Degaussing Watch Winder

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Senior Design 1
Initial Project and Group Identification Document—Divide and Conquer

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Project Narrative

Watches have become increasingly accessible across the economic classes. Collaborations with companies such as Omega and Swatch have shown this to be true. Omega watches start around 6,000 USD whereas the average cost of a Swatch is 200 USD. The Omega x Swatch Bioceramic MoonSwatch collection cost 260 USD. The growing interest of watches and their accessibility has sparked interest in the market for watch accessories. Currently, the market sells degaussers and watch winders as two separate accessories. The goal of this project is to combine these two accessories into one versatile product.

The objective of this project is to design and build a watch winder that records turn per day (TPD), rotation direction, rotations per minute (rpm), and contains a degausser. The function of a watch winder is to keep an automatic watch fully wound while the function of a degausser is to demagnetize a watch that has been over-wound. Usually when an automatic watch is worn, the motion of the individual wearing it, provides energy to wind the mainspring. This in turn makes manual winding obsolete. Once the watch is fully wound, there is ample energy in the mainspring to keep the watch ticking approximately 12 to 48 hours. However, if the watch is not worn everyday it can be placed in a watch winder. A watch winder will slowly rotate the watch in a case. Rotation count can be set between 100 to 1500 TPD depending on the watch's need. Including rotation direction will deliver the option of a watch to be set clockwise, counterclockwise, or bidirectional. The benefit of having a watch winder is that it prevents a watch from draining the stored energy, which can lead to damage to the timepiece. This is ideal for individuals who own multiple automatic watches.

The addition of a degausser is to correct a watch's magnetism. When a watch is worn often, there is a great amount of energy, magnetism, being stored within the watch's spring creating an overwound watch. When a watch is overwound the hands of the watch move faster or slower. This causes an inaccurate measurement and display of time. To correct the watch's accuracy, the watch must undergo demagnetization. The degausser relieves the excessive energy, magnetism, stored in the spring resulting in an accurate timepiece.

Currently, Amazon only sells watch winders and degaussers as separate accessories. There are no degaussing watch winders on the market. However, customer input of these two products seems to be consistent. Constructive feedback of Amazon's "Best Selling" watch winder has consistently mentioned the noise output and power source. The watch winder is known to be loud. Patrons have also expressed interest in a watch winder that can be powered via batteries and AC power. This will ensure a power source if the batteries die. Regarding Amazon's Best Selling degausser, there is no constructive criticism on current models on the market. Customers overall have agreed having a degausser at home is much more economically stable than to have ones' watch serviced by the watch's manufacturer. Amazon's best-selling degausser costs 20 USD whereas Omega will charge 600 USD to have a watch degaussed one time. Customers have expressed their appreciation of both products being lightweight, portable, and user friendly. We intend to implement this feedback into our design to create the perfect watch accessory.

Advance Goal: The goal is to create a website to communicate with the watch winder. Have a database that can store functions as well as erasing the functions. It will be a full-stack website so users can interact back and forth with the watch winder.

Stretch Goal: Once we can complete the basic goal and advance goal then the cherry on top would be to create a mobile app which can interact with the watch winder.

Requirements and Specifications

We wish to design a device that meets all the requirements listed below.

- Device shall rotate and charge an automatic watch.
- Device shall remove magnetic fields associated with the watch.
- Device shall have a user interface to see data and selections.
- Device should use an electric motor to rotate the watch.
- Device should be programmed to rotate when the user chooses.
- Device should accommodate 400-1200 rotations a day.
- Device should be able to remove magnetic fields from the watch when the user chooses.
- Device should be able to read magnetic fields associated with the watch using a magnetometer device.
- Device should contain a Printed Circuit Board that is fabricated in accordance with IPC-6011 and IPC-6012.
- Device should contain a custom Circuit Card Assembly that is assembled in accordance with IPC/EIA J-STD-001.

Some project restraints are lack of data on levels of magnetization picked up by casual watch users. ISO 764 states that a watch must resist exposure to magnetic fields of 4800 A/m but now we have no quantitative data on levels casual watch wearers experience.

