

AUXILIARY TOTAL ARTIFICIAL HEART MONITORING OPERATION IN LABVIEW®

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Abstract. A monitoring system for the Auxiliary Total Artificial Heart (ATAH) operation has been developed. To accomplish that task, the LabVIEW® platform had been chosen because it is easy to deal and because of its blocks programming capability, called Virtual Instruments (VI's). The interface between the microcomputer and the ATAH controller module has been made by its parallel port. A computer program has been developed to acquire the ATAH hall sensors positioning signals. The signals are: ending of left chamber ejection, ending of right chamber ejection and ending of left chamber passive filling. The developed program shows some informations such as: during time of each task showed above, frequency of operation in beats per minute and its graphic, operation mode and differential of left chamber fullment. Also, the program is able to save the acquired data. Although some errors were observed when the application ran in a multitask environment like Windows®, experimental results in vitro and in vivo tests in animals show that the system works properly.

Keywords: LabVIEW®, Auxiliary Total Artificial Heart, Data Acquisition.

1. Introduction

The Auxiliary Total Artificial Heart (ATAH) is an electromechanical pulsatile blood pump developed at Institute Dante Pazzanese of Cardiology, Fig. 1. The device operation is based on the complete filling of the ATAH left chamber. The sequence of operation is: at first time, the controller drives the motor and the system starts with right ejection and, after that, it stay waiting until the hall sensor 3 detection of magnet 3 as shown in Fig. 1. The magnet 3 is positioned in the stabilizer rod, like Fig. 1. So, the controller waits for the complete filling information of left chamber, which is reported by the hall sensor 1 with detects the magnet 1 positioned in the left diaphragm, Fig. 1. Then, the electronic controller drives the system to make a left ejection. The system keeps in that state until de hall sensor 2 detects the magnet 2, positioned in another stabilizer rod, showed in Fig. 1. Therefore, the system keeps in this "infinite loop". (Andrade, 1998)

The operation mode can be chosen between variable rate and fixed rate. The variable rate operation mode was presented like above, but in the fixed rate operation mode, the algorithm is very similar but at that step, when occurs the ending of right ejection, the system do not wait for the complete filling information of left chamber and the electronic controller drives to right ejection. (Andrade, 1999)

In order to monitoring the ATAH operation, a program in LabVIEW® software was developed. The set of information sent by the electronic controller module are: three signals from hall devices and a signal of operation mode – variable rate or fixed rate. (Fonseca, 2004)

2. Materials and Methods

In order to provide the properly acquisition and saving data, an application was built in LabVIEW® environment called Virtual Instrument (VI).

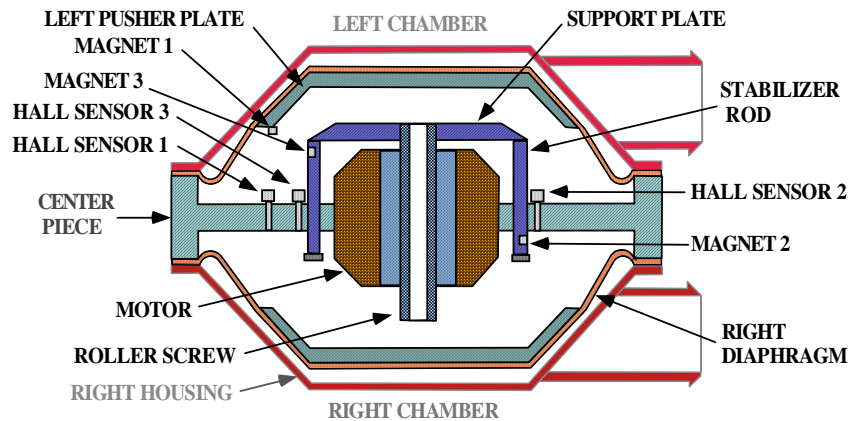


Figure 1. ATA schematic drawing showing the position sensors. The Hall sensor 1 with magnet 1 work together to detect the down position of the left pusher plate. The Hall sensor 2 with magnet 2 detect the up position of the support plate, and the Hall sensor 3 with magnet 3 detect the down position of the support plate (Andrade, 1999).

In LabVIEW[®], all applications have two parts: the panel and the diagram (National Instruments, 2003). In the panel is possible to build the front of VI. It can be made by positioning the controls and displays. The built panel is showed in the Fig. 2. In the present case the controls are: on/off, mode of operation and saving data option. The displays are: event counters – time for ending of right ejection, time for ending of left ejection, time for complete filling up of left chamber, differential of left chamber filling up timer, pulse per minute (ppm) rate and a graphic to show the behavior of ppm signal; lightening signals to show the status of three hall positioning sensors.

