CpE 180
SPRING 2001

CAN BUS DIAGNOSTIC TRANSLATOR
PROPOSAL

TEAM NUMBER 19

BUDGET TOTAL
$179

NAMES OF GROUP MEMBERS
KENNETH HECK
JOHN MURPHY

FACULTY MONITOR
PROFESSOR WILS L. COOLEY

SPONSORS
PROFESSOR ROY S. NUTTER
PROFESSOR G. MICHAEL PALMER

04/06/2001

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SECTION 1. INTRODUCTION

Throughout the 1970's and 80's, the electrical systems in automobiles dramatically increased in complexity and weight with the continuing addition of electrical devices, such as sound systems and on-board computers, and with the increasing use of electrical systems for the control of systems that were previously purely mechanical, such as the brakes. These devices and systems required correspondingly sophisticated control and communications systems, especially as their role in the operation of the car became more central. These developments meant difficulty in the design and maintenance of new automobiles, and often meant that people could no longer repair their own cars. The devices themselves and particularly the wiring connecting them became heavy and complicated, and the opportunities for malfunction increased.

In an effort to simplify the design and maintenance of new automobiles, Robert Bosch invented the Controller Area Network (CAN) standard in the late 1980's. The problems he faced included the need for safety, the high noise environment of a running automobile, and the need for flexibility and speed of high-fidelity communication among electrical devices in a car. His solution was a high speed bus (Referred to as the CAN bus), the signals on which traveled on a pair of polarity-switching lines, and which was capable of extremely reliable performance.

Adoption of the CAN standard by automobile manufacturers came eventually, but the technology found enthusiastic support in other and varied settings, including the fields of industrial automation and medical equipment. Each field that adopted the CAN standard did so with its own small changes and refinements, to the degree that today some implementations have little in common.

The Formula Lightning team at West Virginia University is one such user of the CAN standard. Led by Dr. Roy Nutter, the Formula Lightning team has devoted itself to the design of a fully electric race car. His team has found that in order to continue their work, it is necessary to have a device which will permit them access to the CAN bus of their car.

SECTION 2. DESIGN OBJECTIVES

2.1 Design Goals and Constraints

In order to race a car, everything about that car needs to be in optimal condition. This requires that all the component parts work together well and fluidly without risk of failure. In order to achieve this goal, all the parts of a car must be extensively tested, and all the systems examined. This can be done in the workshop, but often the best measurements and observations are made in the field -- literally, while racing the car around a track.

The Formula Lightning race car uses a CAN bus for the control and operation of its electrical systems. In order to ensure the correct and optimal operation of these electrical systems, a means of accessing the bus must be devised. Access to the bus must be had under both workshop and field conditions in order to be of use.

Since the CAN bus carries all the communications and control signals of various devices, it is necessary to be able to read all of those signals in a timely fashion in order to interpret them. The ability to respond to or elicit these signals is also desirable, since many devices require interaction in the form of signals on this bus.

A device must be built, therefore, to perform this task of communication and control. It must also perform the task of translation from CAN signal to a standard signal that can be read by a technician with a laptop computer running software written by Andy Pertl. This device must enable the technician to read the signals on the bus, whether all the signals or only a selected set, and to write signals to the bus.

While this alone is sufficient for workshop use, the nature of the application requires field testing as described above, and so further constraints are placed on the operation of the device. Due to the economy of space in the Formula Lightning car, the device must operate without a technician or the technician's computer present when the car is in motion. The device must itself, therefore, be of compact size. Due to the occasionally extreme weather conditions of the track, and the conditions present in the interior of a moving race car, the device must be of exceptional durability in order to be of use for any reasonable length of time.

2.2 Design Specifications

According to the notes, this should "never be written in 'essay' format", but I'm not sure how to do it?

In order to be of use for the Formula Lightning project, the device as described above needs to communicate according to the SAE standard described in J1939. It will thus be able to correctly read a signal from a CAN bus line. The signals it must read and write to the bus may be either or both CAN 2.0A and CAN 2.0B, which are similar packet structures differing mainly in length. In order to communicate to the laptop computer, the device must also communicate using the RS-232 standard, using the protocols as defined by Andy Pertl for his software package.

