LabSmith Application Note

Gel Electrophoresis Temperature Regulation with the uProcess™ uEP01 Power Supply

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This application note describes how to improve temperature regulation in a gel electrophoresis application using uProcess software and hardware.

Introduction

Many gel electrophoresis applications benefit from temperature monitoring and regulation. For instance, high temperatures may be necessary for protein denaturation, and temperature regulation can help maintain a consistent migration rate across a gel.

LabSmith's uProcess™ microfluidic automation software and components make it possible to maintain constant temperature, as an alternative to maintaining constant power.

Precise temperature regulation for gel electrophoresis experiments can be achieved using uProcess software, a uEP01 electrophoresis power module, and uTS01 temperature sensors. The uEP01 can be programmed to supply constant voltage, current, or power. uTS01 sensors employ fine-gauge K-type thermocouples for fast response and non-intrusive temperature monitoring and regulation.

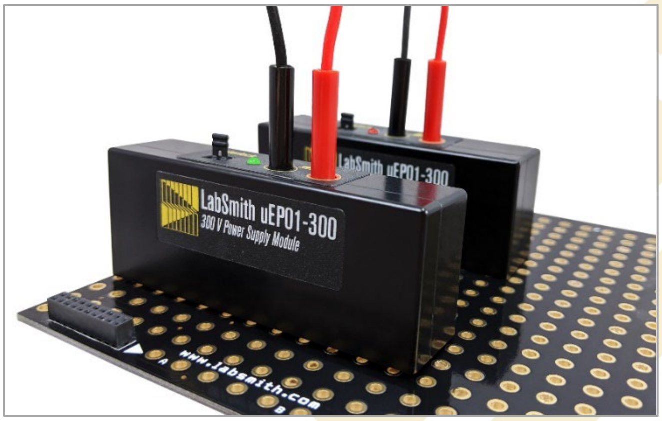

Figure 1. uProcess uEP01-300 Power Supply Modules

Constant Temperature vs. Constant Power Regulation

Most power supplies can maintain constant power to keep a gel within a desired temperature range. For example, proper denaturation for polyacrylamide gel electrophoresis (DNA-PAGE) typically requires a temperature range of 40-60°C.

Figure 2 shows a constant power gel electrophoresis experiment using uProcess and the uEP01.

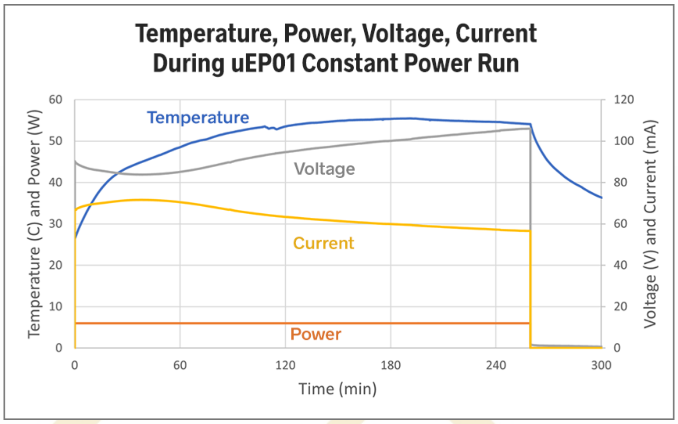

Figure 2. Constant Power Gel Electrophoresis

While constant power output is sufficient to avoid wide temperature variations, there are several possible downsides to using this approach. First, it is necessary to determine the correct power output prior to the experiment (in this case, we empirically determined that a power setting of 6W would keep the gel temperature below 60°C). Secondly, this approach takes considerable time to achieve the desired temperature range (25-30 minutes in this case). Thirdly, the temperature tends to gradually rise throughout the experiment.

The uProcess automation system can provide a more effective approach by maintaining constant temperature. By maintaining temperature rather than power the desired temperature is reached more quickly and is maintained more effectively, and an empirical knowledge of the optimal power output is not necessary.

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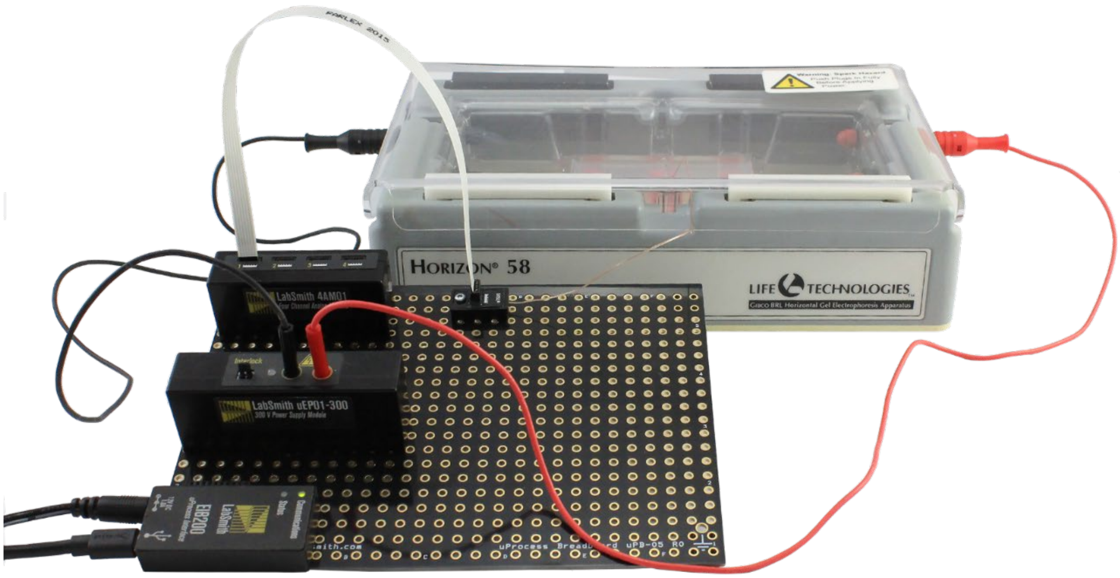

Figure 3. Temperature controlled electrophoresis setup.

