CTEC1630 Embedded Systems Design

This is your first visit ... **Welcome!**

Course Description

This course covers topics relating to the design and development of embedded systems. Students will study the basics of embedded microcontrollers as well as interfacing devices such as LCDs and matrix keypads to these chips. Systems design principles wil be examined including real-world input via sensors, controlled output, user interface, and controlling logic. We will examine the identification of requirements for a system (computational throughput, safety issues, and cost factors involved), issues involved in selecting a platform for a system, and safety-critical systems (e.g. when hardware protection is appropriate). Testing and simulation of control code will be examined. Finally, digital signal conditioning will be examined including the interfacing of digital devices to real-world standads (e.g. 110VAC, 24VAC/VDC).

This course culminates in a term project designed, constructed, programmed, and tested by the student.

At a final-term project demonstration a student demonstrates her project to VP Dr. Bonnie Rose. In her project, Juanita integrated a RISC microcontroller into a Furby allowing a PC (using a Win-32 program written in C++) to control Furby's actions. Though a toy, you'd be surprised at the complexities involved with interfacing a Furby to a computer!

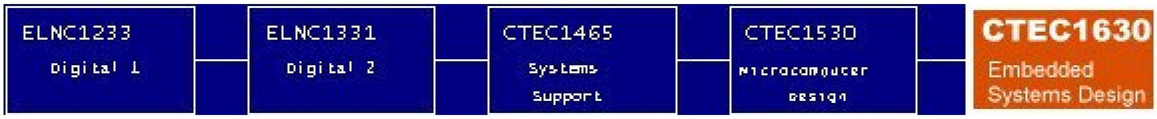
Here Brian describes his project, a Morse-code generator, to president Dan Patterson. His project interfaced a standard PC-AT keyboard with a microcontroller.

Refer to the PAST PROJECTS section of this page for details on these projects and more

Prerequisites

CTEC1530 MicroComputer Design (80x86 architecture, assembly language, and interfacing)

You Are Here ...



This course is offered as part of the 'hardware stream' of courses in the Computer Engineering Technology (3 year, co-op) Program at Niagara College.

Labs

Lab 1: Programming a PIC Microcontroller
An introduction to PIC processor architecture and programming. Students will program a PIC 16F877 processor to display a message on the 7-segment LED display on the PICPROTO-II board.
Due Tuesday, Sept. 24, 2002 at 9:30 a.m.

Lab 2: Using an Emulator and Debugger
Using a simple program students will use an ICD emulator/debugger to step-through a program which writes to the LCD. By adding breakpoints, data may be inspected and changed within the program as it runs. Students will also examine how tables and pointers operate.
Due Tuesday, Oct. 1, 2002 at 9:30 a.m.

Lab 3: Serial Communications
The PIC16F877 features a built-in UART and baud-rate generator. Using this faciity and the on-chip interrupt controller students will create an interrupt-driven Rx/Tx communications terminal which buffers incoming characters into registers before display on the LCD. A MAX232 RS-232 level converter is supplied on the PICPROTO-II board to convert levels as required.
Due Tuesday, Oct. 15, 2002 at 9:30 a.m.

Lab 4: Advanced MCU Peripherals and Structures
Advanced built-in peripherals on the MCU will be examined including the A/D converter, Timer, and EEPROM memory. As well, advanced architecture issues involving paged memory will be examined.
Due Tuesday, Nov. 5, 2002 at 9:30 a.m.

Lab 5: Code Lock *or* Guessing Game
Students will write their choice of an Electronic Combination Lock or a High/Low Guessing Game. Each program uses the LCD display and a 4*4 matrix keypad for input.
OPTIONAL LAB: Due Friday, Dec. 6 at latest!

In case the labs in this course keep you working late nights, check out the Coffee and Caffeine FAQ

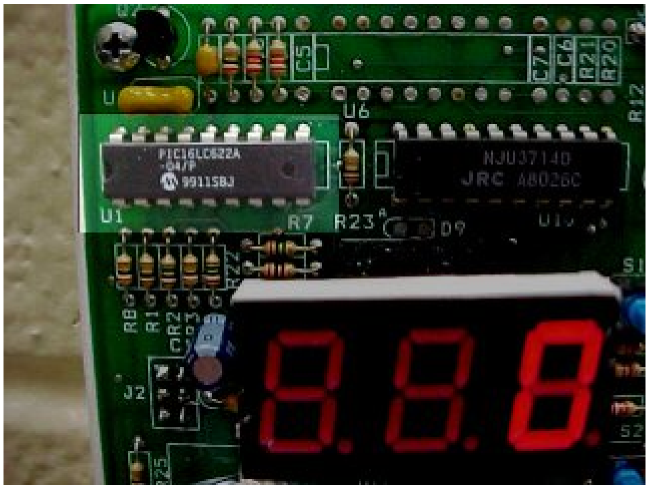
Project

A major emphasis of this course is a microcontroller-based project. This project is to represent a typical design and construction project given to a new technologist. It consists of designing and constructing the project, testing it to ensure it meets specifications, and writing-up the entire project in a report.