The act of writing a signal to the bus requires that the device read the signal from the laptop, and package it correctly for CAN 2.0A or CAN 2.0B. Once correctly packaged, the device must write the signal to the bus according to the arbitration methods defined in the CAN standard. The signal that the device writes may also be stored in such a way that it can be "played back" onto the bus at a predetermined time, or multiple times after predetermined intervals. In order to do this, the device must be able to accept and process instructions regarding its own behavior, and be able to distinguish such instructions from signals that must be written to the bus.

In order to read from the bus, the device must take a signal in its entirety from the bus line, and after determining whether the signal is wanted by the user of the device, relay it to that user. If the user has connected a laptop computer, then the device must communicate the signal via the RS-232 connection described above. If a laptop computer is not connected, the device must store the signals in such a way that they can be retrieved later.

Input Impedance:

CAN-side:	120Ω +/- 12Ω

Device Power Requirements:

Power Sources:	External: 12V,supplied by shielded cable
Current Draw:	<200mA

Communications:

CAN-side:	Max 1Mbit/sec
PC-side:	Max 115.2Kbit/sec

Communications Protocols:

CAN-side	(1) CAN 1.x (2) CAN 2.0A (3) CAN 2.0B (Read Only)
PC-side	RS-232

Connections:

CAN-side	DB-9
CAN-side connector harness	(1) DB-9 to 5-pole (2) DB-9 to 6-pole (3) DB-9 to 9-pole
PC-side	DB-9
PC-side connector harness	(1) DB-9 to DB-9 (2) DB-9 to DB-25
Power	2.1mm barrel

Operational Environment:

Electrical Isolation	Max 24V applied to outside of case
Shock (Force)	Max 4g
Pressure	Max 60psi
Water Resistance	1ft submersible (or equivalent)

Dimensions (excluding external cabling):

Case	2.00” H x 5.00” W x 6.00” D (51mm H x 127mm W x 153mm D)
Weight	3.0 lbs (1.37 kg)

PC Requirements:

Must run CAN software written by Andy Pertl

2.3 Deliverables

The device, when finished, will consist of a box as described above -- no larger than 2"x5"x6", weighing not more than 1.37 kilograms, with four openings. The first opening will allow a cable to connect the device to the CAN bus via DB-9. The second opening will be a DB-9 type socket for a cable connecting to a computer. This second opening will be pluggable to prevent entry of dirt, oil or water. The third opening will allow a power cord. The last opening will permit a flash memory card. This opening will also be sealable.

The power cord and CAN bus cable will be provided with the device. The user must provide the cable connecting to the DB-9 socket. One flash memory card will be provided with the system. Additional cards of the same type may be used by the user, but purchase, storage, and care of these cards is solely the responsibility of that user.

2.4 Validation

In order to determine that the device works correctly, the following tests will be performed:

The delivered device will be connected to a laptop computer and a working CAN bus. This same bus will have on it a similar device (of outside manufacture) for testing purposes. First, the system will be run so that the bus will carry signals from multiple sources. The device being tested will identify all of these signals and relay them. The signals relayed by the delivered device will be compared to those relays by the outside device to ensure that all signals have been received, and no extraneous signals reported.

The delivered device will then be instructed to send certain signals over the bus. The outside device will be consulted to verify that these signals have been sent correctly. The delivered device will be given instructions by the computer to store all signals from a given source on the bus (Identified using a CAN numeric identifier) and then attached to a CAN bus without the computer attached. The system will be run so that the bus carries signals from this source for two minutes, then shut down, and the delivered device attached to a computer to relay the stored data.

Lastly, the device will be dropped onto the ground from a height of three feet, sprayed with water, and then subjected to all of the above tests once more.

