AC 2007-630: INTERFACING AN ANALOG COMPASS TO AN EMBEDDED CONTROLLER

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Interfacing an Analog Compass to an Embedded Controller

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Abstract

This paper describes the development of a compass sensing unit for use on a remotely operated vessel. The sensor determines the direction of the vessel's path to aide the user in operating the boat wirelessly through a laptop. The system provides information to facilitate tracking and controlling the boat when it is not easily seen by the operator. The selected compass, Dinsmore R1655 analog compass sensor, was used in conjunction of an 8051 microcontroller to provide the necessary data. The system was able to read an analog value from the sensor and convert it to digital direction. The paper will describe the system design and present test results.

Introduction

During the design and construction phase of a remotely operated vessel (ROV), it was determined that a compass onboard would benefit the project by providing useful directional information. As a result, an analog sensor, a Dinsmore R1655 analog compass, was selected to complete this task. The unit produces two sinusoidal curves when given proper power and rotated. The position of each individual curve allows one to determine actual position of the sensor. The microMODUL 8051 microcontroller was chosen to read the output curves. This unit was used due to its availability and its onboard A/D conversion capabilities. The rest of this paper describes the system design and presents experimental results that illustrate the functionality of the device.

The Microcontroller Development Board

The kit consists of a microcontroller and development board from PHYTEC (microMODUL-8051, Part #: KMM-207-C04) that has the following features and parts: 12 MHz, AC adapter, user's manual, and circuit diagram. PHYTEC custom builds Single Board Computers (SBCs) in various sizes and configurations and provides development kits for them[1-2]. The SBC is plugged into a socket on the development board for programming and testing. Once the development stage is finished, the SBC can be removed from the development board and plugged into a socket or soldered to the user's hardware application. The serial cable allows connecting the board to a PC for programming, debugging, and testing.

The microMODUL-8051 offers more functionality than a standalone 8051 microcontroller (see Fig. 1). The version available in the DSL includes the Infineon SAB C504-L microcontroller which is an extended version of the Siemens C501 8051-based microcontroller chip.

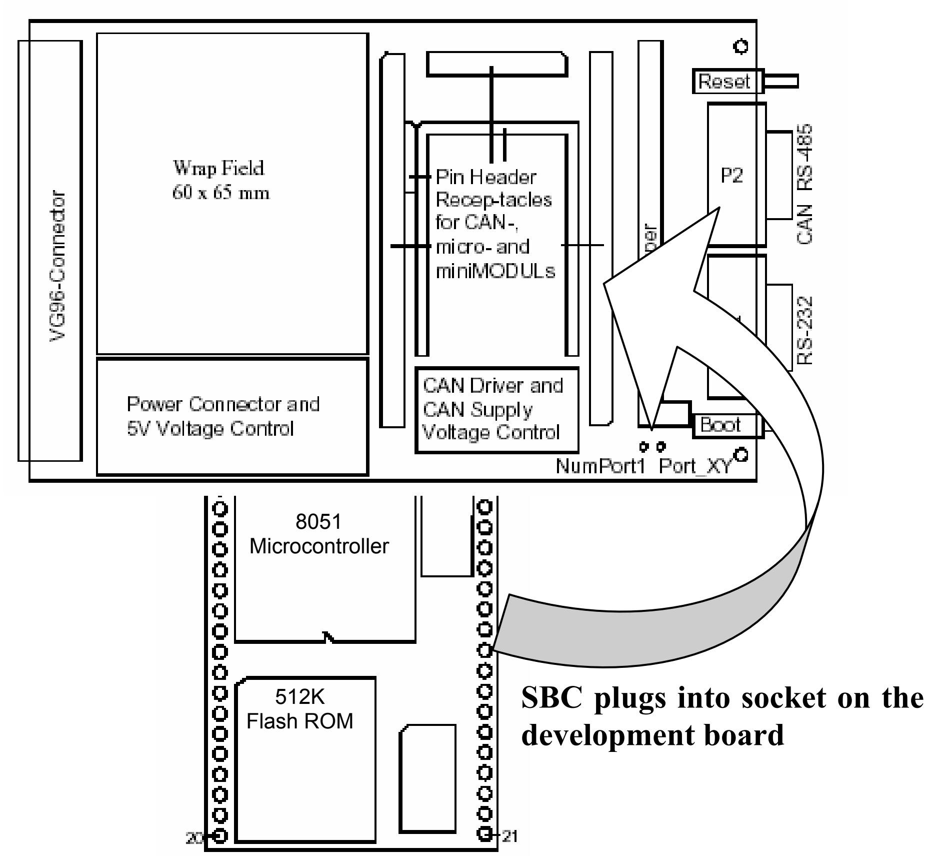

Figure 1. The microMODUL-8051 SBC

Here is a summary of the main features of the C504-L:

- Fully compatible with the standard 8051 architecture
- Four 8-bit ports (2 useable)
- Three 16-bit timer/counters
- Capture/Compare Unit (CCU) for PWM signal generation and capturing
- 10-bit A/D converter with 8 multiplexed inputs
- 12 interrupt sources with two priority levels
- Programmable watchdog timer
- Power saving modes

In addition to the extended features of the 8051 chip, the microMODUL SBC board adds additional functionality to the microcontroller chip. Our particular board includes:

- 128K external SRAM memory
- 512K external Flash ROM
- RS-232 serial interface (can be configured as RS-485)
- All ports and applicable logic signals extend to pin headers at the edges of the board.