House of Quality

User Requirements		Engineering Requirments			
		Mechanical Watch Charging	Degaussing	Magnetic Field sensing	Data Displayed to User
		+	+	+	+
Cost	-	V	^		V
Ease of Use	+	^	^	^	^
Practical	+	^	^	^	^
Maintenece	-	V	V	^	^
User Interface	+	^	^	^	^
			> 200µT	Range of 20µT to 1000µT	induced field strength

Figure 1

Hardware Block Diagram

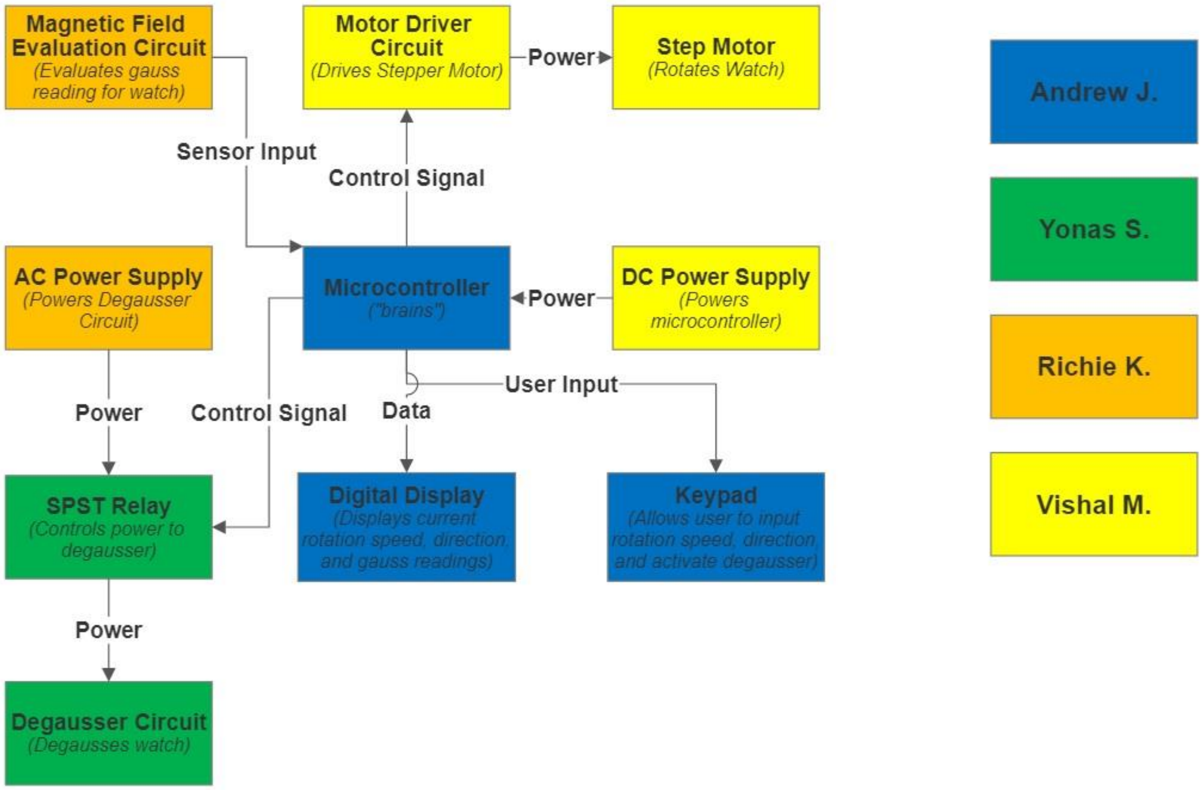

Figure 2

Microcontroller: Ultimately, we decided on the AVR family of microcontrollers for this project, primarily because of the extensive support it offers in terms of communication protocols. Having access to these built-in communication hardware blocks gives us much needed flexibility in choosing sensors, since we will be able to accommodate whatever specific part we choose in the end.

Family	Architecture	Memory	Peripherals	Cost	Examples
8051	8-bit	· 4-8KB ROM · 128-256B RAM	· timers · serial ports · UART · ADCs	~$3	· 8031 · 8051 · 8052
AVR	8-bit	· .5-256 KB Flash · 1-32KB SRAM · 64-4096B EEPROM	· timers · ADCs · U(S)ART · I2C · SPI · USI	~$5	· tinyAVR · megaAVR · AVR Dx · XMEGA
PIC	8-bit	· 32-64 B SRAM	· timers · counters · EUSART · I2C	<$1	· PIC16 · PIC18