SECTION 3. SYSTEM DESCRIPTION

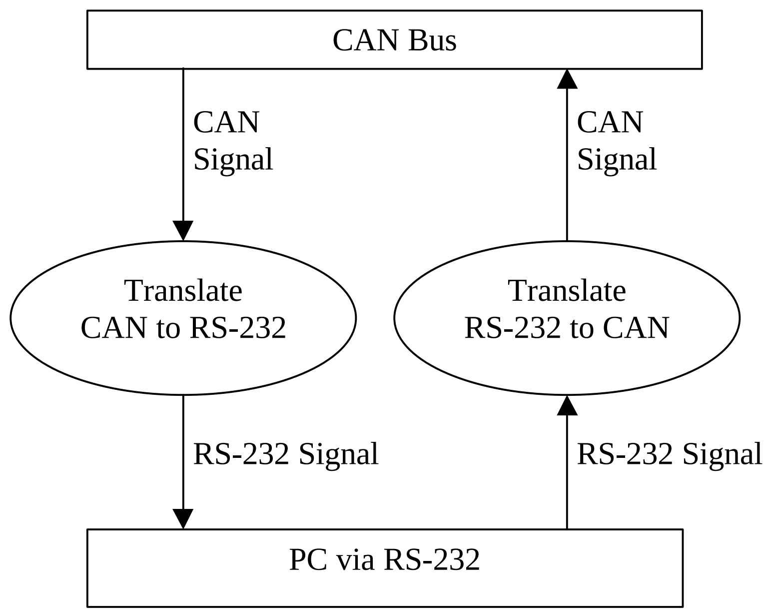
3.1 System Description

The device will be a single-board electronic device with a 12-volt DC power supply (external). It will contain a 20MHz oscillator as the clock, the DB-9 connectors necessary for interfacing the PC and the CAN bus, and a connector for the flash memory card. The PC's DB-9 connector will be electrically isolated from the rest of the device using opto-isolators.

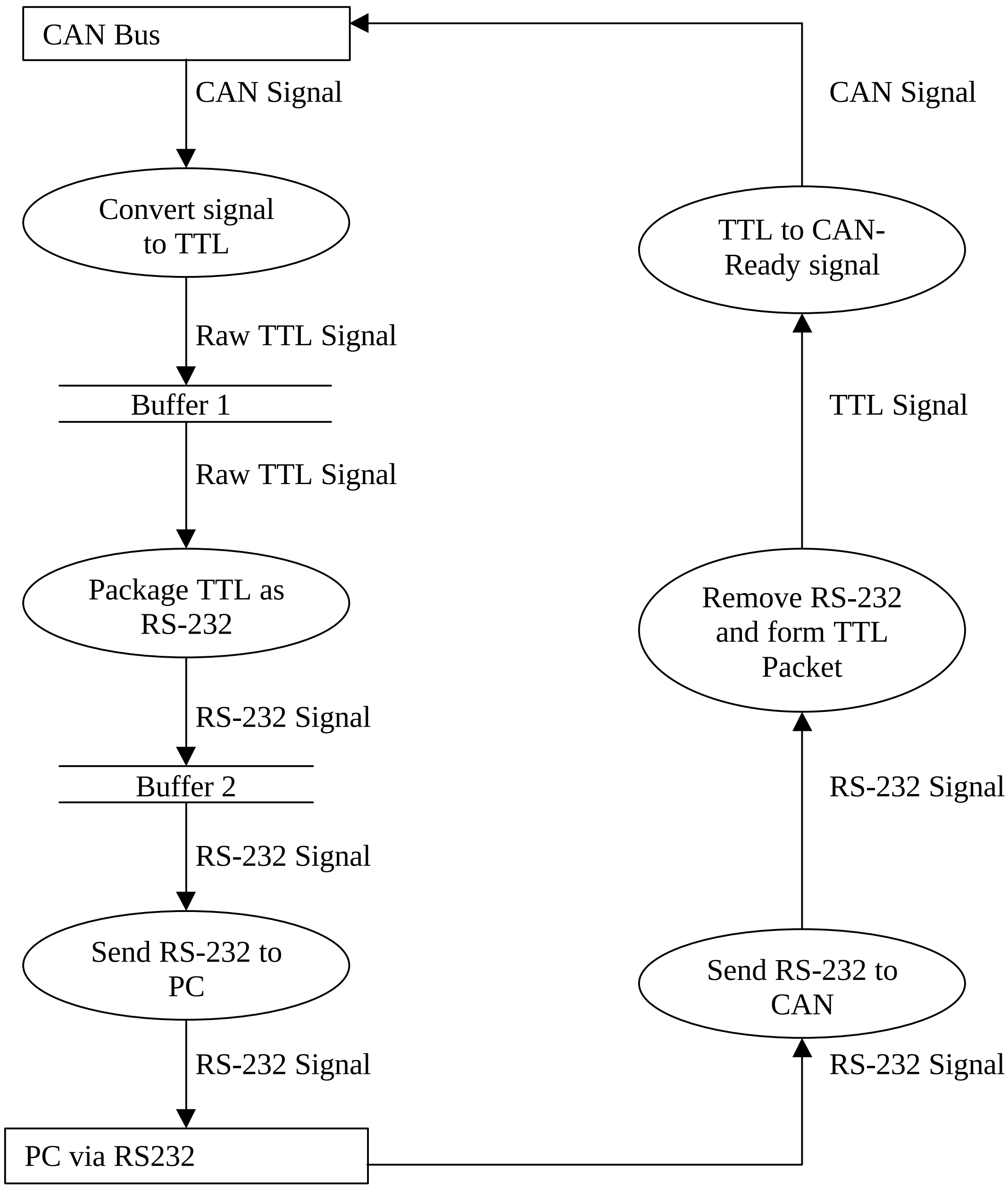
PIC chips will handle the tasks of interfacing with the CAN bus, interfacing with the computer (via RS-232), storing information to the flash memory, receiving and executing instructions from the computer, and both determining then communicating error states.

