Wireless Telemetry + CAR

Argus 682

"We watch so you don't have to…"

Preliminary Report
March 1, 2002

Introduction:

This report is designed to give the reader a concise, yet detailed view of the Argus 682 Project. The wireless sensing module that we are developing is being created for the Design II Class at The Ohio State University under the advisement of Professor Steven Bibyk and Graduate Assistant Duane Skelton.

The report will highlight the individual components and systems as much as possible that comprise the wireless sensing module. The report is designed to be a companion text to the presentation that was given by the Argus 682 group on February 15, 2002. Power Point slides from that presentation are available at the following link:

http://eewww.eng.ohio-state.edu/~bibyk/ee682/argus/midtermslides.ppt

Group Members:

- **Nate Distel**

Nate is a fifth year senior at The Ohio State University. He is a full time student majoring in Electrical and Computer Engineering. He works part time as an electronics salesman at Staples. Nate's hobbies include playing basketball and listening to music. He plans on graduating at the end of spring quarter 2002 and immediately entering the work force. Nate has been instrumental in working with the sensors and the GPS for the sensor module.

- **Richard Fouts**

Richard Fouts is also a fifth year senior at The Ohio State University. He is nearing the end of his undergraduate studies in Electrical and Computer Engineering, in which he specialized in Power and Circuit Design. Richard has recently been accepted into the Nuclear Engineering Master’s program here at Ohio State, and will begin his studies after graduation (21 days remaining as of publication), Rich plans to further his studies here at OSU. His hobbies include playing ice hockey and socializing (studying) with other EE students. Richard focused on the aspects of power systems and wireless communications of the Argus 682 project.

- **Solomon Gibbs**

Solomon is a fifth year senior in Electrical Engineering at The Ohio State University. He is specializing in communications and signal processing and plans to pursue a MSEE in communications after his graduation in March. Solomon has been primarily responsible for development of the Agora user interface. Solomon's hobbies include taking polygraph examinations for kicks and working in the CL 260 NT lab. The user interface, agora, was primarily developed by Solomon.

- **Aravind Mikkilineni**

  Aravind is a senior in The Ohio-State University College of Engineering. He is a full-time student working toward a B.S. in Electrical Engineering concentrating in the digital and circuit areas. He has interned at IBM working with user interface and data model customizations. After completing this degree, Aravind plans on immediately starting graduate study in the same field. Aravind's hobbies include reading sci-fi, listening to web radio and surfing E-bay for LCD screens without controllers. Aravind concentrated on overall product development and MCU code with emphasis on communications.

- **Patrick Stemen**

  Pat is a fourth year Electrical Engineering major, who plans on graduating Autumn quarter 2002. Upon receiving his BSEE he plans on perusing further education at The Ohio-State University. He is currently employed as a network consultant for two local businesses and is the president of the local chapter of Eta Kappa Nu. Patrick worked with the wireless aspects of the product and developed a control system for driving and commanding the car.

- **Max Vilimpoc**

  Mr. Villimpoc is also a fourth year senior at The Ohio State University. Currently, he is working with Dr. Bibyk to develop an interface for analog accelerometers. After graduation, Max plans on working or attending graduate school. Max's hobbies include attempting to build in-circuit PIC programmers and ordering evaluation parts from Analog Devices. Max’s research project for his 683 is integrating nicely into our system.

- **Michael Volkerding**

  Michael A. Volkerding is a fifth year senior at The Ohio-State University and is specializing in Electrical Engineering. His fields of interests are power, communications, and electromagnetics. He is also a Cadet in Air Force ROTC, and upon graduation will earn his commission as an Officer in the United Sates Air Force. Shortly after, he will attend pilot training and further his career as an Air Force Officer. His outside hobbies include flying, snow skiing, wrestling officiating, and performing community service while being a member of Arnold Air Society within Air Force ROTC. Mike is working with Mr. Fouts on the power aspects of the product and is the lead on documentation and operations.

Project Overview – (Entire Group)

The Argus Project is an attempt to develop a wireless control and sensing module capable of recording and relaying information from various sensors to a host system where it will be processed and analyzed. The remote component of the system is suitable for mounting in an automotive or other mobile environment. The design principle behind this project is to provide a platform that is as general as possible, yet suitable for adaptation to any application.