The Flash ROM device is for storage of the user program code and is easily programmed when the development board is connected to a PC. The development board includes a 60 x 65 mm wire wrap field that can aid in system prototyping. On the end of the board is a standard sized VG-96 connector that can also be used when building custom applications. All of the microcontroller signals extend to standard width pin rows that line three sides of the SBC board. This way the board can be removed from the development board and plugged or soldered into a hardware application as if it were a “big chip”. Alternate pin functions for ports 1 and 3 are normally shown next to their corresponding port pin numbers. Detail about the 8051 may be found in reference 3.

System Design

The sensor and microcontroller board are shown in Fig. 2 and details are provided in several references[4-6]. A program was developed to acquire data through the 8051 board using its ADC capabilities. Input is first read in from the A/D converter. The input is checked to see which, of four possible quadrants the data falls in, as shown in Fig. 3.

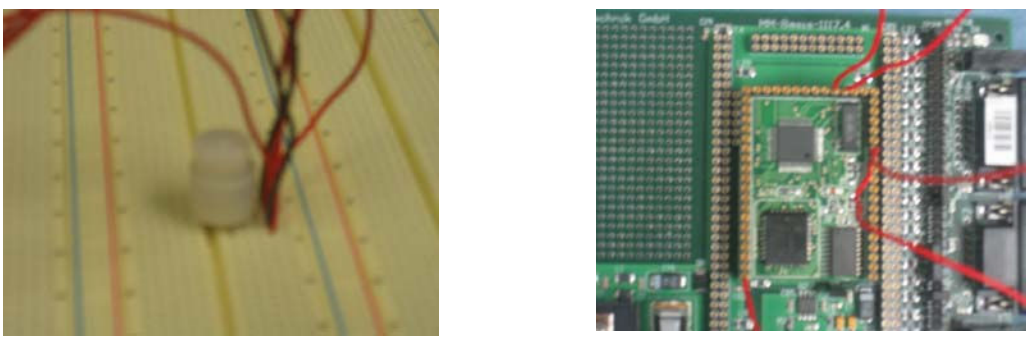

Figure 2. (a) Dinsmore R1655 and (b) 8051 microMODUL

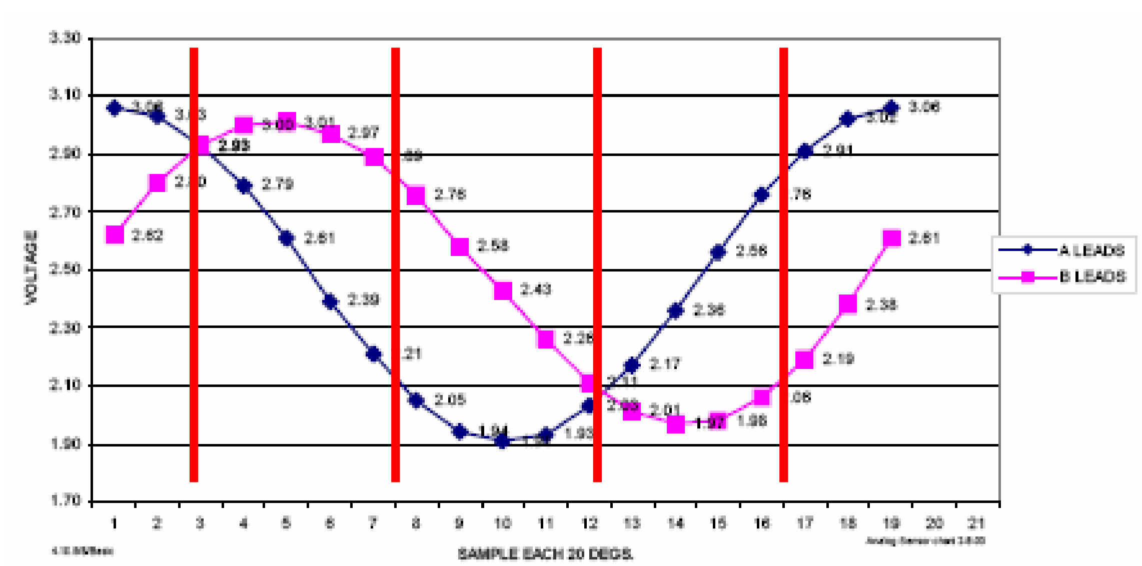

Figure 3. Quadrants Applied to Actual Data

Once this is determined a series of math functions are carried out on the appropriate curve to determine the actual reading in degrees. The functions are as follows:

Section A (0-90 degrees):
RawCompass = (UpLimit – A_Curve) * Scale
Compass = ((Raw Compass/10) * 4) /10

Section B (270-360 degrees):
RawCompass = (B_Curve – LowLimit) * Scale
Compass = ((Raw Compass/10) * 4) /10

Section C (90-180 degrees):
RawCompass = (UpLimit – B_Curve) * Scale
Compass = ((Raw Compass/10) * 4) /10

Section D (180-270 degrees):
RawCompass = (A_Curve – LowLimit) * Scale
Compass = ((Raw Compass/10) * 4) /1

The value computed as above is saved in specified registers. The value is simply sent serially to the microcontroller. This data can be transmitted to the NI controller, onboard the ROV, as shown in Fig. 4.

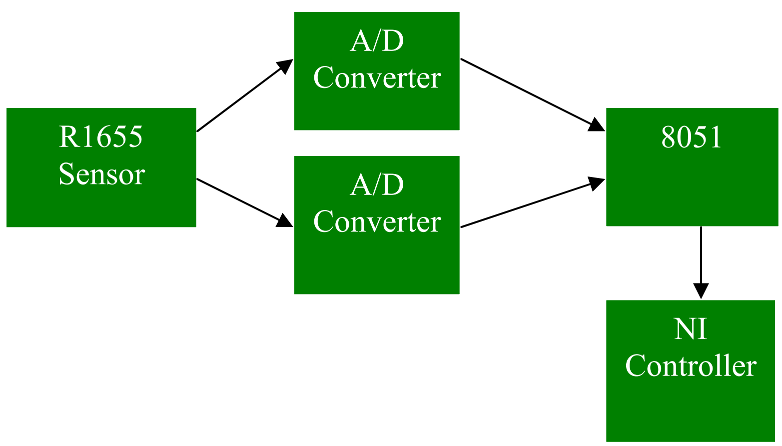

Figure 4. Overall system diagram

Tests Results

The system is tested by acquiring data from the compass. This was achieved by turning the system in steps of degrees and observing the effect. The values were taken by measuring the voltage at the pins on the microcontroller and by using the Monitor51 debugger program.

The values taken with the voltmeter were designated as measured, while the debugger values were referred to as calculated. This is due to the fact that the math functions are used to get the actual value with the raw hex values given by the controller. These calculated values, however, should be viewed as the actual values since they are given by the controller itself. Table 1 is a copy of the spreadsheet created for this project.

Table 1. Collected Data and Calculations

Position	Curve B	Curve A	Measured Value B	Measured Value A	Calculated Value B	Calculated Value A
0	27B	1BF	3.09	2.2	3.1	2.18
45	27B	237	3.09	2.77	3.1	2.77
90	245	27D	2.82	3.11	2.84	3.11
135	1EF	289	2.41	3.17	2.42	3.17
180	1AA	245	2.05	2.85	2.08	2.84
225	194	1 E4	1.96	2.37	1.97	2.36
270	1D 0	19A	2.25	2.02	2.26	2
315	237	190	2.75	1.96	2.77	1.95
360	27B	1C5	3.08	2.23	3.1	2.21

The first column called "Position" is the degree measurement that the compass was turned in the course of testing. The columns designated as "Curve B" and "Curve A" are the actual hex values that were returned by the microcontroller. As discussed above, the measured values were taken with a voltmeter and the calculated values were found using the hex values and the math function discussed earlier.

After the data was collected, it was compared with the data sheets of the compass. Two graphs were created and compared to this given graph (one for the measured values and one for the calculated values). These are shown in Fig. 5.