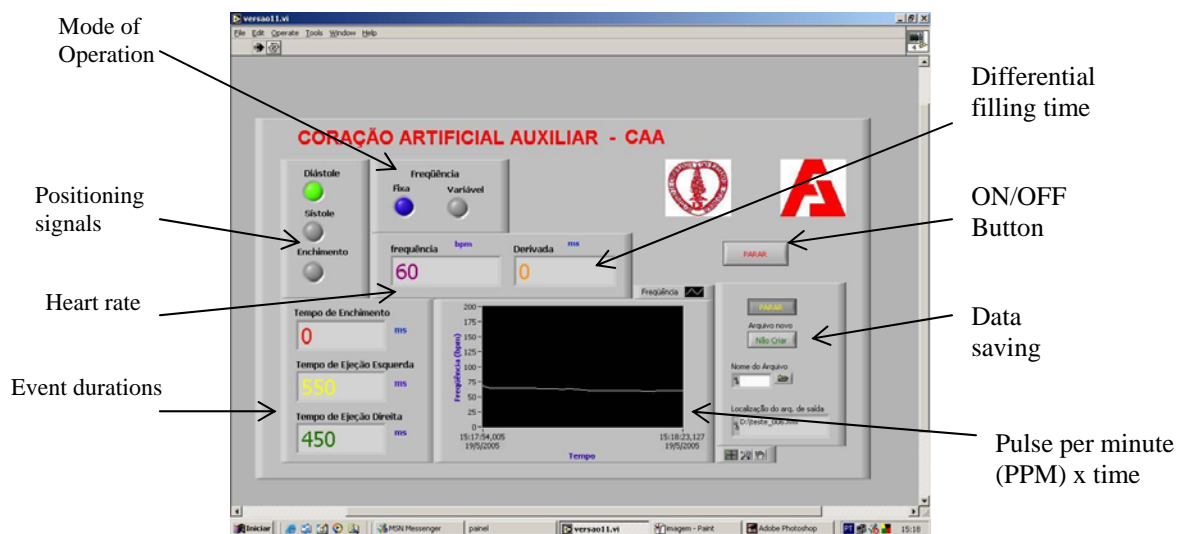


Figure 2. Panel of assembled LabVIEW[®] application and its functional controls and displays.

In the diagram windows it is possible to build the running application. In that windows there are VI's and connections to make the application functional. Figure 3 shows the diagram window built in LabVIEW[®] for the monitoring system.

The connection between the ATA controller unit and the microcomputer where the developed application was installed was established using the parallel port of computer.

3. Tests

In order to verify the developed application, in a first moment, *in vitro* tests were performed in our laboratories. In those tests the time of events was measured with objective to compare them with the time displayed by developed program. *In vivo* tests performed in calves, the operation of the developed system was compared with another system, that was already working properly, developed in "C" language.