Table 1

Stepper Motor Comparison – Table 2

Stepper Motors	Permanent Magnet Stepper Motor (PM)	Variable Reluctance Stepper Motor (VR)	Hybrid stepper motor (HY)
Cost	Cheapest	Moderate	Most Expensive
Design	Moderate	Simple	Complex
Resolution	Step Angle: 3° to 30°	Step Angle: 1.8°, 0.9° and smaller	Step Angle: 1.8°, 0.9° and smaller
Speed Torque Curve	High torque at low speed, more pronounced torque drops at high speed	Less pronounced torque drops at high speed	High torque at low speed, more pronounced torque drops at high speed
Noise	Quiet	Noisy	Quiet (Can be quieter if using Microstepping)
Heat	Low temp rise	High temp rise (Will probably need heat sink)	Low temp rise
Microstepping	Full, Half and Microstepping	Typically runs in Full-Step only	Full, Half and Microstepping
Rotor Material	Ferrite magnet or Neodymium magnet (NdFeB)	Silicon steel sheet or iron	Neodymium magnet (NdFeB)

Stepper Motor: When it comes to choosing the right stepper motor, we decided to go with the Permanent Magnet Stepper Motor as it is compact which makes it useful for our design. We don’t need something that produces speed as watch winders take their time while winding a watch.

Motor Driver Comparison

Motor Driver	DC Motor	AC Motor	Stepper Motor	Servo Motor
Types	Brushed & Brushless	Synchronous	PM Motor, VR Motor, & HY Motor	Positional Rotation, Continuous Rotation, & Linear
Efficiency	Brushed: 75–80%; Brushless: 85-90%	Lower efficiency compared to DC motors (Up to 30% less efficient compared to DC)	Not as efficient because the loss is heat	Highly Efficient
Design	Brushed: Complex Brushless: Simple	Complex	PM Motor: Moderate VR Motor: Simple HY Motor: Complex	Varies but not as complex as Stepper Motors
Cost	Cheapest	Most Expensive	Cheapest	Moderate

Table 3

Motor Driver: The motor driver that we would like to use is the stepper motor. For our application stepper motors are great for holding position and tend to have a long lifespan. This would be perfect for our design.

DC Power Supply Comparison

DC Power Supply	Battery	Linear	Switched
Cost	Inexpensive	Expensive	Expensive but less than linear
Lifespan	3 to 5 years	5 to 10 years	5 to 10 years
Efficiency	Efficient but also depends on the type of battery	Less efficient then switched power supply as it releases more heat	More efficient than linear power supply
Design	Complex	Simple	Complex

Table 4

DC Power Supply: For the DC power supply, we need something small and compact that will not fry our components which is why we are sure a battery will work for our design.

SPST Relay Comparison

SPST Relay	Switch contact	Switching performance	Durability	Cost	Example
Electromechanical	Physical contact	5 to 15 ms	1Million cycle	Cheap	P251003E
Reed	Electromagnet contact	200 to 500 microsecond	100 Million cycle	Moderate	P711004E
Solid State	Solid State devices	100 microseconds	>100Million cycle	Expensive	1611001E

Table 5

SPST Relay: Understanding the strength and weaknesses of different relay technologies, we can pick electromechanical relays that best suit for the project. The reason is that it is small, easy to construct, and cost very low. It has the advantage that they can handle large amounts. In addition, when compared to other technologies, this relay is galvanically isolated from the relay contacts for safety reasons. Moreover, this electromechanical relay can switch and settle in 5 to 15ms which makes the electromechanical relay an excellent choice.

Degausser Technology Comparison

Degausser	Duration of Demagnetizing	weight	Power Source	Example
Coil	30 seconds	Light	230V , 0.65A	P251003E
Impulse Degausser	40 seconds	Heavy	120V, 3A	P711004E
Permanent Magnet	8 seconds	Heavy	No-power It is manual	1611001E

Table 6

Degausser: Based on the research, the technology that best suits our project is coil degausser. The reason is that the duration of the demagnetizing and demagnetizing performance is excellent. Also, the coil degausser has the advantage of being lightweight which is easy to construct. Moreover, the 230 v, 0.65A power supply would be a great selection for our project.

Keypad: There really are many characteristics to a keypad, at least not in any capacity that would significantly impact this project, switch debouncing will likely be handled software side so there really isn't any need for additional hardware. The keypad technology will be a basic matrix membrane type.

