

# PC-Based PCR Thermal Cycler

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**Abstract.** This paper presents a PC-based PCR thermal cycler with a host-local architecture, where a PC is employed as the host. The local system only executes the thermal cycling process and the PC is responsible for the management of PCR protocols with a convenient GUI. The presented host-local system greatly reduces the development time and the maintenance cost, providing an economical PCR thermal cycler.

**Keywords:** host-local architecture, PCR thermal cycler, graphical user interface, PCR protocol management

## 1 Introduction

Thermal cycling of a PCR mixture involves repeated exposure to a cycle of three levels of temperature for denaturation, annealing, and polymerization [1]. PCR thermal cycler controls the temperature of a metal block with holes for the sample-containing tubes usually using Peltier thermoelectric devices [1]. PCR thermal cycler also should possess the system management functions such as the protocol data handling and the user interactions [1,2]. Since even the simplest electronic devices now require a graphical user interface (GUI) and data accessibility through Internet, there are many advantages when assigning the system management function to a general computer [1-5]. The monitoring and controlling of the basic thermal cycling processes, however, needs to be implemented within a separate computing system in order to satisfy stability and the constraints of real-time and deadline. If the basic function and the GUI are integrated into one system, it would take an order of magnitude more time and human resources to implement and stabilize the interface requirements than with the basic control alone [2-5]. Such an integrated system has almost no trouble in realizing the basic functions such as handling the protocol or controlling the temperature. However, the UI functions including management can cause a problem. Therefore it is more efficient to move the UI functions to a host by utilizing the host-local architecture. Moreover, there are additional benefits in using a PC as a host, such as convenient file management and being granted with the development environment for user interactions. Considering the GUI design

environment or user accessibility, both human and time resources will be conserved by using a Windows PC or its embedded versions as the host [2,5].

## **2 Implementation and performance comparison**

The presented thermal cycler has no other UI component excluding the LEDs to minimize the system cost and to reduce the development time and the maintenance cost. LEDs only indicate the status of the power on-off, the connection to the host, and the errors. Instead, the host PC controls and checks the system. The communication failure can often occur by the window hangings or the accidental disconnection of the USB cable. In that case, if all the PCR protocol was handled by the host, the system would stop the cycle, thus damaging the PCR samples. To prevent unwanted stoppage by the connection failure, the thermal cycler runs independently after receiving the PCR protocol from the host.

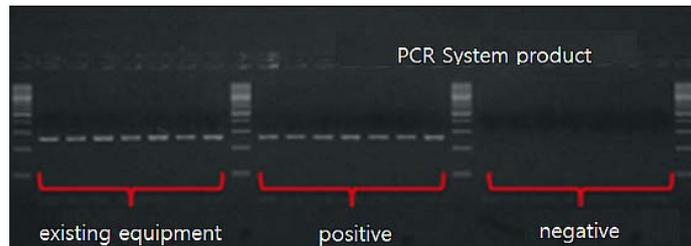
The presented thermal cycler is comprised of a heat block to hold 25 tubes, the heat sink of the PC processors for the Peltier device, and a PCB-based lid heater. Three NTC thermistors are employed to measure the temperature of the Peltier device, the heat sink, and the lid. This combination of the components greatly reduces the system cost.

When the host sends the temperature protocol to the system, it starts the thermal cycle unless the system failure is occurred or the stop command from the host is received. This simple state control enables the system to be robust and cost-effective. The temperature of the heat block is managed by a procedure that controls the current of the Peltier device by periodic measurement of the temperature. In the presented thermal cycler, the block temperature is measured and calculated to set the pulse width modulation (PWM) duration for the Peltier device driver. The temperature is controlled with proportional-integral-derivative controller (PID).

The main UI in the host PC is hidden and only the summarized information is displayed on the brief window for the minimum information for the routine PCR experiments. It includes the protocol name that is currently running, a start button, the remaining time, and the LED buttons that show the same information as those of the thermal cycler. The main window has the whole information and interactions such as the temperatures of the heating block, the edit box for the lid temperature setting, the protocol detail, and the unique number of the thermal cycler. The protocols can be read from any text file with the predefined format. The windows file system is sufficient enough for various users to manage the various protocols.

The efficiency of the presented thermal cycler was verified through comparison with the conventional one that is more than 10 fold higher in cost. PCR was performed using HPV DNA (BIOMEDLAB, Co. Ltd., Korea) with the company provided protocol. Figure 1 shows the resultant gel image. The first 7 bands except the ladder marker image are for the amplicons from the conventional cycler and the second seven bands are for those from the proposed thermal cycler. The last seven bands are

for the amplicons of the negative samples. The visual inspection of the image shows that the presented thermal cycler has the same amplification performance as the conventional one.



**Fig. 1.** The gel image for the performance comparison

## 4 Conclusion

This paper presents a host-local system architecture which shifts the user interface of the conventional PCR thermal cycler to a host PC, yielding a highly reduced cost. The proposed scheme was implemented and compared with the conventional thermal cycler. The results showed that the proposed thermal cycler has a similar performance to the conventional one in spite of the greatly reduced cost. The proposed scheme also can take advantage of the strong GUI developing environment to shorten the development period and to reduce the maintenance cost.

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