Concept of Operations for Timer with Light Gate.

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1.0 Introduction

1.1 Project Description

This section will provide a brief overview of the development activity and system context as delineated in the following two subsections.

Our main goal is to build a timer of millisecond precision. The main component of the timer is the light gate that will record the instants of crossing its line of sight.

1.1.1 Background

Summarize the conditions that created the need for the new system. Provide the high-level mission goals and objectives of the system operation. Provide the rationale for the development of the system.

In the lab experiments we have problems with measuring periods of the oscillations. The problem is severe for measuring the free fall acceleration with the simple pendulum. The reason is the low precision of measurements based on the human reaction (using conventional timers as phone timer). Calculations show that the precision must be of the order of milliseconds. The human reaction time is much longer than this.

Thus our goal is building a timer based on the light gate with a precision of millisecond. The execution of the project for the student may be divided it into the following stages:

- Learning Arduino environment
- Research for the methods of the execution of the project.
- Building and testing the circuit of the device.
- Construction of the mechanical parts of the device
- Developing the software part of the project
- Testing the device and comparing the results with the results obtained with traditional methods of measuring the period of oscillations.

1.1.2 Assumptions and Constraints

State the basic assumptions and constraints in the development of the concept. For example, that some technology will be matured enough by the time the system is ready to be fielded, or that the system has to be provided by a certain date in order to accomplish the mission.

It was supposed that all of the stages of the development of the project will not be very time consuming. The project is not expensive requires less than 100 $ for component purchase during development stage. Technological constraints that may slow down the project execution is the poor initial background knowledge. We must find an appropriate protocol for IR remote communication that will be suitable for our device. It must provide an accuracy of 1 millisecond.

We are going to test another method for developing such a device in case of having troubles with this method. The alternative approach is based on the laser beam and a receiver based in the photoresistor (LDR).

The device has to be developed and tested till the May.

1.2 Overview of the Envisioned System

This section provides an executive summary overview of the envisioned system. A more detailed description will be provided in Section 3.0

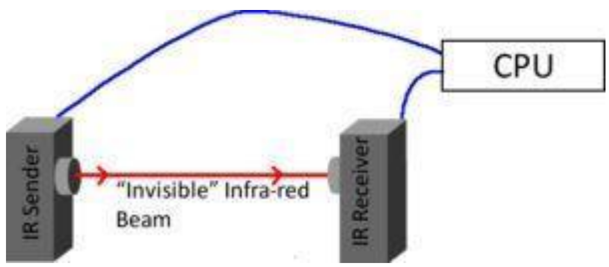
We are going to make a device that will measure the time with an accuracy up to milliseconds. Further testing will show does it make sense to improve the accuracy of time measurment (up to 0.1 ms, 0.01 ms or microseconds).

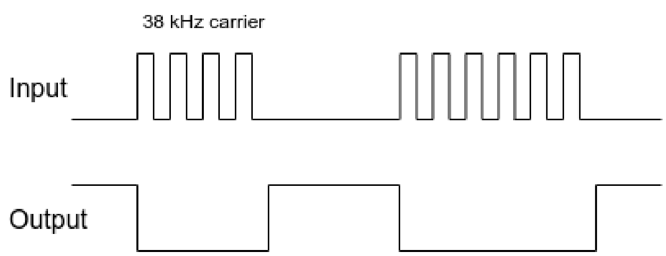
1.2.1 Overview

This subsection provides a high-level overview of the system and its operation. Pictorials, graphics, videos, models, or other means may be used to provide this basic understanding of the concept.

The systems main components are transmitter and receiver. The transmitter should send signal of a certain carrying frequency and modulation. As the receiver is sensitive to that carrying frequency, it will “ignore” background radiation such as IR part in the spectrum of the sun rays, bulb lights and etc. Thus the level of IR part in the spectrum of a normal background radiation is not important.

