Data Converter Unit / WMEC UPGRADE
Project Background

The data converter unit aboard the 270' Famous class cutters is used to consolidate the information provided from the anemometer, Doppler speed log, optical surveillance system (OSS), gyrocompasses, and fathometer. The Data Converter Unit (DCU) takes the different analog signals from these instruments, converts them into a digital signal in the form of data sentence that the Shipboard Command and Control System (SCCS) can read.

The problem with the current DCU is primarily its age. The circuitry is outdated and can no longer easily be repaired. This process is neither time nor cost effective. Also the data word provided by the current DCU is in Naval Tactical Data Standard (NTDS) which is no longer the preferred format. The preferred format for the SCCS is the National Maritime Electronics Association (NMEA) standard, the accepted protocol for the marine community.

This project will be to update and replace the independent system that interacts with the OSS. The first objective is to research and identify the characteristics of the synchro signals and the output NMEA word.

Using off the shelf items to convert the synchro signals, currently represented in the lab by a synchro simulator, a 16bit digital word with resolution down to hundredths of degrees will be produced. This digital word is sampled by a Basic Stamp©, a Programmable Read only memory (PROM). The program in the Basic Stamp© will interpret the binary inputs into a serial output. The information will be in the form of a NMEA word.

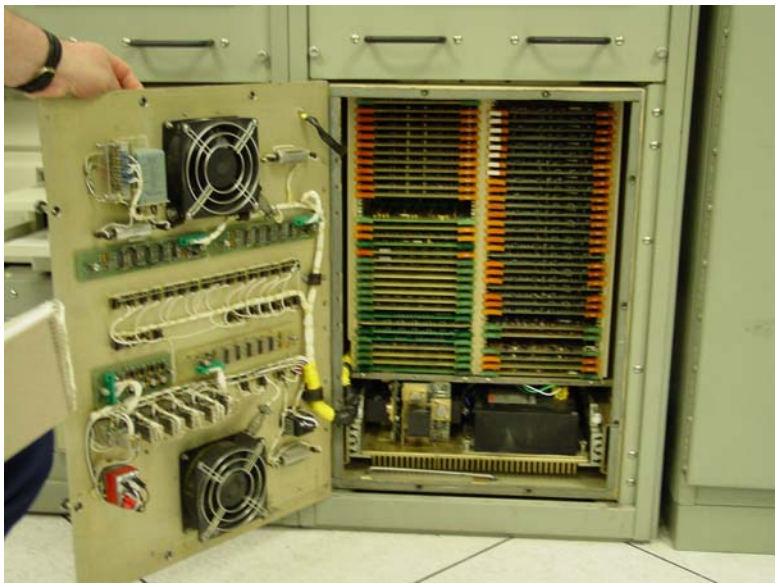
In the future the system will control the OSS using a NMEA to synchro system. The final phase will be the implementation aboard a 270' cutter to test the results.

Cadet 1/c Benjamin Norris
Project Advisor: LCDR Routhier

Introduction

The Data Converter Unit (DCU) aboard the 270' Famous class cutters is used to consolidate the information provided from the anemometer, Doppler speed log, optical surveillance system (OSS), gyrocompasses, and fathometer. DCU takes the different analog signals from these instruments, converts them into a digital signal in the form of data sentence that the Shipboard Command and Control System (SCCS) can read.

The purpose of this project is to upgrade the data converter unit aboard the cutters. Using a National Maritime Electronics Association (NMEA) (ref 1) standard to increase the compatibility with the SCCS and working with Command and Control Center (C2CEN), I hope to develop and engineer some helpful solutions for our fleet's aging equipment.



The current DCU uses aged military standard to communicate with the SCCS. This standard limits the ability to send needed information. Also, as the Coast Guard moves towards using commercial off the shelf (COTS) products, systems need to be designed to be compatible with each other. NMEA is a universal maritime standard that is greatly accepted and used among maritime electronics. By redesigning the DCU we can cut space, repair and production costs, and increase usability and compatibility.

Background

The original DCU has become outdated and is no longer manufactured. The Coast Guard is looking to a new system that can easily be fixed, easily built, and universally compatible for future upgrades on the 270' medium endurance cutters (WMEC 270s).