3.2 Block Diagram

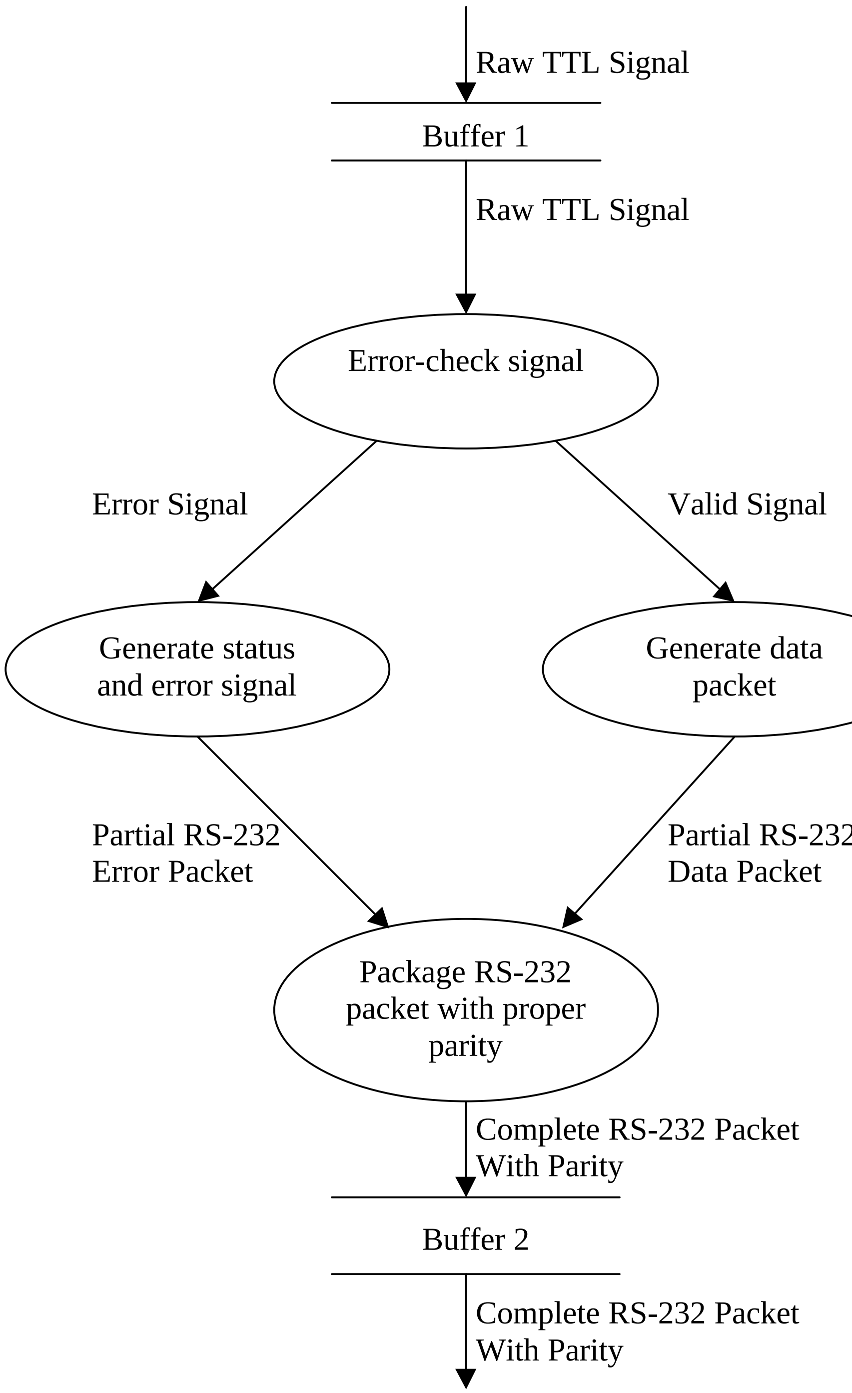
3.3 Data Flow Diagrams



Level 0 DFD


CAN Bus
CAN Signal
Convert signal to TTL
Raw TTL Signal
Buffer 1
Raw TTL Signal
Package TTL as RS-232
RS-232 Signal
Buffer 2
RS-232 Signal
Send RS-232 to PC
RS-232 Signal
PC via RS232
RS-232 Signal
Send RS-232 to CAN
RS-232 Signal
Remove RS-232 and form TTL Packet
TTL Signal
TTL to CAN-Ready signal
CAN Signal

Level 1 DFD


Raw TTL Signal
Buffer 1
Raw TTL Signal
Error-check signal
Error Signal
Valid Signal
Generate status and error signal
Generate data packet
Partial RS-232 Error Packet
Partial RS-232 Data Packet
Package RS-232 packet with proper parity
Complete RS-232 Packet With Parity
Buffer 2
Complete RS-232 Packet With Parity

Level 2 DFD

SECTION 4. ORGANIZATION AND PLANNING

4.1 Scheduling

(OK, this is just a list of things we'll need to do)

buy parts

build case

lay out and build circuit

program PICs

learn how to use flash memory cards

learn how to use Pertl's program (And make any changes needed to access our additional functionality)

write instruction calls

write user manual

test

parts should be bought soon, and all the "learn" stuff, too. How are we going to deal with the summer in all this?

Do we include it in our plans, or just pretend we're not doing anything over the summer?

4.2 Division of Responsibility

Task	Effort		Week Beginning														
	KAH	JM	08/20	08/27	09/03	09/10	09/17	09/24	10/01	10/08	10/15	10/22	10/29	11/05	11/12	11/19	11/26