If an object crosses the line of site connecting the transmitter and receiver the signal detection of the receiver will be interrupted. This interruption will be served as an evidence for the event. The timings between these interruptions will be used for determining the values of the time intervals we are interested in, e.g. period of the oscillations. The modes of the operation will enable the user to select the number of crossings between which the time must be measured.





The microcontroller operates the IR emitter to send signals with the desired carrying frequency and modulation. Also it monitors the receiver to check if it is receiving an IR signal. If so, we know there is nothing to block the beam sent by the IR transmitter.

The total cost of the system including components for learning will be about 60$.

2.0 Documents

2.1 Applicable Documents

This section lists all the documents, models, standards or other material that are applicable and some or all of which will form part of the requirements of the project.

For the first method we are going to develop

- manual for using the device (the specifications of the device will be presented in the manual)
- worksheets for the labs that will use this device

2.2 Reference Documents

This section provides supplemental information that might be useful in understanding the system or its scenarios.

Supplemental information to understand the devices and libraries used in this system are the following:

1) https://www.arduino.cc/reference/en/libraries/irremote/
2) https://www.vishay.com/docs/82491/tsop382.pdf
3) https://www.arduino.cc/reference/en/language/functions/usb/keyboard/
4) https://liudr.wordpress.com/2010/10/05/arduino-and-photogates/
5) https://www.etchkshop.com/products/lightgate

3.0 Description of Envisioned System

3.1 Needs, Goals and Objectives of Envisioned System

This section describes the needs, goals, and objectives as expectations for the system capabilities, behavior, and operations. It may also point to a separate document or model that contains the current up-to-date agreed-to expectations.

- We are going to make a simple device that will measure the time with an accuracy up to milliseconds. Further testing will show does it make a sense to develop a device with accuracy up to microseconds
- The modes of operation must enable the user to choose the number of interruption of the light beam before presenting the time interval.
- The user may see the value of the time interval on the LCD screen
- The modes must be selected by the touchpad.

3.2 Interfaces

This section describes the interfaces of the system with any other systems that are external to the project. It may also include high-level interfaces between the major envisioned elements of the system. Interfaces may include mechanical, electrical, human user/operator, fluid, radio frequency, data, or other types of interactions.

3.2.1 Sensors used

The only sensors used

- IR receiver of the TSOP328xx model.
- 3x4 Matrix Array Keyboard for Arduino

3.2.2 Output and Input information

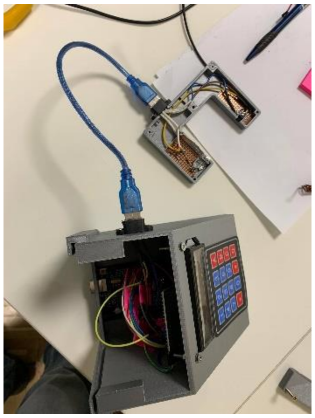
In the simple device the input information will be the number of the interruptions. The output information will be the measured time between that number of interruptions.

3.3 Modes of Operations

This section describes the various modes or configurations that the system may need in order to accomplish its intended purpose throughout its life cycle. This may include modes needed in the development of the system, such as for testing or training, as well as various modes that will be needed during its operational and disposal phases.

During the development process we are going to test its operation with different IR protocols. At first we try a signal with carrying frequency without any modulation. The results of this tastings will show the roadmap of the next steps. In case of failure of this method we are going to use simple “laser and LDR” method described in the section 1.1.2.

For developing the mechanical part of the system we will do testing by the use of lab stands and stamps. We will start the designing the box and fixing aids of the receiver and transmitter after determining the suitable distance between the receiver and transmitter and the actual requirements for the space of the other components of the system such as microcontroller, keyboard, resistors. Now we made two blocks: one contains both receiver and transmitter and the second one contains other electronic parts, LCD screen and keypad mounted on it. The power supply must be connected to the last block.