The name of our product, Argus, comes from Greek Mythology. Argus was a shepherd for the gods, responsible for guarding Io and was famed for his hundred eyes. These eyes are where our slogan comes from. Our product is designed so its eyes can watch your automobile or other platform so yours don't have to.

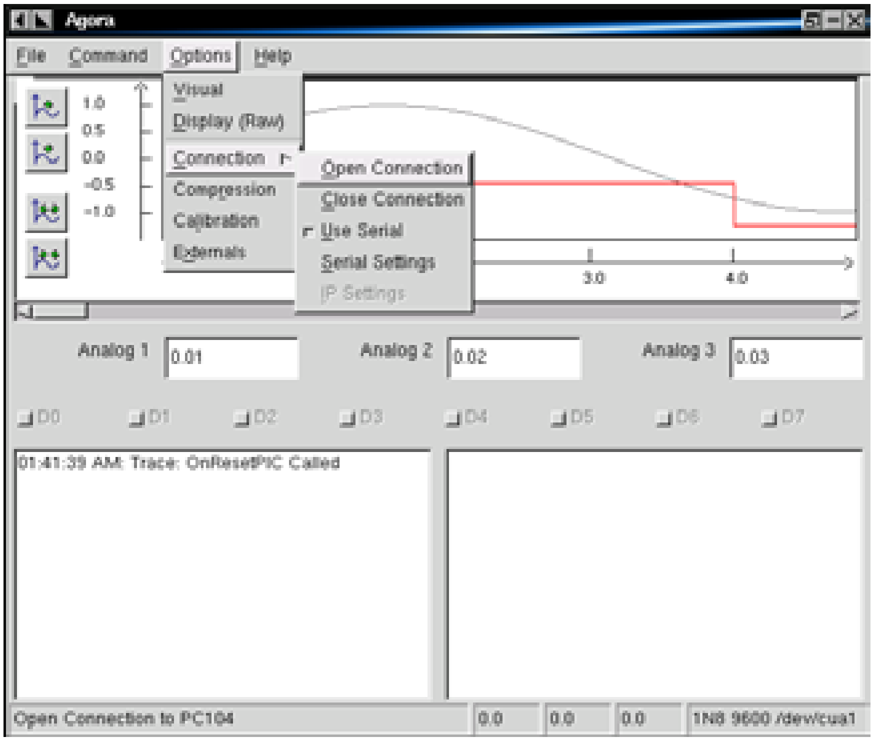
Technical Overview – (Entire Group)

The Argus product can be divided into two major components: the remote sensor package, and the local host computer. Two-way communication between the sensor package and the host computer is accomplished using either wireless RS-232 transceivers or 802.11 wireless ethernet. A block diagram of the system is shown below.

<INSERT PICTURE>

The purpose of the local host computer is to receive the transmitted data and render in a meaningful fashion for the user. The computer hosts our user interface which provides both real time display of sensor data as well as a central point of contact to control certain functions of the vehicle which are relevant to the operation of the sensor module.

The figure below shows the user interface in the process of gathering data and plotting it on a graph. *(Figure 1)*



Analog 1 0.01 Analog 2 0.02 Analog 3 0.03

01:41:39 AM: Trace: OnResetPIC Called

Open Connection to PC104 0.0 0.0 0.0 1N8 9600 /dev/cua1

(Figure 1: "Agora" User Interface on Win32 Platform)

Development Environment – (Solomon Gibbs)