The problem with the current DCU is primarily its age. The circuitry is outdated and can no longer be ordered from the original company. All maintenance must be done at C2CEN by hand. This process is neither time nor cost effective. Also the data word

provided by the current DCU is in Naval Tactical Data Standard (NTDS) which is no longer the preferred format. The preferred format for the SCCS is in NMEA , as specified by C2CEN, which is standard across the maritime community. [1]

Objective/Scope

The overall goal of this project is to learn the systems, simulate a ship scenario, and develop a working solution. First signal inputs for the DCU and the NMEA data sentences had to be researched. This will ultimately lead to designing analog to digital converters for the synchro-signals from the Optical Surveillance System (OSS). A prototype will then be built integrating the input from each signal, converting and compiling it into NMEA sentences and then sending the data to the SCCS. The next phase of the DCU upgrade will be developing the control aspect of the OSS. Finally the system will be implemented aboard a 270' cutter to test the results.

Technical Approach

The priority order for the systems to be upgraded is as follows:

1. OSS
2. Anemometer
3. Doppler speed log
4. Gyrocompass

The OSS is used aboard cutters for two primary purposes. The first is defense. It was originally designed to be able to train the MK-29 on targets. By using a video setup and locking on to a target the OSS could track a target or be controlled from Combat Information Control (CIC) to aim the forward gun. The second use for the OSS is navigation. The system can be used as a high-tech bearing taker. By aiming the camera at an object the bearing can be taken and used as a line of position.

Working specifically with the OSS it must be understood how the system converts a bearing to a synchro signal. The OSS uses a set of synchros to convert relative heading and azimuth to a synchro signal. This synchro signal is then transmitted to the synchro converter. A synhcro signal is composed of 3 sine waves with varying amplitudes (fig 1). The three differences between these amplitudes represent a relative bearing or azimuth.

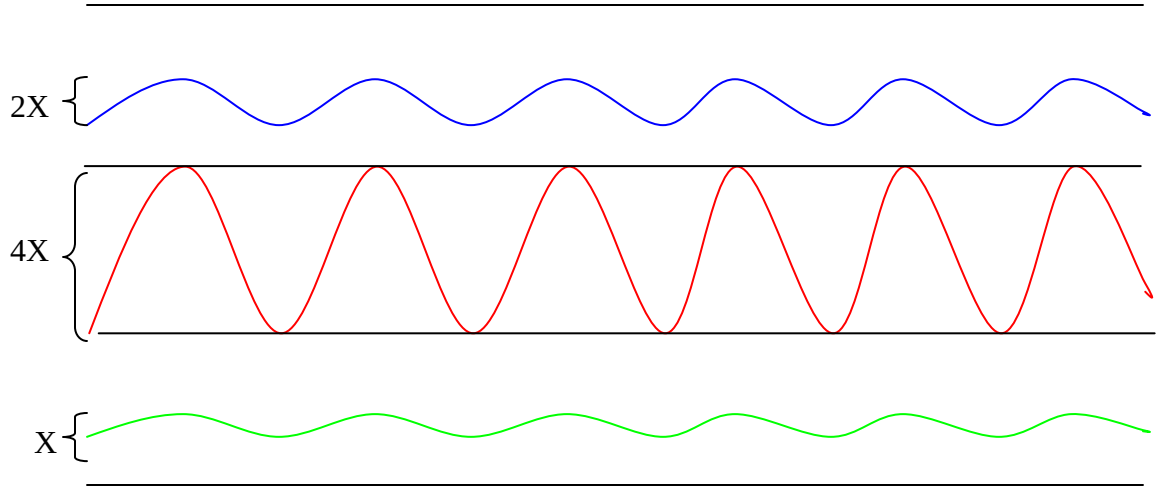


Fig 1.
Synchro Signal

We purchased a synchro to digital converter board form Control Sciences Inc. (CSI). This board splits the heading into a 10 bit word. The most significant bit represents 180°, the second most significant bit represents 90°, so on and so forth. These ten bits are then read by a Basic Stamp©, or EPROM chip, twice a second. The EPROM sums up the bits into a numerical value, or in this case azimuth and elevation.

The Basic Stamp© accepts up to 32 bits of input at one time. This allows us to convert both azimuth and amplitude at the same time. Both digital signals are input into the Basic Stamp© which then converts both sets of data into an decimal number. The code for the Basic Stamp© is contained in appendix A.

The next step in the process is generating the NMEA word with the appropriate data. The current specified NMEA string for this project is shown in figure 2.

$HDG,125.3,0.0;20.3,0.0;1,0,hh<CR><LF> ref [1].

