Haptic Feedback Block

ECE441 Wearable Sensor for the Blind Project

Jacy Barr

ECE Senior Design

Oregon State University,

Corvallis, OR USA

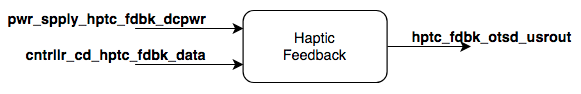
barrja@oregonstate.edu

# Introduction

The purpose of this document is to describe the Haptic Feedback block of the ECE441 Wearable Sensor for the Blind project so fellow 4th year ECE students will be able to reproduce and verify this components functionality without further research. The haptic Feedback block is implemented using a Coin Vibration Motor. This document provides an overview of the overall block function including interface properties and a schematic, verification for the design in the form of a step-by-step testing process, and support for the validity of the design in the form of outside research and numerical justification addressing individual properties.

# Block Overview

The Coin Vibration Motor for this block interprets a digital signal from the microcontroller to vary the frequency and time that the motor is powered. The block must be capable of producing distinct frequencies of vibrations to relay the information processed by the sytem back to the user. Fig. 1 shows the black box diagram. The block is powered from the **pwr\_spply\_hptc\_fdbk\_dcpwr** interface from a 3.3V source with a nominal current draw of 80mA. Signals indicating when to power the motor are sent via a digital pin over the **cntrllr\_cd\_hptc\_fdbk\_data** interface. Finally, the output is represented by the **hptc\_fdbk\_otsd\_usrout** interface. Due to the nature of the interface, its properties rely on the users intrepretation of the vibration, so to ensure the user experiences match the signals passed, the properties are identical to the data intererface. The full listing of interface properties are listed below in Table 1.



1. Black Box Diagram of Haptic Feedback Block

1. Haptic Feedback Interfaces and Properties

| Interface | Properties |
| --- | --- |
| **hptc\_fdbk\_otsd\_usrout** | * + - 1. Min Frequency: 1Hz       2. Max Frequency: 5Hz       3. Frequency Interval Step: 1Hz       4. Number of Frequency Intervals: 5 (0-1, 1-2, …, 4-5m)       5. Type: Haptic Feedback       6. Usability: 9/10 users can detect the vibrations frequency changing with 100% accuracy |
| **pwr\_spply\_hptc\_fdbk\_dcpwr** | 1. Vmin: 2.7V  2. IPeak: 80mA  3. VMax: 3.3V  4. INominal: 60mA +/- 15% at 100% Duty Cycle |
| **cntrllr\_cd\_hptc\_fdbk\_data** | 1. Min Frequency: 1Hz 2. Max Frequency: 5Hz 3. Frequency Interval Step: 1Hz 4. Number of Frequency Intervals: 5 (0-1, 1-2, …, 4-5m) |

# Verification

Based on the interfaces for this block, a verification (testing) process is provided below to verify interface property functionality. This information will allow for the final implementation of this block to be tested, verifying that each interface property has been satisfied and that the block is ready for integration into the complete system.

## Power Testing

This test will verify that the haptic feedback motor will not exceed the current draw threshold and function properly with the provided voltage.

1. Connect feedback motor and additional testing components to breadboard according to wiring diagram in Fig. 2
2. Connect the Haptic Feedback Block to power via the **pwr\_spply\_hptc\_fdbk\_dcpwr** interface at 3.3V using a DC power supply. Insert a current meter (DMM) inline OR use a power supply that displays the used current.
3. Connect a microcontroller to the **cntrllr\_cd\_hptc\_fdbk\_data** interface.
4. Mount breadboard(via tape or weight) to surface to prevent vibrating too violently.
5. Load test program to the microcontroller that produces a series of five distinct frequencies followed by a max duty cycle.

PASS: This test passes if peak current does not exceed 80mA, max voltage does not exceed 3.3V, min voltage does not drop below 2.7V, and nominal voltage during max duty cycle stays within 10% of 3V on **pwr\_spply\_hptc\_fdbk\_dcpwr** interface.

[**Link to Video**](https://youtu.be/z8ibpUJ79lo)

## Signal Output(User) Testing

For this test, we will verify that the output, **hptc\_fdbk\_otsd\_usrout** is able to produce the frequencies provided by the **cntrllr\_cd\_hptc\_fdbk\_data** interface with enough clarity for the user to distinguish when the frequency changes.

1. Connect feedback motor and additional testing components to breadboard according to the wiring diagram in Fig. 2
2. Connect oscilloscope probes to the negative and positive terminals of the haptic feedback motor and configure the oscilloscope to measure frequency.
3. Load a test program to the microcontroller that produces the following frequencies: 1Hz, 2Hz, 3Hz, 4Hz, and 5Hz.
4. Measure the frequency of vibration signals the motor is receiving on the oscilloscope for each frequency interval.
5. Have testing subjects place their finger on the vibration motor while the frequency stepping code runs.

PASS: This test passes if 9/10 users are able to distinguish when there is a change in frequency of vibrations with 100% confidence and the oscilloscope frequency measurements are within 10% of the data signals provided by **cntrllr\_cd\_hptc\_fdbk\_data**.

[**Link to Video**](https://www.youtube.com/watch?v=z4GEiELODtY)

## Signal Input Testing

This test will verify that the digital signal interface **cntrllr\_cd\_hptc\_fdbk\_data** is able to provide the haptic feedback motor with a range of distinct frequencies in 1Hz steps.