For designing the modes of operation we need to measure the errors in measuring the time that may appear due to the finite size, blurred edges of the obstacles that will interrupt the beam. The transition time delay of the IR receiver is also a source of errors and its impact on the precision of time detection should be estimated. If it comes out that the errors are too small one of the modes will be just measuring the time between two closest blockings. In case of low accuracy, it may be required to count more (10, 50) successive screenings and calculate the mean time. Since the total time is important, it is not effective to waste 5 min for making one measurement, we must get as high accuracy as possible. And the modes of operation must involve a number of oscillations that require in total less than a minute of time. Other options may be developed during the implementation process.

3.4 Proposed Capabilities

This section describes the various capabilities that the envisioned system will provide. These capabilities cover the entire life cycle of the system's operation, including special capabilities needed for the verification/validation of the system, its capabilities during its intended operations, and any special capabilities needed during the decommissioning or disposal process.

The envisioned system will serve as a facilitator during the education process. The envisioned system throughout the lifecycle will offer to the students a method for measuring time intervals which are of the order of human reaction time with a precision of milliseconds. No special capabilities are needed for the verification/validation of the system.

4.0 Physical Environment

This section should describe the environment that the system will be expected to perform throughout its life cycle, including integration, tests, and transportation. This may include expected and off-nominal temperatures, pressures, radiation, winds, and other atmospheric, space, or aquatic conditions. A description of whether the system needs to operate, tolerate degraded performance, or just survive in these conditions should be noted.

- The operating supply voltage for the device is 5 V, recommended input voltage is between 5V-12V. The voltage must be supplied by the USB cable. Any software installations and updates also must be done through the same USB port.
- The background IR radiation frequency must have low intensity at frequency close to 35-37 kHz bandwidth.
- The device will be suited to the conditions provided in the university or school lab. The environment in which the system is expected to work during its lifecycle is room temperature, normal pressure.
- It is not expected that the device must work in off-nominal temperatures, pressures, winds, out of atmospheric (space) or aquatic conditions.
- Since the system is quite cheap, in case of degradation of the performance of the system the degraded components must be replaced with new ones.

5.0 Support Environment

This section describes how the envisioned system will be supported after being fielded. This includes how operational planning will be performed and how commanding or other uploads will be determined and provided, as required. Discussions may include how the envisioned system would be maintained, repaired, replaced, it's sparing philosophy, and how future upgrades may be performed. It may also include assumptions on the level of continued support from the design teams.

It is supposed that the system will be accessible during its lifecycle after being "fielded" in the lab. The uploads for the updates of the systems software will be done via USB port. The commanding uploads will be done through the Arduino keyboard.

To maintain the system, it will be required replacing the damaged components, which are quite cheap. To facilitate the maintenance process one must keep spare parts in the lab. The user must avoid applying high voltages to the systems input (out of the range 5V-12 V). Other requirements are similar to the requirements of an Arduino UNO/Nano microcontroller.

We should monitor to see a way for improvements of the device during its use in class. The expected improvements are mechanical and software design or electronic components. In The electronic components are replaceable by soldering. Software updates can be installed through the USB port on the device. For mechanical updates we must build a new system. It is expected to find ways of improvement since the offered device will be a new for us as a developer the likelihood of bugs and errors is high.

6.0 Operational Scenarios, Use Cases and/or Design Reference Missions

This section takes key scenarios, use cases, or DRM and discusses what the envisioned system provides or how it functions throughout that single-thread timeline. The number of scenarios, use cases, or DRMs discussed should cover both nominal and off-nominal conditions and cover all expected functions and capabilities. A good practice is to label each of these scenarios to facilitate requirements traceability; e.g., [DRM-0100], [DRM-0200], etc.

6.1 Nominal Conditions

These scenarios, use cases, or DRMs cover how the envisioned system will operate under normal circumstances where there are no problems or anomalies taking place.

