Wireless Control of Fed-Batch Fermentation Systems

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Abstract

Bioreactor operation requires continuous monitoring of fermentation parameters and real-time control over bioreactor devices. Remote monitoring and control of the bioreactor's computer via the Internet avoids the necessity of personnel being continually on-site during operation. A Sartorius Biostat A Plus® bioreactor (2 Liter) and its computer control system were interfaced with the commercial software GoToMyPC®. The bioreactor was equipped with all controls for monitoring during experiments: oxygen sensor, pH sensor, temperature sensor and agitation. Other calibrations (media inflow & outflow, antifoam additions) were calibrated with the system's peristaltic pump adjusted for time. Remotely controlled night-vision web cameras allowed monitoring capability of the glass fermentation vessel. A Wi-Fi connection via wireless router allowed multiple system connections to the host computer. The window screen of the main computer can be accessed from any wireless device with an Internet connection. The secured Internet Protocol (IP) address assures that the system can only be controlled by the main users. This wireless interface permits the remote control of fed-batch fermentations and other culturing protocols.

Introduction

Research in microbiology and in many other scientific areas that involve the cell or tissue culturing may require constant and real-time control over devices that monitor different culturing parameters. These parameters are mainly controlled through real-time actions that usually require the presence of laboratory personnel to perform, therefore there is a great need for complete cell culturing automation.

Fermentation systems are usually controlled through automation (Figure 1) and require little oversight. However, for the system to be completely automated, a computer network needs to be established with the fermentation system(s) where a single user can control the culturing system outside of the laboratory (e.g. home, school, out of country). Once all of the equipment, monitors and supplies are setup, the user can monitor and control, through real-time, the culturing system from any place in the world that allows for an internet connection. The user can then make adjustments to many parameters including pH, pO_2, temperature, agitation rate, media input/output, and other parameters set by the system or the user.

Figure 1. Sartorius-stedim Biostat® A Plus fermentation system

Network Components

Components used in the establishment of this network include various hardware, software, visual and internet technologies.

Hardware:
- Sartorius-stedim Biostat A Plus fermentation system controller
- Sartorius-stedim 2 liter fermentation vessel
- OxyFerm FDA 225 oxygen sensor probe
- EasyFerm Plus K8-200 pH probe
- PT100 Temperature probe
- Dell laptop computer with Wi-Fi capability
- Netgear ProSafe 5-port Ethernet switch

Software:
- PC-Panel µDCU allows control and detection of multiple Sartorius-stedim fermentation systems

Visual:
- Foscam FI8908W wireless/wired IP camera with infrared capability

Internet:
- Web browser (e.g. Internet Explorer, Safari, Firefox, etc.)
- https://www.gotomypc.com (user account or guest invite)

Networking and Connectivity

Software that allows control of the fermentation system was installed to a lab computer. The fermentation system is set-up with fermentation hardware (e.g. pO_2, pH, temperature probes). Probes are calibrated according to manufactures specifications and culture media was added to the fermentation vessel. The software for the IP camera was installed to the lab computer and accessed through a Uniform Resource Locator (URL) to obtain functionality of the camera. The user can manipulate the camera in order to view many systems within the laboratory. The IP camera is equipped with infrared capabilities which aids the user to view the fermentation system at night when the laboratory lights are off. An account was created through GoToMyPC, a company that provides services for remote access to any host computer. A service account was set-up with this company allowing the utilization of the laboratory computer as the host computer. Login information was obtained and through this account the user is able to control and monitor system parameters anywhere on the face of the planet.

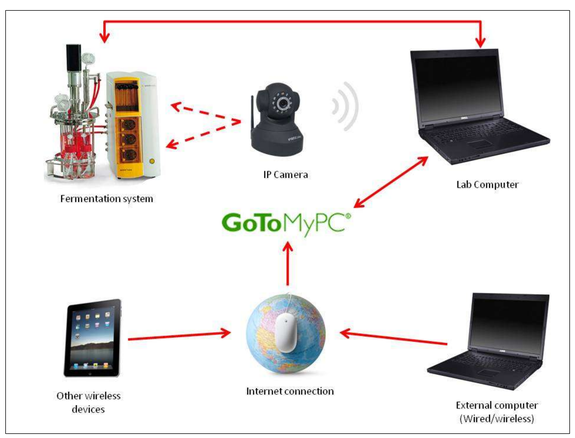

Diagram 1. Networking of the Sartorius-stedim Biostat® A Plus fermentation system

Discussion

The Sartorius-stedim Biotechnology Laboratory was successful in monitoring and controlling the fermentation process for remote control culturing. We were successfully able to connect to this network from an external computer (Figure 2). Not only were we successful in obtaining network access, we could also monitor culturing processes while performing other tasks (Figure 4). With the use of this newly obtained technology, we can perform calibration procedures outside of the lab (Figure 3). This technology will allow the user to invite guests to view the fermentation process and its parameters to help educate the use of wireless controlled fermentation systems using modern computer technologies.

Figure 2. External Computer connected to host/lab computer

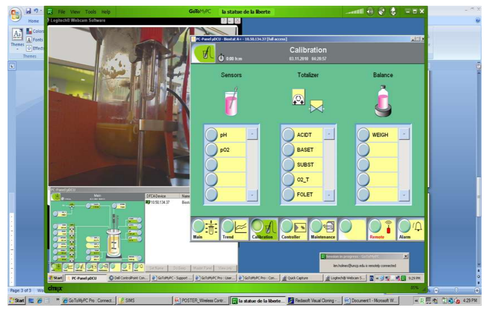

Figure 3. Calibration can be performed outside of lab

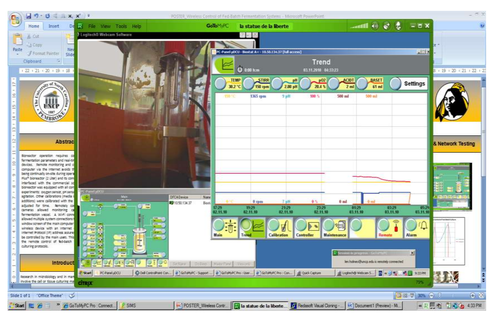

Figure 4. Other tasks maybe performed while monitoring cultures

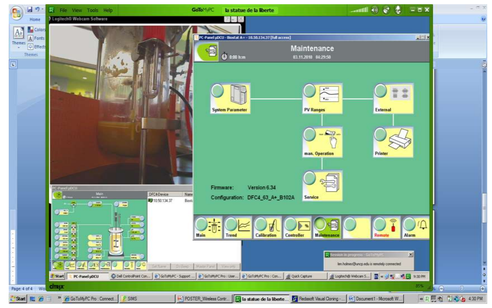

Figure 5. Maintenance can also be performed outside of the laboratory

Figure 6. 10 liter fermenter

Figure 7. 30 liter fermenter

Acknowledgements

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