1. Connect feedback motor and additional testing components to breadboard according to the wiring diagram in Fig. 2
2. Connect oscilloscope probes to ground and the digital signal **cntrllr\_cd\_hptc\_fdbk\_data** pin connected to the rail of the breadboard and configure the oscilloscope to measure frequency.
3. Load a test program to the microcontroller that produces the following frequencies: 1Hz, 2Hz, 3Hz, 4Hz, and 5Hz.
4. Measure the frequency of vibration signals the motor is receiving on the oscilloscope for each frequency interval.

PASS: This test passes if the oscilloscope frequency measurements provided by the **cntrllr\_cd\_hptc\_fdbk\_data** interface matches the following frequencies of 1Hz, 2Hz, 3Hz, 4Hz, and 5Hz produced by the microcontroller.

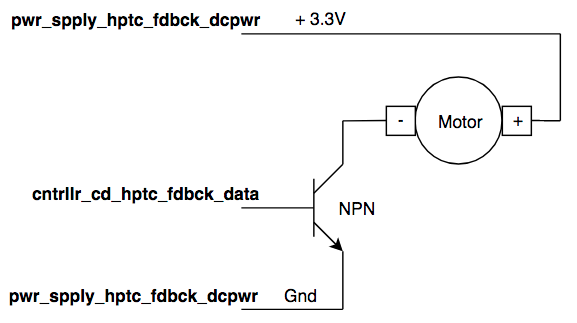
[**Link to Video**](https://youtu.be/1DMSywgpWQM)

If the block passes all of the listed tests, all interface properties have been verified and the block is ready for inclusion into the system.

# Design

The Wiring Diagram (Fig. 2) presents the block design, including the interfaces of the block. These interfaces are further elaborated through the validation information provided in Table 2, which demonstrates the feedback motors ability to satisfy each defined interface property.

## Wiring Diagram



1. Wiring Diagram for the Display Block

## Design Validation

For this block, a coin vibration motor was chosen to relay processed sensory information back to the user. The 3V C0720B015F model of vibration motor accompanied with a 2N4401 NPN transistor to act as a switch for the data signal pins fits the needs of the system into interface properly with the block.

Table 2 includes the interface property validation for this block. All interface properties have been addressed and the design meets or exceeds the properties.

1. Interface Property Validation for the DIsplay Block

| Property | Validation |
| --- | --- |
| **hptc\_fdbck\_otsd\_usrout** |  |
| Min Frequency: 1Hz | To provide clear instances of vibrations, the duration of motor being powered high is chosen to be 0.1s. Any frequency lower than 1Hz diminishes clarity of which distance interval is being observed. |
| Max Frequency: 5Hz | The ceiling of a 5Hz frequency is implemented because the distribution of pulses provides a clear distinction that an obstacle is in the immediate vicinity while the delays between pulses is long enough to maintains unique vibrations. |
| Frequency Interval Step: 1Hz | Given the set minimum and maximum pulse frequency, a 1Hz step provides an even scaling of feedback incidences. |
| Number of Frequency Intervals: 5(0-1m, 1-2m, …, 4-5m) | Utilizing the five distinct intervals of distance feedback is a system wide decision that provides a method of discerning obstacle distances while avoiding overwhelming the user with too many possible variations. |
| Type: Haptic feedback | Project is developed for individuals with impaired vision, so a haptic motor provides the clearest method of relaying sensory information without over stimulating the users auditory sense. |
| Usability: 9/10 users can detect the vibration frequency changing with 100% accuracy | The user’s ability to distinguish the distance from nearby obstacles is a defining feature of our design, so ensuring the intervals of feedback remain clear is crucial. |
| **ps\_to\_display\_dcpwr** |  |
| Vmin: 2.7V | Datasheet specifications for 3V Coin motor C0720B015F minimum operation voltages stated as 2.7V [1] |
| IPeak: 80mA (per motor) | Datasheet specifications for 3V Coin motor C0720B015F maximum current rating stated as 80mA [1] |
| VMax: 3.3V | Datasheet specifications for 3V Coin motor C0720B015F minimum operation voltages stated as 2.7V [1] |
| INominal: 60mA +/- 15% at 100% duty cycle | Initial powering of the motor creates a spike in current draw which quickly settles to around 60mA at 100% duty cycle. |
| **cntrllr\_cd\_hptc\_fdbck\_data** |  |
| Min Frequency: 1Hz | To provide clear instances of vibrations, the duration of motor being powered high is chosen to be 0.1s. Any frequency lower than 1Hz diminishes clarity of which distance interval is being observed. |
| Max Frequency: 5Hz | The ceiling of a 5Hz frequency is implemented because the distribution of pulses provides a clear distinction that an obstacle is in the immediate vicinity while the delays between pulses is long enough to maintains unique vibrations. |
| Frequency Interval Step: 1Hz | Given the set minimum and maximum pulse frequency, a 1Hz step provides an even scaling of feedback incidences. |
| Number of Frequency Intervals: 5 (0-1m, 1-2m, …, 4-5m) | Utilizing the five distinct intervals of distance feedback is a system wide decision that provides a method of discerning obstacle distances while avoiding overwhelming the user with too many possible variations. |

##### Bill of Materials

# References

[1] http://www.vibration-motor.com/products/download/C0720B001F.pdf