1) Buy Parts	1	1															
2) Learn to use and wire CANBus PIC	20	5															
7) Program the CANBus PIC	20	0															
3) Learn to use and wire PIC#2	20	5															
8) Program PIC#2	10	0															
6) Learn to use and wire memory card	20	10															
4) Learn to use Andy Pertl's software	10	10															
5) Make changes to AP software	0	40															
9) Design power supply	5	0															
10) Learn to use and wire the serial port	0	5															
11) Learn to etch boards	5	5															
12) Learn to build/etch prototype board	10	10															
13) Build case to meet specifications	3	3															
14) Test project to ensure specifications	5	5															
TOTAL	119	119															

SECTION 5. BUDGET

5.1 Budget

	Project Cost	Proposal Cost
1. CANBUS PIC – MCP2510	$7	$7
2. Additional PIC for other Functions	$10	$10
3. PICStart Plus Programmer	$150	$0
4. MAX232A	$5	$0
5. DB9 connector (Receptacle)	$3	$3
6. DB9 connector (Plug)	$3	$3
7. Circuit Board Etch Kit	$30	$30
8. Capacitors, Resistors, Inductors	$5	$5
9. Case (Aluminum)	$15	$15
10. Power Connector (Receptacle)	$1	$1
11. Power Connector (Plug)	$4	$4
12. Oscillator	$3	$3
13. IC Sockets	$1	$1
14. Compact Flash Memory (32MB)	$45	$45
15. Compact Flash Socket	$5	$5
16. DC-DC Converter	$9	$9
17. Fuse Holder	$1	$1
18. Power Switch	$2	$2
19. Any other discrete components	$5	$5
20. Miscellaneous (solder, etc.)	$5	$5
21. Shipping/Handling Charges	$20	$20
TOTAL	$334	$179

