High Resolution Digital Compass

USING MULTIPLE ANISOTROPIC MAGNETIC SENSORS

The purpose of the team's project is to increase the accuracy of a single AMR IC compass by incorporating multiple ICs. The goal is to increase the accuracy of a magnetic sensor by the number of ICs used. This is done by obtaining data from within the most accurate regions of operation for each sensor and applying a weighted averaging algorithm.

The future implications of this research is the potential use of nanowires to replace existing Wheatstone bridges inside current sensors. The nanowires' decreased size and decreased accuracy would require many bridges to work together to achieve a desirable performance. This feasibility study shows whether or not the number of bridges can be increased to improve performance.

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Honeywell

The HMC6532

DIGITAL COMPASS SOLUTION FROM HONEYWELL

From the HMC6532 datasheet:

"The Honeywell HMC6352 is a fully integrated compass module that combines 2-axis magneto-resistive sensors with the required analog and digital support circuits, and algorithms for heading computation. By combining the sensor elements, processing electronics, and firmware in to a 6.5mm by 6.5mm by 1.5mm LCC package, Honeywell offers a complete, ready to use electronic compass. This provides design engineers with the simplest solution to integrate high volume, cost effective compasses into wireless phones, consumer electronics, vehicle compassing, and antenna positioning."

Key features of the HMC6532 include:

- Compass with heading output
- Raw bridge voltage output
- Full integration of 2-axis magnetic sensors and electronics
- Low voltage operation
- Small surface mount package
- I^2C 2-wire serial interface

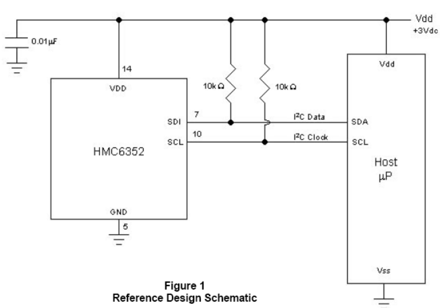
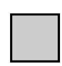


Figure 1
Reference Design Schematic

The actual size of the HMC6532 is shown below (6.50mm x 6.50mm)



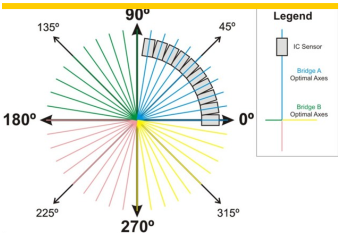
Above is a picture of the HMC6532 digital compass. An example schematic of the HMC6532 implementation is shown on the left. The sensor needs to be connected to power, ground, I^2C data, and I^2C clock. The pull up resistors are also necessary for the I^2C network to function correctly.

Honeywell

Sensor Positioning and Hardware

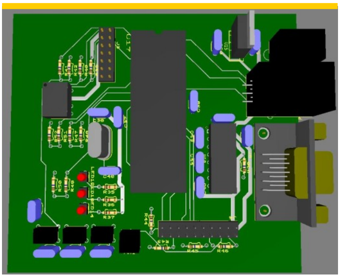
CREATING THE MOST ACCURATE IMPLEMENTATION

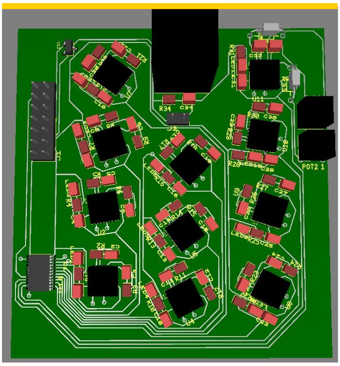
Each individual sensor is most accurate when the magnetic field is perpendicular to one of the two bridges. This is because the magnetic response of the bridge is in the linear region of operation. Therefore, each sensor is most accurate at 0, 90, 180, and 270 degrees to the orientation of the IC. By changing the orientation of each chip in respect to the entire system, the overall accuracy can be maximized. Many different orientations were simulated, and the one found to be most effective is shown below.



Here the orientation of 10 sensors spread evenly across 0-90 degrees is shown. This leads to optimal axes which are distributed across the entire 360 degree spectrum, at 9 degree intervals.

On the right is a 3-dimensional representation of the main circuit board. The PIC18F4520 microcontroller running at 20MHz is used for the calculations and data acquisition. It can also transmit any data on the RS232 port. Also included is a programming port for reprogramming the microcontroller. An additional EEPROM module is also included in the event more memory is needed.





To the left is a 3-dimensional representation of the daughter board. The daughter board hosts a total of 11 sensors, 10 oriented in the fashion discussed above, and one additional sensor at 0 degrees as a control. Each sensor also includes a power LED and RC networks for scaling if necessary. The single control sensor has adjustable range via the potentiometers.

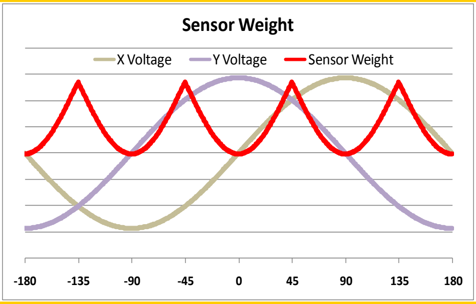
Software and Results

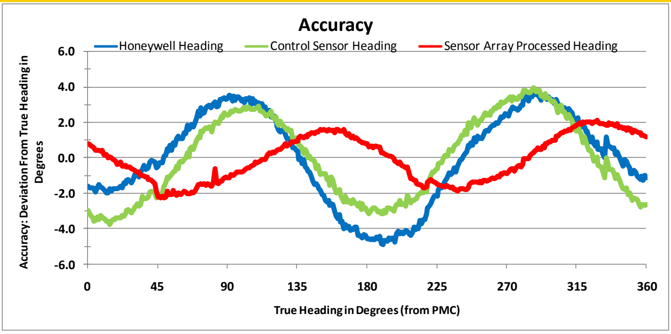
The basis for the heading calculation is the weighted average algorithm shown below. The sensor heading is calculated by using the arctangent function of a sensor's bridge readings. The sensor weight is calculated with the equation shown. The processed heading is then calculated by summing each sensor heading and weight product and dividing by the sum of the weights as shown below.

$$Sensor\ Weight = 1 - Influence\ Factor \left| \frac{x^2 - y^2}{(Maximum\ Amplitude)^2} \right|$$

$$Processed\ Heading = \frac{\text{Heading}_1 * \text{Weight}_1 + \text{Heading}_2 * \text{Weight}_2 + \cdots \text{Heading}_{10} * \text{Weight}_{10}}{\sum_1^{10} Weight_n}$$

This is an image representing the weighting algorithm used for each sensor. The purple and tan lines represent each individual bridge output. The red line is the weight of the sensor at a given angle. It is worth noting that the weight is high when the x and y bridge magnitudes are closest, which is the basis for the sensor weight equation.





It was determined that multiple sensors working together can indeed increase the precision, accuracy, and repeatability of the system. The graph above shows the accuracy across 360 degrees. The table below shows the overall improvements in each of these areas. This shows that this type of implementation is very feasible and could potentially lead to more accurate digital compasses in the near future.

Results	Single Sensor	Sensor Array	Improvement
Accuracy	2.169	1.135	47.65%
Precision	.162	.078	51.69%
Repeatability	.174	.096	44.70%