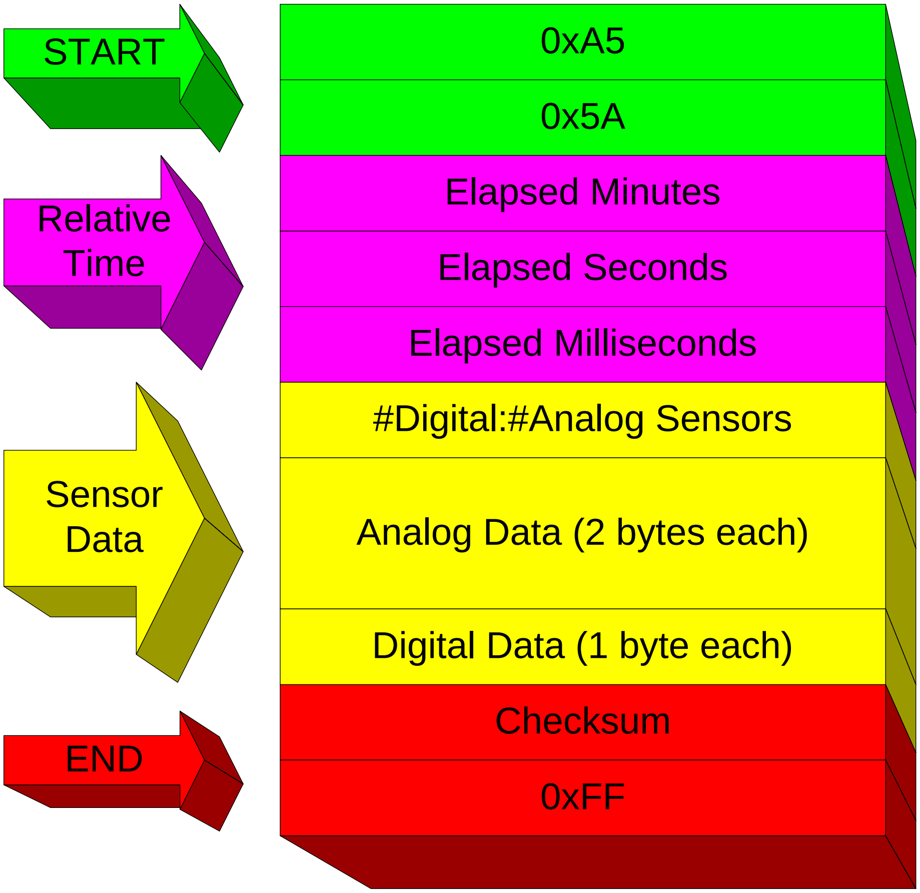
The Agora user interface is designed to be as flexible as possible so that it can be customized to individual applications. With that in mind, the code was written using a cross-platform GUI toolkit called *wxWindows*. *wxWindows* is a C++ derivative that ships with many components that are useful for communications and the manipulation of data. The Agora source code has been tested on RedHat Linux 6.2 using GTK and on Microsoft Windows 2000. The most challenging aspect of the development has proven to be rendering the incoming data in a live, graphical, fashion. To this end, we are adapting code from an Open Source sound-editing project called Audacity. The Audacity code is being incorporated into the Agora code as a separate C++ object.

Data Presentation – (Aravind Mikkilenini)

Our user interface presents data to the user in two different ways. For easy reference versus time, a graph is displayed at the top of the window with different colors indicating different numerical values. In addition, real-time numerical values for the analog data are given below the graph area. These numerical values are scaled specifically for resistance and temperature. We will discuss more about scaling and conversion in later sections.

Data Packet Format - (Aravind Mikkilenini)

Data sent between the host computer and remote sensor module needs to be formatted in such a way that is simple for the user interface to interpret. In addition, the data format must not be error prone when it is transmitted wirelessly. To solve these issues, packetized data is a basic requirement. An example of one of our data packets can be seen in figure 2 below.



Our micro controller and user interface engineers have co-developed a packet structure that keeps with the ideas of the Argus project by being flexible, yet robust. Each packet that is transmitted to the host computer begins with a start code equal to 0xA5. Research was performed to determine what value should be transmitted first. We learned that the limitations of certain off-the-shelf wireless transceivers necessitated that a byte value with several transitions between ‘1’ and ‘0’ would perform very well to “bring the transceiver up to speed”. This is clear from viewing the binary representation of 0xA5:

1 0 1 0 0 1 0 1

This value is sent twice to signify the start of a packet with the second byte being sent in reverse order (0xA55A). After the start code, a three-byte time stamp is sent indicating the time in minutes, seconds, and microseconds after power on the packet is being sent from the remote sensor module.

Following the time stamp, a single byte is transmitted indicating the number of analog and digital sensor data values that will be transmitted within the packet data. Analog values are sent using two bytes (16 bits) and digital data is sent using individual bits within a single 8-bit byte. This format allows the packet to be of variable length and allows for the addition of other sensors to the remote platform without re-developing the user interface parsing routines.

Finally, the packet is concluded with an 8-bit checksum and then a two byte stop code, which has the same value as the two-byte beginning code in reverse order (0x5AA5).