Requested from Sponsors=$79

Requested from CSEE Department=$100

Sponsor Signature Date

Chair Signature Date

Monitor Signature Date

5.2 Budget Justifications

1. CANBUS PIC – MCP2510	Digi-Key
2. Additional PIC for other Functions	Digi-Key
3. PICStart Plus Programmer	Digi-Key
4. MAX232A	Digi-Key
5. DB9 connector (Receptacle)	Newark
6. DB9 connector (Plug)	Newark
7. Circuit Board Etch Kit	Newark
8. Case (Aluminum)	Newark
9. Power Connector (Receptacle)	Newark
10. Power Connector (Plug)	Newark
11. Oscillator	Newark
12. Compact Flash Memory (32MB)	Buy.com
13. Compact Flash Socket	Newark
14. DC-DC Converter	Newark
15. Fuse Holder	Newark
16. Power Switch	Newark

SECTION 6. QUALIFICATIONS

6.1 Kenneth Alan Heck, MS

Kenneth Alan Heck, MS
Route 2 Box 182
Fairmont, WV 26554

Home Phone : (304) 363-6824
E-Mail: kheck2@wvu.edu

Education :

01/98-Present:

University :	West Virginia University, Morgantown, WV
Coursework :	Pursuing BS in Computer and Electrical Engineering

08/96-12/96 :

College :	Santa Fe Community College, Gainesville, FL : EMT - B, December 1996
Registration :	National Registry of Emergency Medical Technicians - #B1103946
License :	West Virginia - #B-036323

08/92-02/96 :

University :	University of Florida, Gainesville, FL : MS, December 1995
Thesis :	"General Synthetic Methods for Alpha-hydroxy Ketones"
Research Director :	Dr. Alan R. Katritzky, Kenan Professor, Center for Heterocyclic Compounds
Graduate Coursework :	1 sem. each : General Organic, Organic Synthesis, Organic Mechanism, Organic Spectroscopy, Inorganic, Organometallics, Quantum Theory
Equipment Skills :	300MHz NMR's : Varian Gemini-300, VXR 300, GE QE-300; HPLC
Other Duties :	Katritzky group lab steward, miscellaneous equipment repair

08/88-05/92 :

University :	West Virginia University, Morgantown, WV : BA, Chemistry December 1992
Coursework :	Mostly BS and Honors courses, organic courses with microscale techniques
Special Topics Course :	X-Ray diffraction
Equipment Skills :	IR : Perkin-Elmer; PC-based systems
Honors/Scholarships :	(i) WVU Presidential Scholarship (ii) John A. Moore (Chemistry) Scholarship (iii) WVU Honors Program

Experience :

01/00-Present :

Business :	Heck Solutions
Title :	Owner
Functions:	Software Development specializing in Access 97 Custom-built PC's/Upgrades PC Diagnosis/Repair

08/97-12/99 :

Employer :	West Virginia University, Financial Aid Office, Morgantown, WV 26506-6004
Title :	Information Systems Technician
Supervisor :	Tresa Weimer, Supervisor : (304) 293-8571 ; 1-800-344-WVUl
Duties :	System Administrator of Local Area Network running Novell Netware 4.11 Training employees to use software : Netware 4.11, Win 95, Win 98, WP6.1, FoxPro 2.6, BANNER 2.15, MS Office Pro 97 Maintenance and Repair: Various PC's and Printers Developing need-specific software for varying uses in the office : Access 97 , FoxPro 2.6 Supervision of Work Study employees

06/97-Present :

Employer :	Monongalia General Hospital, 1200 JD Anderson Drive, Morgantown, WV 26505
Title :	Part-Time Monitor Tech
Supervisor :	Glenda Broad: (304) 598-1506
Duties :	Watching 5 monitors capable of 8 strips each, paging nurses for dysrhythmias Recording and analyzing rhythm strips once per shift Tracking patient room assignments, notifying necessary personnel for admits/discharges Maintaining patient information board for physicians, nurses, administrative personnel

06/96-02/97 :

Employer :	Farchan Laboratories, 4906 NW 53rd Street, Gainesville, FL 32653
Title :	Bench Chemist - Research and Development
Supervisor :	Dr. Radi Awartani : (352) 374-6825
Duties :	Running small (50mL) to large (22L) scale reactions as directed Supervising technicians in running reactions Quality control analysis by GC, HPLC, IR, Karl-Fischer water analysis, titration, melting point and refractive index Lab equipment maintenance