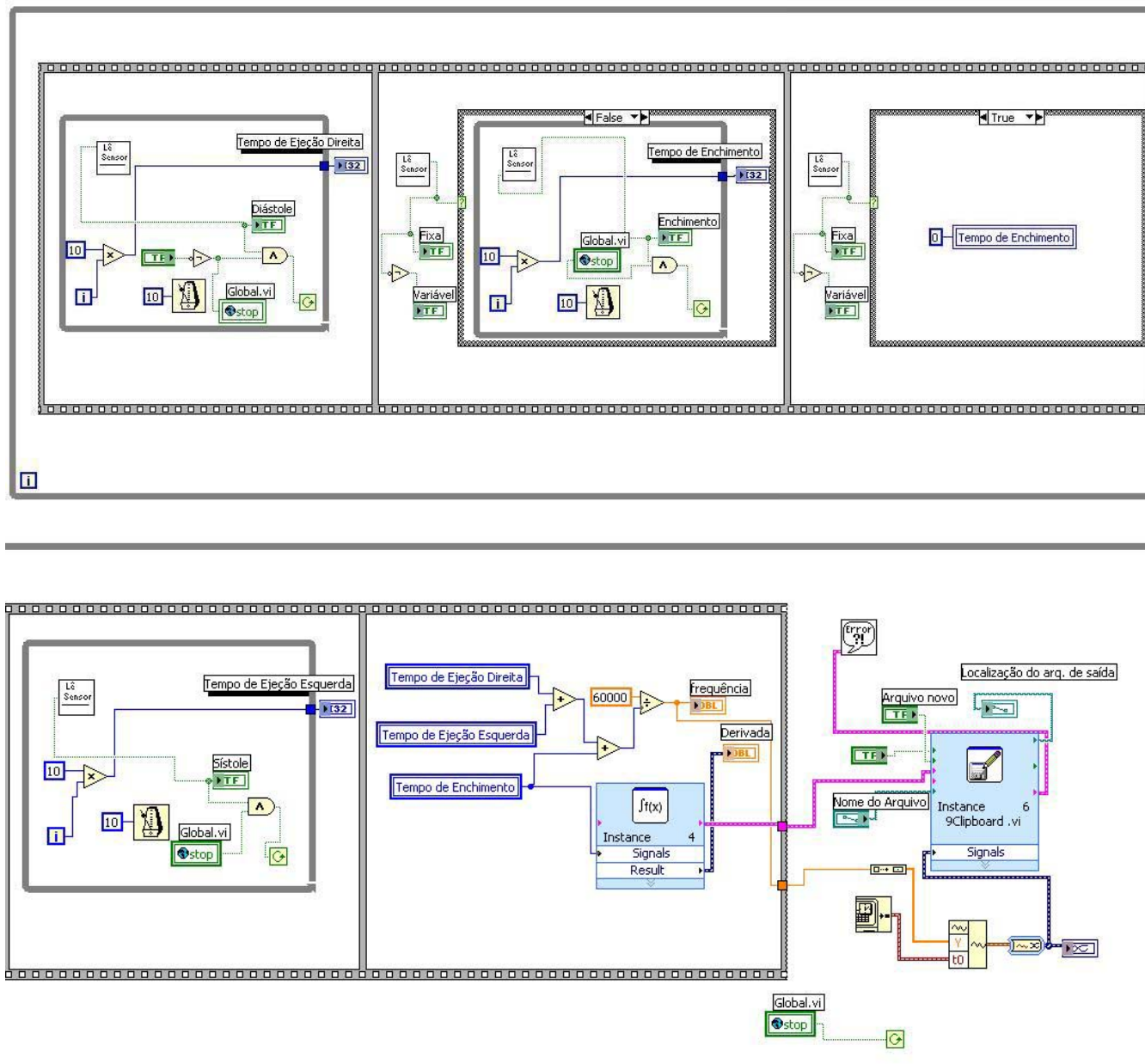


Figure 3. Diagram window built in LabVIEW® for the monitoring ATA operation.

4. Results

Figure 4 shows the application behavior during a systolic phase.

Figure 5 shows the diastolic period confirmed by corresponding indication and Fig. 6 shows the period during the “waiting state”, showed by correspondent indicator.

In the conditions showed above, the system is operating in variable rate mode; the Fig. 7 presents the device operating in fixed rate mode, indicated in the panel.

5. Conclusions

The obtained results of tests showed that the use of the program developed in LabVIEW® offer a good way to visualize the device operation.

In variable rate mode is possible to verify the duration time of each event. The information about differential filling time for left chamber filling, is important too for instantaneous analyze of ATA operation.

The graphic window shows the ATA behavior versus time.

The comparison between the reported time by developed program and the program developed in language “C”, noticed that the event during time was the same. It proves the reliability of developed system.

The system operation was considered satisfactory, although some time errors were observed because the Windows® multi-task environment.

“The Windows® operating system is designed to offer time-slices or processor time to background tasks as it sees fit. Because the user often has little control over how processor time is shared, Windows® is not considered a real-time operating system. Consequently, non-critical tasks (such as screen savers and virus protection software) may interfere with a time-critical process in LabVIEW®, such as a data acquisition application or control loop, starving it of valuable processor time.” (National Instruments, 2005)

Because of mentioned above, the counter of developed program shows a wrong measurement. A possible solution to solve this problem is to use another kind of hardware like a specific data acquisition card which has an owner tick counter. Another possible solution is to use a kind of buffer acquisition, which executes a data saving then sent it to PC in lower frequency.