Fig 2.
NMEA string

The second field represents the azimuth angle of the OSS. The third field is for future fine tuning. The fourth field represents the elevation angle of the OSS^{o}, and the following is for future fine tuning not used at this point in the project. The 1 in the seventh field, in the NMEA word, represents that the OSS is on target and the 0 in the eighth field represents that the Slave Enable is not engaged. HH is a checksum field required for all NMEA transmitted sentences.

Results

To face the problem of converting a synchro signal to a digital signal two systems were purchased. One from CSI for $500 and another from BBG for $2000. Both boards were purchased to determine the capability and suitability for the project. The BBG board offered a LCD display and preformatted serial outputs. Compared to the CSI board which only provided 16 bits of data outputs.(fig 3) For the needs of this project the CSI board was more than adequate providing better than needed resolution.

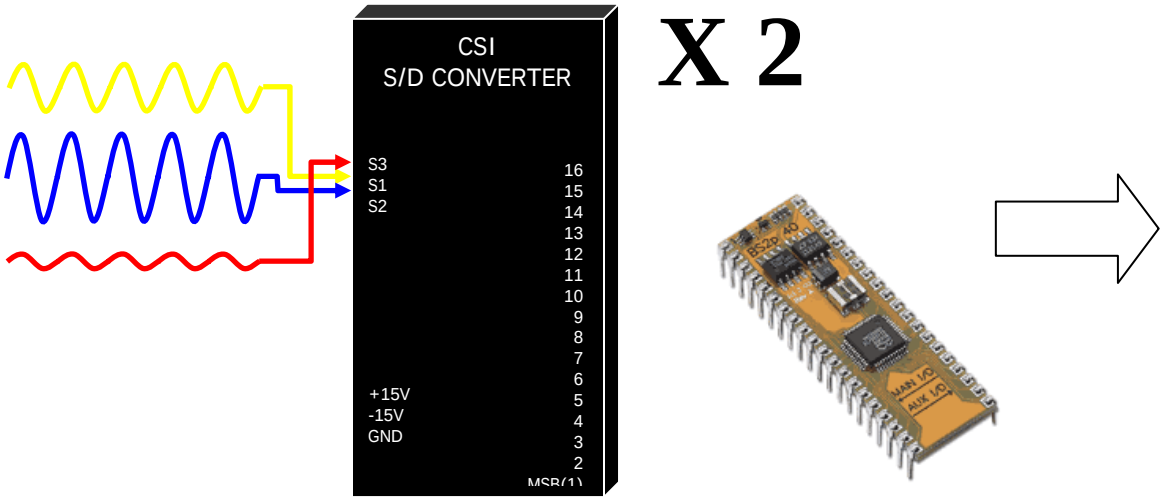


Fig 3
Design Layout

Basic Stamp ©
(EEPROM)

The second step was overcoming the conversion of the digital word from the CSI board into a NMEA sentence. Through some discussion it was determined that using a Basic Stamp© would be the best way to solve the problem. Initial investigation showed that Basic Stamps© only had 16 I/O pins.(Basic Stamp Manual) The set up for this project required at least 22 I/O pins. From this conclusion a 40 pin Basic Stamp© was discovered and purchased. (Basic Stamp Manual)

Designing a program for the Basic Stamp© proved to be one of the greatest challenges for the project. The design requirements called for an angle accuracy within $\pm$ 0.5^0, and requiring a value to tenths of degrees. The Basic programming language does not utilize real numbers, only integers. To overcome this obstacle each bit was multiplied by its respective value representation multiplied by 100. For example: Bit0 is multiplied by 18000. The bits were summed and divided by 100. This result was still only an integer. To obtain the tenths of degrees field the remainder of the bearing is displayed after a "." to give the overall appearance of a real number. For example the remainder of 31514/100 is 14 to give a result of 315.14. (fig 4)