01/93-02/96 :

Employer :	University of Florida, Department of Chemistry, Gainesville, FL 32611
Title :	Graduate Research/Teaching Assistant
Supervisor :	Prof. Merle A. Battiste : (352) 392-0552
Duties :	3 sem. General Chemistry, 2 sem. Organic Chemistry Lab

08/88-07/92 :

Employer :	West Virginia University, Financial Aid Office, Morgantown, WV 26506-6004
Title :	Clerical Assistant
Supervisor :	Brenda Thompson, Director : (304) 293-5242 ; 1-800-344-WVUl
Duties :	Clerical work : Filing, typing, answering phones, stocking, errands Developing need-specific software for varying uses in the office : FoxPro 2.0 LAN Training employees to use software : Netware 2.10, WP5.1, FoxPro 2.0, DOS PC Maintenance

03/91-07/92 :

Employer :	First National Bank of Morgantown, 201 High Street, Morgantown, WV 26505 (now Huntington Banks, WV)
Title :	Part-Time Computer Operator
Supervisor :	Scot Epling, Assistant Vice President : (304) 367-2452 ; 1-800-377-BANK
Duties :	Unsupervised after hours final sorting of personal checks using a Honeywell DPS 6 Developing need-specific software : dBase IV 1.1 and QuickBasic Software installation : WP5.1, Lotus, PCTools Diagnosing and correcting PC hardware problems

Publication :

A. R. Katritzky, K. A. Heck, J. Li, A. Wells, C. Garot, "1-(1-Alkenyl)benzotriazoles: Novel Equivalents for the Synthesis of α-Hydroxy Ketones", *Synth. Commun.*, 26(14), 2657-2670. (1996)

6.2 John Murphy

John Murphy
910 Montrose Ave
Morgantown, WV
26505
(304)292-8870
murphyj@csee.wvu.edu

Resume

Objectives:

To obtain a graduate degree in electrical engineering in the particular field of robotics.
To gain experience designing, building, controlling, and maintaining robotic systems.

Job Experience:

Intern, NASA IV&V Summer, 1996
Fairmont, WV (Funded by George Washington University)

Involved with SORT (Software Optimization and Reuse Technology) project, a software engineering effort as related in particular to Marshall Space Flight Center's flight furnace project.
Oral demonstrations of progress given both to peers and superiors at the end of the internship

Math tutor, West Virgina University Math Department Aug 2000 - present
Morgantown, WV

Education:
West Virginia University 1997-present
Morgantown, WV
(Expected graduation date: Dec 2001)
Degrees to be received:
BSCpE, BSEE, emphasis in control systems

Kansai Gaikokugo Daigaku (Kansai Foreign Language University) Fall 1999
Hirakata-Shi, Osaka, Japan

Morgantown High School 1994-1997
Morgantown, WV

Skills:

Programming (Windows, MS-DOS and UNIX environments):
C, Java, Intel x86 assembly, PIC assembly, PIC C, Ada, Matlab, Perl, Lisp
Spoken and Written Japanese
Use of fuzzy logic and genetic algorithm techniques, particularly in control applications
Experience designing with and programming for PIC chips

SECTION 7. REFERENCES

7.1 Standards

1) SAE J1939

7.2 Publications

1) *Design with PIC Microcontrollers*, Peatman, John B., Prentice Hall, New Jersey, 1998.

7.3 Websites

1) AnyBus Official Site : http://www.hms.se/

2) CAN in Automation : http://www.can-cia.de/

3) Dearborn Group, Inc. : http://www.dgtech.com/products/dpa.phtml

4) DeviceNet-ODVA Official Website : http://www.odva.org/10_2/00_fp_home.htm

5) International Organization for Standardization homepage : http://www.iso.ch/

6) KVASER Controller Area Network pages : http://www.kvaser.com/can/index.htm

7) OSEK/VDX : http://www.osek-vdx.org/

8) Triangle Data : http://www.triangledigital.com/products/productscanbus.htm

9) Wesley Tang's Can Links : http://www.warwick.ac.uk/~esrpy/links.htm

10) Zanthic Products : http://www.zanthic.com/can4usbm.htm

SECTION 8. APPENDICES

8.1 Reliability Estimate

8.2 Failure Modes and Effects Analysis

8.3 Supporting Information