃. At high temperatures above 600℃, the temperature ramp profile showed nonlinearity. It is belived that the nonlinearity is mainly due to the nonlinear response of the temperature sensor used. The temperature sensor used is the combination of a K-type thermocouple and a AD597 (Analog Device) thermocouple amplifier[4]. The nonlinearity can be corrected easily if the temperature controller is controlled by a computer by adding offsets to the reference temperature, otherwise it must be corrected by obtaining a calibration curve at high temperatures. The temperature controller can be made using readily available components at low cost. The complete system can be built with less than ₩50,000. Also, compact design with reasonable accuracy makes it ideal for the system temperature control in various chemical instrumentations.

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Stereochemical Control in Baker's Yeast Reduction. 2: Stereoselective Reduction of Alkyl 2-Methyl-3-oxopentanoates under Different Conditions

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Baker's yeast (*Saccharomyces cerevisiae*) has often been applied to stereoselectively convert 2-methyl-3-oxobutanoate derivatives to the corresponding chiral hydroxy ester derivatives.[1] However, the studies on the baker's yeast reduction of alkyl 2-methyl-3-oxopentanoate derivatives (**1**) to the corresponding hydroxy ester derivatives **2** as the useful chiral building blocks[2] is limited until now.[3] Recently, our laboratory has reported by the baker's yeast reduction of **1** to the corresponding *anti*-alkyl 3-hydroxy-2-methylpentanoate (**2**) with high diastereoselectivity.[4] Especially, butyl 2-methyl-3-oxopentanoate was reduced to *anti*-butyl 3-hydroxy-2-methylpentanoate in remarkably high diastereomeric excess (*de*,