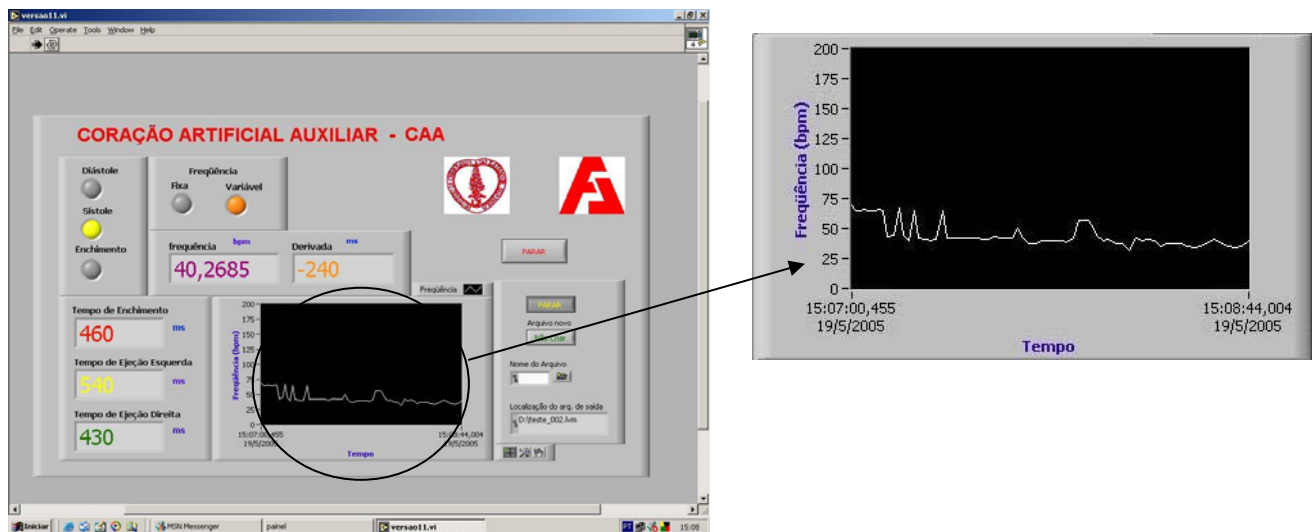


Figure 4. System behavior during a systolic period in variable rate operation mode.

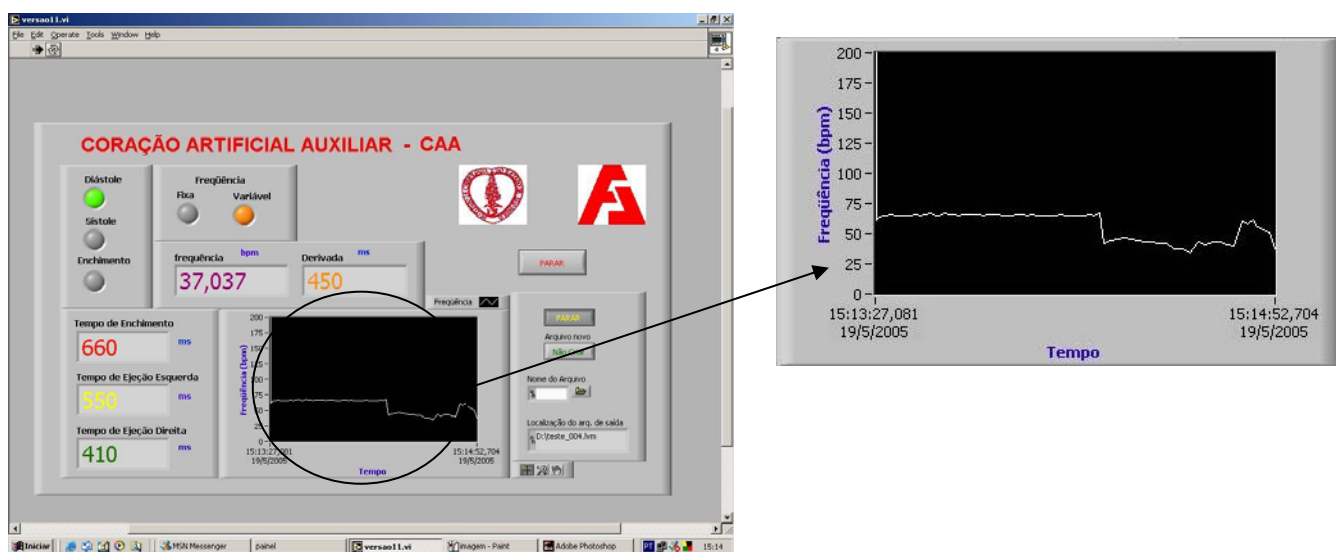


Figure 5. System behavior during a diastolic period in variable rate operation mode.