Experimental Setup

The constant temperature experimental setup (Figure 3) includes one uEP01-300 power supply module and uTS temperature sensor, along with a Life Technologies Horizon 58 Horizontal Gel Electrophoresis System and other components. The tip of the uTS thermocouple was coated in DOWSIL™ 3140 RTV silicone coating to provide electrical insulation, before being inserted into the gel. Table 1 lists all of the components used for this setup.

Table 1. Experimental Setup Components

LabSmith Part Number	Description	Qty
uPB-5	uProcess Breadboard	1
EIB200	Electronic Interface Board	1
4AM01	4 Channel Analog Manifold	1
uEP01-300	Electrophoresis Power Supply & Cables*	1
uTS01	Temperature Sensor	1
	Life Technologies Horizon 58 Horizontal Gel Electrophoresis System	1

*uEP01 cables were modified for use with the Horizon 58 box. Contact Labsmith for more information.

Constant Temperature Regulation

Figure 4 shows the experiment from Figure 2 repeated using uProcess to control temperature rather than power. With this method the gel temperature reached 45°C in just 16 minutes and stayed within 2°C of the target (50°C) from 25 minutes until the end of the run.

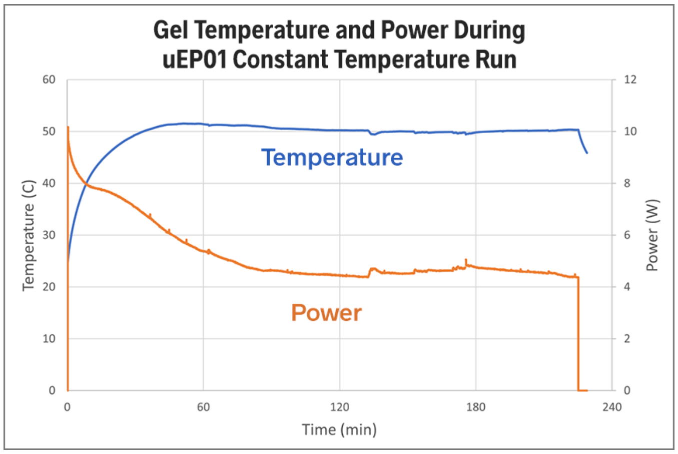

Figure 4. Temperature Regulated Gel Electrophoresis

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Programming Temperature Regulation

Figure 5 shows the script created in the uProcess software to regulate temperature. The script employs a feedback control loop to regulate power from the uEP01 based on gel temperature. The uProcess sequencer allows for substantial control over the instrumentation, with unlimited steps.

The script can be downloaded here.

Voltage-time Integrator

The script also incorporates uProcess's SetVTimer() function, which terminates power output after the set volt-time. In this experiment the value was set for 400 volt-hours, which was reached after 3 hours and 49 minutes. This approach allows for better repeatability with successive tests, even if the ambient temperature or test specifications vary from test to test.

Note that uProcess uses seconds as its time unit, so the input volt-time must be in volt-seconds. Volt-hours can be converted to volt-seconds by multiplying by 3600 (see Figure 5).

The uProcess automation system simplifies and improves experimentation in microfluidics, electrophoresis, MEMS and many other fields. In addition to the uProcess software and components shown above, the uProcess product line also includes microfluidic valves, syringe pumps, temperature controllers and pressure sensors. The system can also integrate with LabSmith's SVM340 fluorescence microscopes as well, for an unparalleled level of experiment control.

```
*EP01    =      uEP01
*4AM     =      4AM
*EIB200 =       EIB
*T00008 =       uTS

Tset = 50
Tint = 0

;Setting 400 volt-hours
Vt = 400*3600
EP01: SetVTimer(Vt)

Start_time:
        t0 = scripttime()
        Terr = Tset - T00008.Reading
        Wait(10s)

        Terrf = Tset - T00008.Reading
        dTerr = Terrf - Terr
        tf = scripttime()

; derivative of temperature error
        dt = tf-t0 + 0.00001
        Tdif = dTerr / dt

; integral of temperature error
        Tstep = Terr*dt
        Tint = Tint + Tstep

; PID tuning
Kp = 0.4
Ki = 0.0005

Kd = 10
P = Kp*Terr + Ki*Tint + Kd*Tdif

if (P < 0)
{
        EP01: SetPower(1W)
        EP01: SetOutput(1)
        Goto Start_time
}

EP01: SetPower(P)
EP01: SetOutput(1)

if(EP01.VTime > 100)
{
Goto Start_time
}

End_run:
        EP01: SetPower(0)
        EP01: SetOutput(0)
WaitDone()
```

Figure 5. uProcess temperature-power control loop.