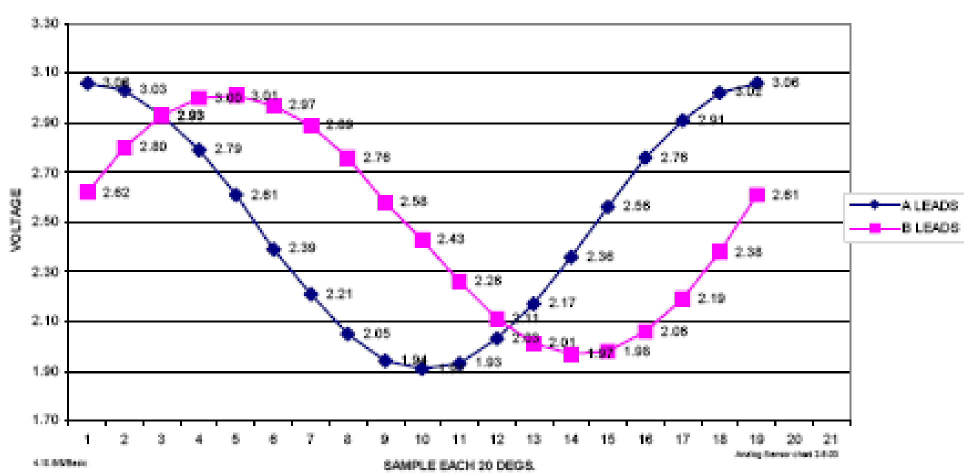

Figure 5. Graph Provided W/ Dinsmore Compass

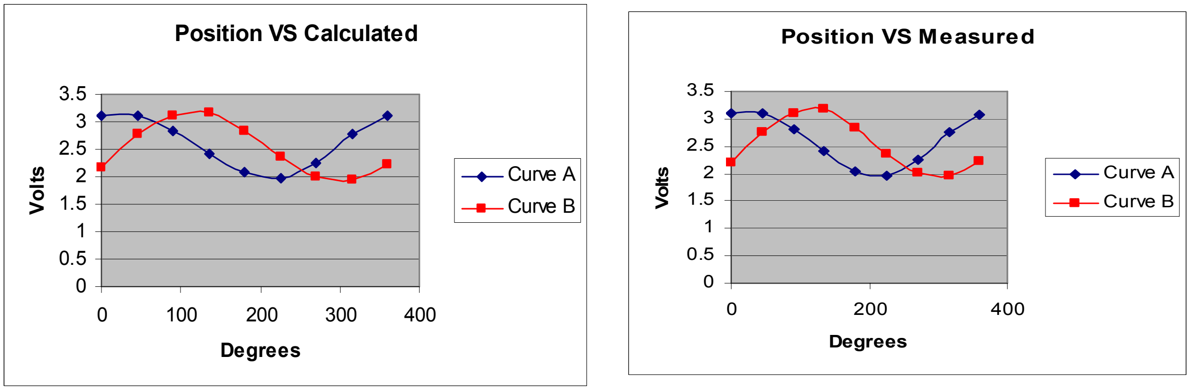

Figure 6. (a) Degrees VS Calculated and (b) Degrees VS Measured

These graphs were determined to be very close to the given chart. To ensure that the data from the testing phase was correct, a graph was created which combines both the measured and the calculated graphs. This graph is shown in Fig. 7.

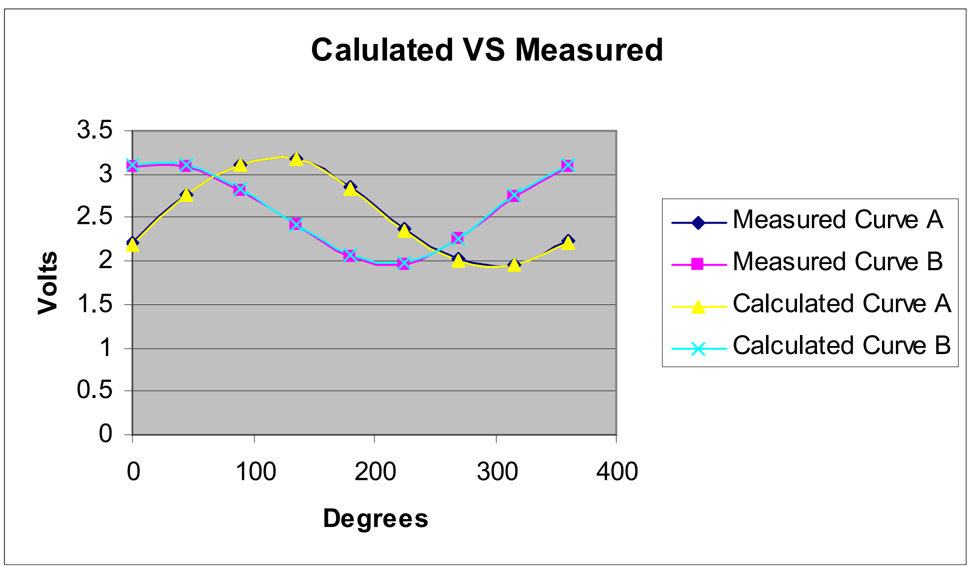

Figure 7: Calculated VS Measured Curves

From this graph, it can be seen that the data calculated and measured do match. After comparing this data to that of the given graph, the project was deemed to be a success.

Conclusion

This paper presented the development of a compass sensing unit that is used to determine the direction of a moving vessel. The system is able to read an analog value from the sensor and provide a digital output representing the direction. Working with the above components was a challenge and proved students with a very productive learning experience.

Acknowledgement
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