Communication Link – (Pat Stemen)

In order to send information between the host and sensor module, some type of wireless link needs to be established. This link needs to be able to take an RS-232 signal from the PIC, transmit it, and receive and reconstruct it on the other end. Various solutions have been tested and found satisfactory for our purposes. These include wireless RS-232 boards from ABACOM, and 802.11 ethernet. The ABACOM boards are simple transceivers, which can be connected directly to the serial ports on the PIC and the host machine.

On the other hand, the hardware for 802.11 ethernet currently requires a PCMCIA interface. This interface is not easily feasible using a PIC so instead a small board computer (SBC) is used to interface to it. The particular SBC we are using is a MPC823 based board with PCMCIA, RS-232, among other features. Its use here is only as a communications link; no processing of data will be done on this board.

Sensor Module – (Nate Distel)

The sensor module consists of two PIC microcontrollers, one to gather data and one to control various aspects of the vehicle. The data gathering PIC will be connected to a GPS unit, temperature sensor, current sensor, and an accelerometer. In addition there are 8 digital TTL signals that can be sensed. The temperature sensor, the current sensor use the PIC's on-board A/D converter to translate the analog output of the sensors to a digital value between 0 and 255.

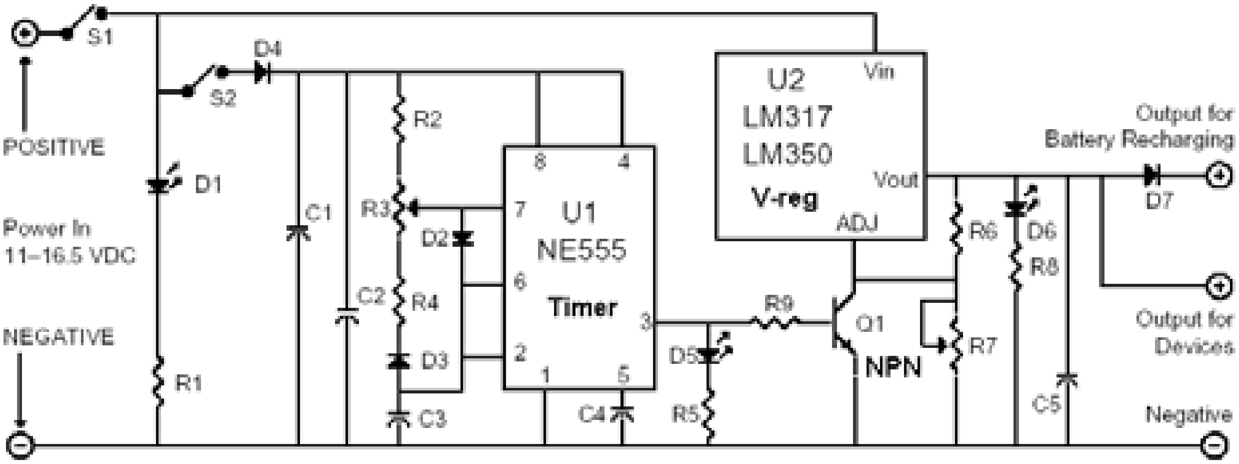
Currently, our group is working on the interface to the GPS unit. Because each PIC microcontroller that we are using has both the ability to send and receive serial data, we are exploring using the sensor PIC microcontroller to also receive serial RS-232 data from the GPS unit. This may seem simple at first, however the GPS unit can only send data at 4800 baud (bits per second) and our sensor PIC is currently transmitting data at 9600 baud over the wireless communications link.

It may be possible to switch the serial port speeds in real-time such that the PIC can receive the GPS data, package it into our packet and then send it to the user interface over the wireless link.

Power – (Rich Fouts)

The sensor module's power will be independent from that of the vehicle on which it is mounted. It will instead be powered by a 9 Volt rechargeable battery pack consisting of 8 Nickel-Cadmium AA rechargeable batteries. The battery back will be charged from an on-board charger. Although, NiCad batteries hold about 1/2 of the energy (measured in mAh) than a disposable alkaline battery, you can use NiCad 200-1000 times, depending on the quality of the cell and how it is recharged.

The charger we are using is designed to extend the number of times that the battery pack can be recharged by using a pulse width modulator to efficiently charge the batteries. The figure below shows a schematic of the circuit to be used in implementing the charger. Note that the charger can also be switched to serve as a DC power supply for the module. This allows powering of the sensor module on the workbench, without draining the battery pack.