Type	# of buttons	Maximum Rating	Examples
matrix-membrane	4-n^2	24 VDC, 30 mA	• 4x4 Matrix Membrane Keypad (#27899)

Table 7

Digital Display: The choice in display is relatively inconsequential, we are only looking to display basic characters and no images, and both technologies appear to support multiple communication protocols, so in the end we chose to go with the cheapest technology available.

Type	**Communication Protocol**	**Cost**	**Examples**
LCD	I2C, Serial, SPI, GPIO	~$20	• GDM1602K
OLED	SPI, I2C, Serial, GPIO	~$40	• UG-2856KLBAG01

Table 8

Magnetic Field Sensing Technology Comparison

Magnetic Sensor Technology Study	Hall effect sensor	Anisotropic magnetoresistance (AMR)	Giant Magnetoresistance (GMR)	Tunnel Magnetoresistance (TMR)
Typical Applications	Current and position sensing	Oxygen sensing, linear position systems	Orientation, navigation, position sensing	Contactless current measurements
Design Theory	Lorentz force	Anisotropic magnetoresistance	Giant Magnetoresistance	Tunnel Magnetoresistance
Cost				Highest cost
Pros	Weak output signal, finite offset	Fabrication of sensor is easier, widely used.	High sensitivity and resolution, Higher bandwidth, lower operational noise	Highest sensitivity, Consume less power than GMR
Cons	Expensive for higher sensitivity devices	Low sensitivity		Easily affected by noise

Table 9

Magnetic Sensor: Based on the research, the technology that best suits our magnetic sensor would be Anisotropic magnetoresistance due to our market research on currently available sensors. Many of the sensors on the market seem to use anisotropic magnetoresistance.

AC Power Supply Technology Comparison

AC Power Supply Technology study	Linear	Switching
Typical Applications	AC/DC Converter	AC/DC Converter
Design Theory	Excess power loss to heat	off/on switching
Cost	Relatively inexpensive	Relatively inexpensive
Pros	Simple, less noisy	Efficient
Cons	Inefficient, heat sinking	Can be noisy, circuitry more complex

Table 10

AC Power Source: Based on the research, the technology that best suits our AC Power Source would be some form of linear AC/DC converter, possibly a wall plug. This method occurs in most consumer products and was chosen to simplify the design. If we use a wall plug the excess heat would be contained to the converter located outside of our unit.

Budget

The parts cost listed below is a rough estimate of price based on averaging of component costs found online. Exact part numbers are excluded given the current supply chain situation may cause acquisition of specific components to be unfeasible. The project has no sponsor, all costs will be split evenly amongst group members.

Part	**Cost**
High-resolution stepper motor	$50
Motor Driver circuit	$15
SPST Relay	$40
Degaussing circuit	$40
Digital display	$15
Keypad	$20
Microcontroller	$15
Magnetic Field Evaluation Circuit	$15
3-D printed casing	$30

Initial Project Milestone for Both Semesters

Senior Design I

Week	**Dates**	**Milestone Description**
1	05/17/22 to 05/20/22	Submitting project idea and forming project group
2	05/21/22 to 05/27/22	Start working on Divide and Conquer document
3	05/28/22 to 06/03/22	Complete and submit initial D&C
4	06/04/22 to 06/10/22	Meeting with Dr. Wei and begin working on updated D&C
5	06/11/22 to 06/17/22	Submit updated D&C document
6	06/18/22 to 06/24/22	Start working on 60 pages draft Senior Design I Document
7	06/25/22 to 07/01/22	Continue working on 60 pages draft
8	07/02/22 to 07/08/22	Submit 60 pages Senior Design I Document
9	07/09/22 to 07/17/22	Receive feedback on our 60 pages Senior Design I Document and start working on 100 pages report
10	07/16/22 to 07/22/22	Submit updated 100 pages report
11	07/23/22 to 08/02/22	Continue working and perform any modification then submit final document report

Senior Design II

Week	**Dates**	**Milestone Description**
1 to 2	8/22/22 to 09/02/22	Project design review
3 to 5	09/03/22 to 09/23/22	Prototyping
6 to 9	09/24/22 to 10/21/22	Construction and Assembly
10 to 12	10/22/22 to 11/11/22	Demonstration and Presentation of Project
13 to 14	11/12/22 to 11/25/22	Project final written documentation
15 to 16	11/26/22 to 12/09/22	Project website development