EE 448 Lab Tachometer

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Executive Summary

The Problem





Project Plan

Requirements

| Functional | Non-Functional |
|---|--|
| Perform all lab functions 99% accuracy Range from 100 to 2000 RPM | More cost-effective User friendly Documented sufficiently Resistant to breaking |

Use Cases

| | Student | ETG Worker |
|---|---|---|
| • | Change the COM port Check the motor RPM Use the 'help' button | Mount the tachometer Test the mount stability Load the software |

System Design & Development

Design Plan / Objectives







• Satisfy all requirements

- Approval from all user groups
- Field testing

System Constraints

| Assumptions | Limitations |
|--|--|
| Used by two students Used in the EE 448 lab Lab/lab setup will not be drastically changed Students will refrain from touching The lab computers run on Windows | The RPM should only go from 100 to 2000 RPM The size of the tool should be no larger than the motor it is evaluating The cost to produce the end product should not exceed \$500 |

Design Trade-Offs

| Optical EncoderFast, easyExpensive | Low-Pass Filter Cheap and easily accessible Requires time to design |
|--|---|
| Tiva BoardStarted hereNeed to rewrite | Arduino Easy to code fast No previous experience |
| Java Previous experience but required learning new, unfamiliar functionalities | Python Client suggested Limited previous experience |

Design Block Diagram / Description of Modules / Interfaces



Architectural Diagram / Constraints



GUIPrice

- Motor
- Lab

Implementation

Implementation Diagram



Technologies / Software Used and Rationale

| GUI | Microcontroller | Hardware |
|---|--|--|
| IDE: PyCharm Libraries: tkinter, serial, PyInstaller | Microcontroller: Arduino Nano Language: Arduino | Filter: Low-pass Sensor: Hall effect CAD: SolidWorks, MultiSim |

Standards / Best Practices

- IEEE Standard for Software and System Test Documentation
- IEEE Standard for System, Software, and Hardware Verification and Validation
- IEEE Guide for Selecting and Using Reliability Predictions Based on IEEE 1413
- Peer Code Reviews

Testing, Validation, & Evaluation

Test Plan

- All manual tests
- Unit, Interface, System Integration, and Field testing
- Focus on linking to requirements

Unit Testing / Interface Testing

| Unit | Interface |
|---|---|
| (Software) Function Requirement #4:GUI for user interaction | (Hardware) Requirement: Hardware output a pulse should be clean and consistent With 0.5% accuracy From 100 RPM to 2000 RPM |
| (Hardware) Requirement: Hall effect sensor will create clear pulse | (Software) Requirement: Calculate RPM with 0.5% accuracy From 100 RPM to 2000 RPM |

System Integration Testing / Field Testing / Validation and Verification

| System | Field | Validation and Verification |
|--|--|---|
| Functional Requirement #2 & #3: Accuracy of 99% From 100 to 2000 RPM | Non-Functional Requirement #2: It will have a user-friendly GUI | Non-Functional Requirement #1:Cost effective |
| Functional Requirement #1:Perform all lab functions. | Non-Functional Requirement #3: It will be documented sufficiently | |

Evaluation

- Meets all requirements
- Client, student, professor, and TA approval

- 88% cost reduction
- 80% time reduction
- Removed direct user/motor interaction
- Rated 9.5/10 for ease of use

Project & Risk Management

Roles and Responsibilities

| Role | Member |
|-----------------------|------------------------|
| Hardware Team | Kyle, Katrina, Seth* |
| Software Team | Meghna, Jessica, Seth* |
| Systems Engineer | Seth |
| Testing Team | Meghna, Jessica, Seth |
| Timeline Manager | Katrina |
| Communication Manager | Jessica |

* refers to member holding this role for a partial semester

Task Decomposition

| Task | Team Member(s) | Task | Team Member(s) |
|-----------------------------|--------------------------|-------------------------|-----------------------|
| GUI creation | Jessica, Meghna | Mounting | Katrina, Kyle |
| Arduino programming | Jessica, Meghna | Low-pass circuit design | Seth |
| GUI/Arduino interface | Jessica, Meghna | PCB Design | Kyle |
| Software testing | Jessica, Meghna, Seth | Hardware testing | Seth |
| Picking/ordering components | Seth, Katrina, Kyle | System-level testing | Seth, Meghna, Jessica |