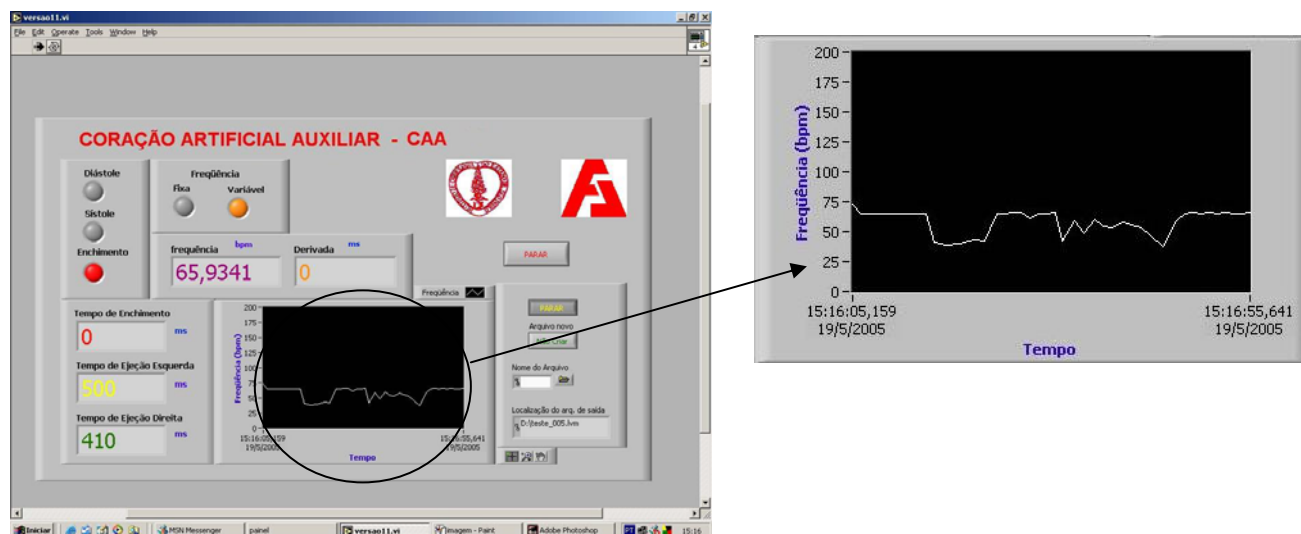


Figure 6. System behavior during a waiting period in variable rate operation mode.

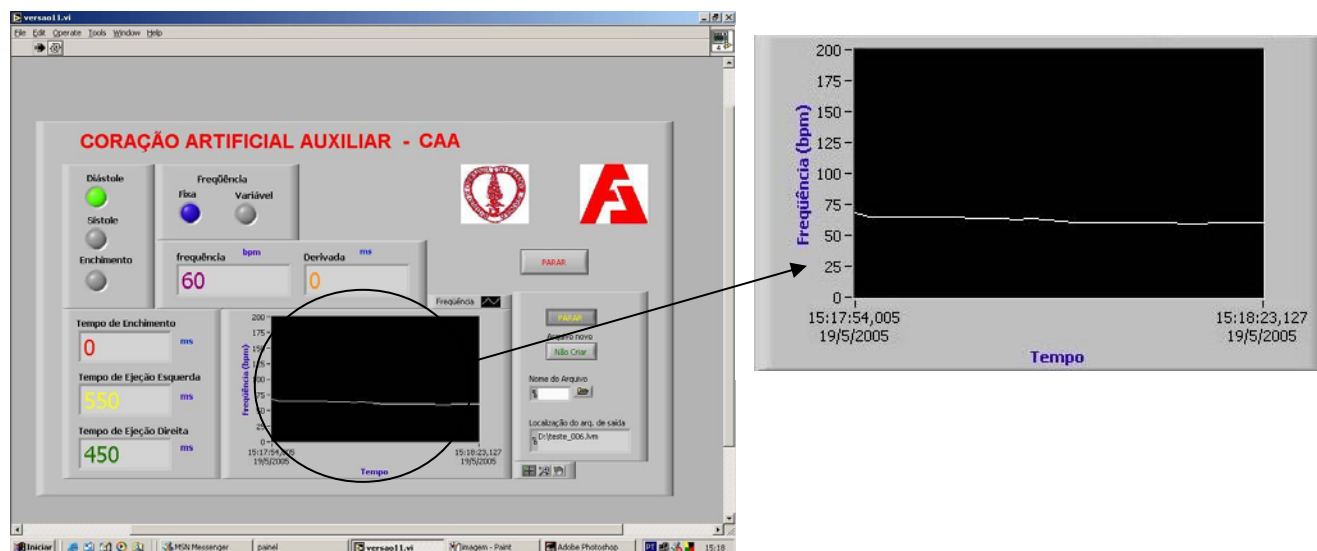


Figure 7. System behavior during a fixed rate operation mode.

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5. Responsibility notice

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