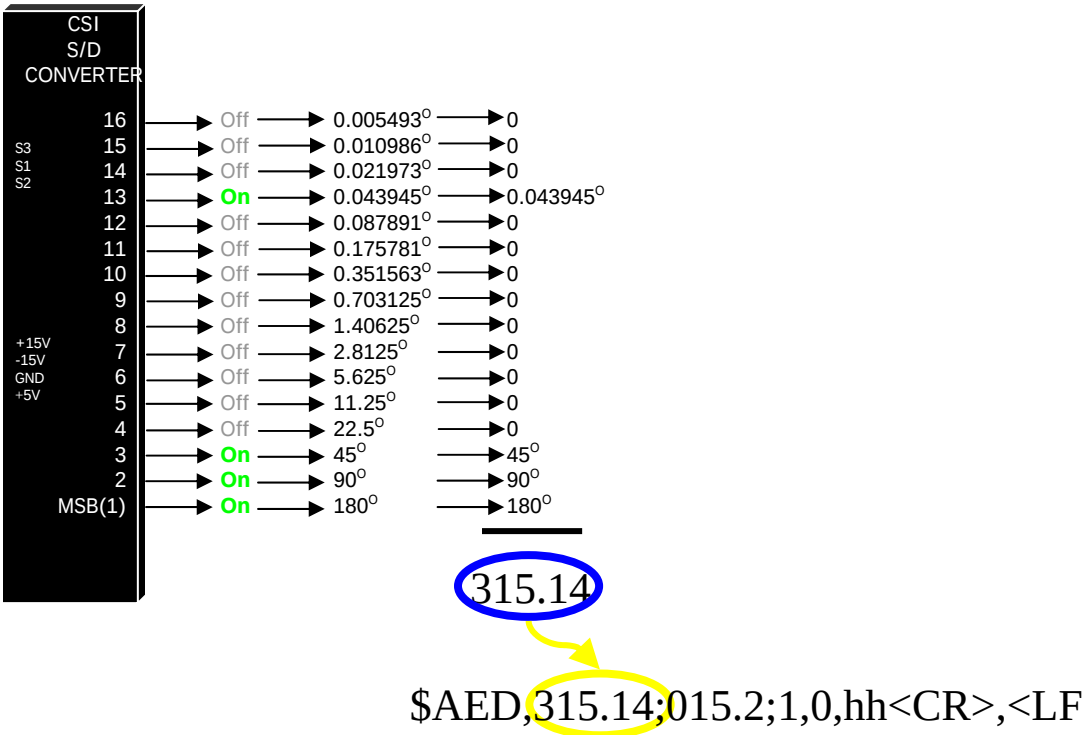


Fig. 4
Outline of program

Conclusions

Beginning this project has brought many administrative obstacles. Most of the time is concentrated around setting up and gathering information. In this I have learned how important it is utilize resources and seek information from more than just one place.

Technically speaking I have learned a great deal about shipboard systems. The aging state of the Coast Guard has become more real to me in the project than ever before. I have also learned how to adapt and seek out the most efficient way to bring a solution to all sides of the problem.

Another major issue that was faced in this project was the synchro simulator. The first simulator obtained did not generate a clean synchro signal. After some minor trouble shooting the equipment was sent back to the manufacturer for repair and a loaner was sent to use. Upon initial set up of the second simulator a similar problem was encountered as the first. The display didn't work correctly and the simulator did not accept any input. In an effort to rearrange my workspace dropped the simulator from a few inches accidentally. Out of concern to see if it would now even operate at all I powered the system back on and to my astonishment the simulator worked.

One lesson learned was concerning synchro signals. At the conclusion of the first semester I originally believed that a heading was determined by the difference in the

amplitude at varying phases between the 3 signals. Upon obtaining a synchro simulator and analyzing the signals with a DSA a different conclusion was made. The phases of the three different sine waves are always constant and never varying. The amplitude, however, changes as the angle is changed. And the differences in varying amplitudes is used to determine the current heading.

The input side of the project is completed. Looking into the future for next semester the control side of the project needs to be developed and created. Using the Basic Stamp© to pull the numerical values out of a control sentence a set of 16bit words could be generated. These words would then be sent to a digital to synchro controller. The controller would then drive the OSS completing the project.

Works Cited

[1] NMEA, NMEA 0183 Ver 3.00,
July 1, 2000 New Bern, NC

[2] LCDR Routhier, Thomas. "Gyro Notes"
Email to the author. 8 Nov 2001.

References Reviewed

Basic Stamp Manual, Ver 2.0b
Parallax, Inc; Rocklin, CA

DCU Operations and Maintenance Manual, Vol 1
CG7610-01-GF0-2505, Portsmouth, VA

DCU Operations and Maintenance Manual, Vol 2
CG7610-01-GF0-2505, Portsmouth, VA

DCU Parts and construction notes, C2CEN

NMEA, NMEA 0183-HS Ver 1.00,
July 1, 2000 New Bern, NC

The Nuts & Volts of Basic Stamps, Vol 1
Edwards, Glazner, Williams
Parallax, Inc; Rocklin, CA

The Nuts & Volts of Basic Stamps, Vol 2
Edwards, Glazner, Williams
Parallax, Inc; Rocklin, CA

Technical Manual for AN/SVD-1B "Optical Surveillance System"
CG7610-01-GF3-6901, 1 October 1997