Project Schedule

| Tachometer | | | | | | | | | | | | | | |
|--|------------|----------|-------|----|----------------------|----|----------------------|----|------------------|----|----------------|-------------|----|----|
| | | | | | % Software Completed | | % Hardware Completed | | % Team Completed | | % Receiving Fe | ed; Testing | | |
| | | | Weeks | | | | | | | | | | | |
| ACTIVITY | PLAN START | PLAN END | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| Re-evalute design to add hall effect sensor | 14-Jan | 28-Jan | | | | | | | | | | | | |
| Safety Training with Lee Harker to maintanence shop | 28-Jan | 3-Feb | | | | | | | | | | | | |
| Write Arduino code to take input and note change between pulses to calculate RPM | 28-Jan | 3-Feb | | | | | | | | | | | | |
| Take measurements of spacing in lab. Create mock mount for sensor | 3-Feb | 10-Feb | | | | | | | | | | | | |
| Create GUI | 3-Feb | 10-Feb | | | | | | | | | | | | |
| Test max and min distance of sensor. Create 3D model of sensor mount | 10-Feb | 18-Feb | | | | | | | | | | | | |
| Connect microcontroller to GUI | 10-Feb | 18-Feb | | | | | | | | | | | | |
| Adjusted sensor to fit more properly and added height adjustments | 18-Feb | 24-Feb | | | | | | | | | | | | |
| Connect mircocontroller to GUI (Continuation of last week) | 18-Feb | 24-Feb | | | | | | | | | | | | |
| Add adjustments to sensor mount. Sketch arduino mount and implement in Solid works | 25-Feb | 24-Mar | | | | | | | | | | | | |
| Test software component for accuracy | 25-Feb | 24-Mar | | | | | | | | | | | | |
| Design a fork mount to in | 25-Mar | 31-Mar | | | | | | | | | | | | |
| Implement code bug fixes as found in testing | 25-Mar | 31-Mar | | | | | | | | | | | | |
| Rework fork mount and arduino mount | 1-Apr | 7-Apr | | | | | | | | | | | | |
| Allow the user to modify the com port | 1-Apr | 7-Apr | | | | | | | | | | | | |
| Create low pass filter to fix noise coming from AC motor | 8-Apr | 14-Apr | | | | | | | | | | | | 1 |
| Create an executable file for the GUI | 8-Apr | 14-Apr | | | | | | | | | | | | |
| Test in 448 lab with students. Receive feedback of design | 15-Apr | 21-Apr | | | | | | | | | | | | |
| Solder lower pass filter and arduino on board. Create hardware for all motors | 15-Apr | 21-Apr | | | | | | | | | | | | |
| Make sure software is up to date | 15-Apr | 21-Apr | | | | | | | | | | | | |
| Update documentation | 22-Apr | 3-May | | | | | | | | | | | | - |
| Feedback given is implemented into final design | 22-Apr | 3-May | | | | | | | | | | | | |

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Risks and Mitigation

| Anticipated | Actual |
|--|--|
| Shipping time for parts | Shipping time for parts |
| Redo design and implementation | Testing software without hardware |
| Redo our documentation | System needed to be mounted securely |
| Work on hardware and software at the same time | System would not be documented well enough to maintain in future |

Lessons Learned

- Test in the environment early
- Check with first to third party users early
- Order parts early

Conclusions

Closing Remarks

- Met all requirements
 - Client, student, TA, and professor approval
 - Less cost
 - Higher durability
 - Save time

Future Work

- Use the GUI to control the motor
- Set the microcontrollers to the same port
- Put the program icon on the desktop



List of References

IEEE Standard for Software and System Test, IEEE Standard 829, 2008.

IEEE Standard for System, Software, and Hardware Verification and Validation, IEEE Standard 1012, 2012.

- *IEEE Guide for Selecting and Using Reliability Predictions Based on IEEE 1413*, IEEE Standard 1413.1, 2002.
- T. Bigelow. "EE 448 Lab 5 Report.doc." Unpublished manuscript, EE 448: Introduction to AC Circuits and Motors, Iowa State University, Ames, Iowa, U.S.A.
- T. Bigelow. "EE 448 Lab 6 Report.doc." Unpublished manuscript, EE 448: Introduction to AC Circuits and Motors, Iowa State University, Ames, Iowa, United States.

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Additional Information

Hardware Output Waveform



GUI

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|------------------------------|-------------|---|
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| | | |
| 786 RPM | | |
| | | |
| | | |
| | | |
| Input port name here | | |
| Please pick a valid com port | | |
| Submit | | |
| | | |
| | | |

System Accuracy Graph

System Level: RPM (stroboscope) and RPM (Arduino)



Student Feedback

| Feedback | Status |
|--|-------------|
| Add 'help' button | Done |
| Do not use 'start' button | Done |
| Get rid of junk values that come up on start | Done |
| Move executable file to desktop | In-Progress |
| Make the measurements faster | Declined |
| Have more accuracy (1 RPM instead of 6 RPM) | Declined |