DRM - 0100:

The device will measure periods with an accuracy of milliseconds by detecting the waves transmitted only frim the transmitter inserted. dedicated into the system. And the use of this device will rise the accuracy of the measurements of the free fall acceleration. may be used for measuring the instantaneous speeds, for measuring the period of various oscillating systems. I

6.2 Off-Nominal Conditions

These scenarios cover cases where some condition has occurred that will need the system to perform in a way that is different from normal. This would cover failures, low performance, unexpected environmental conditions, or operator errors. These scenarios should reveal any additional capabilities or safeguards that are needed in the system.

1. We do not consider to use it in off-nominal conditions.

7.0 Impact Considerations

This section describes the potential impacts, both positive and negative, on the environment and other areas.

7.1 Environmental Impacts

Describes how the envisioned system could impact the environment of the local area, state, country, worldwide, space, and other planetary bodies as appropriate for the systems intended purpose. This includes the possibility of the generation of any orbital debris, potential contamination of other planetary bodies or atmosphere, and generation of hazardous wastes that will need disposal on earth and other factors. Impacts should cover the entire life cycle of the system from development through disposal.

The system relies on a low cost materials and requires an educational practice. There is a need of measuring or educational devices in many schools. This device will be an example for the application of universal methods for filling the gaps in required facilities in the school. The main potential waste that can arrive from this project, are the damage of any electronic components that have either: burnt out, backfired.

It will mostly be used as an educational/measuring tool for the students. Throughout the lifecycle of the development the device will be integrated and tested under normal lab like conditions. Comparing the results yielded by methods it is possible to get skills for finding the required precision and choosing methods for carrying out experiments. The end result will be a light gate with capabilities to measure the oscillations with optimal precision.

It is essential that any electrical components that are used and then have the plan to be discarded, to be properly disposed of or recycled/reused for future use. The second impact, although not direct, is the use of electricity throughout the entire lifecycle of the development, precautions will be taken to ensure usage of electricity is not unnecessarily too much, to reduce waste as much as possible.

7.2 Organizational Impacts

Describes how the envisioned system could impact existing or future organizational aspects. This would include the need for hiring specialists or operators, specialized or widespread training or retraining, and use of multiple organizations.

First it was required Arduino software installed in a user’s PC in order to choose the mode of operation of the device When the system is implemented. Now, due to upgrades in software and hardware the requirement is to have only the two blocks: probe and main part (which can be assembled and disassembled) and power supply. Choosing the mode for operation will allow to use the maximum potential of the device. A documentation will most likely cover all the bases needed for learning how to use the device.

7.3 Scientific/Technical Impacts

This subsection describes the anticipated scientific or technical impact of a successful mission or deployment, what scientific questions will be answered, what knowledge gaps will be filled, and what services will be provided. If the purpose of this system is to improve operations or logistics instead of science, describe the anticipated impact of the system in those terms.

It will not have any scientific impacts. In the case of successful operation, it will facilitate educational services. It will be a good sample of case study to show the importance of accuracy in measurements.

8.0 Risks and Potential Issues

This section describes any risks and potential issues associated with the development, operations or disposal of the envisioned system. Also includes concerns/risks with the project schedule, staffing support, or implementation approach. Allocate subsections as needed for each risk or issue consideration. Pay special attention to closeout issues at the end of the project.

There are several problems that can occur during the development of this system ranging from mild inconveniences to potential risks. The following are potential issues that are listed least to most concerning:

1) Learning the Arduino environment and some electronics takes too much time.
2) Users were required to bring PCs with them and install the required software but now we do not need a PC. Instead we must add a power supply providing 5V output voltage.
3) Give user some instructions of how to use it and to avoid potential, unexpected risks
4) Each student must be provided with the device during lab sessions, thus we need multiple examples of the same device. The multiplication will be time consuming and will require some finance.

Appendix A: Acronyms

This part lists each acronym used in the ConOps and spells it out.

Appendix B: Glossary of Terms

The part lists key terms used in the ConOps and provides a description of their meaning.