Modifications need to be made to the charger to prevent from overcharging the batteries. This will be accomplished by monitoring either the ambient temperature change of the battery pack, or the voltage of the battery pack. Also, research is currently being done to see what modifications would have to be made to the charger to allow the use of Lithium-ion cells, which contain approximately the same amount of energy as alkaline cells.

The sensor module will require two voltage rails, +5V and +9V, and about 13W. The +9V rail will be used to power the Abacom SILRX receiver and TXM-4XFF transmitter. Currently, all other components of the sensor module require +5V. The +5V rail will be powered from a voltage regulator.

In order to make the sensor module truly wireless, we will also hook up solar cells on the vehicle, which will be used to charge the battery pack. However, due to limited surface area on the current car that is available to mount solar cells, charging the battery pack with solar energy will be for demonstration purposes only.

Accelerometer Interface - (Max Vilimpoc)

Part of the research being conducted adjacent to the mobile sensing platform is the use of accelerometer data to track the position of the car. With the addition and successful integration of a GPS unit, it will be possible to determine the platform's starting position to an accuracy of 50 feet. However, for more localized information, it will be possible to use an accelerometer and mathematics to determine the acceleration, velocity, and position of the car to a higher degree of accuracy.

The accelerometer device under investigation currently is the Analog Devices ADXL 202, which is capable of detecting acceleration of up to ±2g. Data that is captured from the device will be transferred wirelessly to a host computer which will calculate the above mentioned parameters.

Command and Control – (Pat Stemen)

Although the project started with the desire to create a mobile wireless sensing platform, it seems appropriate to delve into bi-directional wireless communications. To this end, we have developed a method to use the transmission of data from the user to the mobile platform to active functions or even control the automobile if necessary.

Currently, a simple VisualBasic user interface continually sends 4-byte packets to a second Abacomm receiver on the underside of our vehicle. This receiver sends the packets onto another 16F877 PIC microcontroller which activates lights, horns and even can activate the four main control aspects of the automobile (forward, reverse, left turn, right turn).

The control work is in its preliminary stages and is offered as a highlight of the possibilities for the platform. As we look forward, we will be working to eliminate errors from the microcontroller packet parsing routines, as well as find methods to reset parts of the car from the user interface.

Moving Forward – (Mike Volkerding)

At the moment we are beginning to wrap up the quarter and have began to put much more of our focus on getting more of the "hands on" aspects of the project complete vs. the demo aspects of where we began (i.e. sending useful information from our car instead of just sending packets of data wirelessly from one laptop to another). Just recently we have been able to control the car wirelessly directly from a user interface on a laptop. This is a very important stride for we would later like to control every aspect of this wireless module (car movement, sensor readouts, etc.) just using a small hand-held mini computer with a variant form of our original user interface. Later, we also would like to use the PC104 to transmit data over the Internet rather compared to our current use of serial wireless interfaces.

Another part of the project we have begun to focus our efforts on has been with the newly arrived Garmin GPS unit. With the short time left, having the bugs worked out and being able to successfully receive position data of our car would me most desirable. This would also be somewhat more unique to our project since we can control our car outdoors (where GPS signals can be received) vs. an indoor platform where GPS signals are skewed at best. Being able to control the car, send and receive useful data, and know the relative position is a very important sales aspect of our project.

Our last few mini parts of the project underway are to add headlights, turn signals, fog lights, a horn, and possibly an AF/FM radio to our car. These will be controlled by the UI, which again will be controlled by a hand held mini computer. Though these added features may seem to be just added “bells and whistles”, it deeply helps define what this platform is capable of in terms of a real life wireless sensor module, and thus would greatly benefit its sales interest.

Conclusion (Mike Volkerding)

As it can be seen, our team has very cleverly and uniquely incorporated our EE 582 ideas, as well as many new ones, into an actual tangible and working product that produces accurate results. It is a tribute to our group members and to all the hard work that has been spent making the ideas a reality. We believe that this project has taught us and will very much further our abilities to work well in a team, incorporate new ideas, and be able to better understand complex engineering problems in the future to come. We would also like to think Dr. Bibyk and Duane Skelton for their help and guidance through this very rewarding project.