The project is to be chosen by the student from a list of acceptable topics. If a student has a particular idea not on the list, discuss it with the professor. Only ONE student will be allowed to choose each topic on a first-come, first-taken order. Choose a topic which is of interest to you: If you are interested in writing an interpreter then the micro-PLC project might be of interest to you. If you like communications, perhaps the CAN network project is a good choice.

Each lab incorporates important principles such as interfacing the MCU to a 16 char by 2 line LCD display and matrix keypad, data acquisition, real-world interfacing, etc. Software will consist of the actual control task programming in RISC assembly language. Software must be reliable, functional, as well as user-friendly. On some projects, bonus marks are available for enhancing the project using advanced MCU features and/or extra hardware.

Examples Of Commercial Microcontroller-Based Designs



The popular Nighthawk brand of CO detector uses a PIC16C622 as it's brain. This processor, seen highlighted in the right photo, provides an on-chip ADC to convert analog values from both the electrochemical cell (which senses the presence of CO) and a thermistor (which senses ambient temperature) into binary values. The amount of CO is then computed in the PIC and is displayed on the multiplexed LEDs.

FOR CON ED PROTECTION AGAINST RISK OF FIRE
REPLACE Y WITH SAME TYPE & RATINGS OF FUSE
GES20W05V0104-A
U5
C45
CN16
CN15
U9
U13
U3
LED2
LED1
U8
U10
U7
DELTA

An unintteruptible power supply from a CISCO router employing a PIC. This MCU, a PIC16C72A, features an on-chip ADC allowing the processor to monitor voltage levels from the battery and notify the system accordingly.

Past Projects

Project Web Pages From Fall, 2001 ... *NOTE: Please do not contact the course professor regarding these project pages. They are maintained individually by the students who have built these projects.*

Project Luey: An MCU controller robotic arm	Pic Controlled Security System	A Watt-Hour Meter	An MP3 Front End	An MP3 Front End
IR Remote Control for Multimedia Apps.	Enigma enciphering machine	Data Graphing Device	An LCD Clock	Video Tic-Tac-Toe
Mare-Y Go Round	Serial Rotation Encoder	Video Ping Pong	Infrared X-10 Controller	Spectrophotometer
Laser Diode Driver	Win-32 Based PIC Programmer	A pH Meter	A dial-in VCR Programmer	RF Packet Controller

Past Projects from 1998, 1999, and 2000

Project Photos from Fall 2001	Project Photos from Fall 2000

Future Projects (Available for Fall 2003)

I NEED IDEAS !!! ... If you've got ideas for a project this fall, E-Mail me!

Model Railroad Block-detection and signalling
In a traditional approach, each block on a model railroad has a twin-tee current detector wired to up to six signals on either side of that block ... wiring is quite a mess. In this new approach a small network will be used to convey information about block occupancy to signals and operator so that wiring consists of a simple two wire bus onto which all devices are attached. The best network protocol for this application is likely a RS-485 multidrop type with a PC acting as the master controller. The professor has a document outlining a proposed system of this type.

An IR Spectrometer
Consists of adding a data-acquisition unit to a MIRAN-1A IR spectrometer we have in the spectroscopy lab (Click Here for details). The system acquires and stores data (in an external EEPROM) then allows download (via a serial connection) and graphing on a PC. Essentially, the unit emulates an old strip-chart recorder currently in use. Just ask and I will show you the unit up-close in V14A ... it's not as scary as it looks. Less hardware than the unit below (only one digital and one analog output from the unit) but timing is critical for data sampling (the PIC has a several timers to help with this).

A High-resolution Visible Spectrometer
Consists of adding a data-acquisition unit to a McPherson 1m Monochromator with Photomultiplier detector in the spectroscopy lab (Click Here for details). The monochromator already has a step-motor and limit switches so the project consists of adding a controller allowing the user to select start wavelength, stop wavelength, and sample resolution. Samples can be acquired via the on-chip ADC and stored in EEPROM for downloading to a PC. Again, just ask and I will show you the unit up-close in V14A ... it's not as scary as it looks.. More hardware than the above unit (i.e. a step-motor driver must be constructed so four digital outputs are required plus the analog input) but timing is not critical.

An EEPROM programmer
A programmer allowing the programming and reading of various serial EEPROMs. Connects to a PC using a serial (COM) connection, buffers incoming data, then burns and verifies memories. Should support both SPI-type (e.g. 93Cx6 series) and IIC-type (e.g. 24Cxx series) EEPROMS. Front-end PC software (Win-32) allows the user to select EPROM type as well as upload/download hex files.

A USB interface for an IT-20
Using a commercial USB transceiver with I2C output the PIC will allow emulation of a PC bus over USB. In the target application an IT-10 board will be wired to the PIC and a win-32 demonstration interface written. Good project for those who understoof logic and address decoding in CTEC1530.

A Laser Scaner Waveform Generator
A arbitrary waveform generator ("arb") which has two DAC outputs feeding the X and Y channels of a laser scanner. Using a PC a complex waveform can be programmed into the unit and continually played-back to generate a laser-light show pattern. Must allow pattern upload (128 points per channel is sufficient) as well as allow the user to select playback speed on the local LCD. Use the internal EEPROM to store the pattern so that it is stored even when power is interrupted.

A Small Language Interpreter
A BASIC-like language interpreter which allows the user to store a program into the on-chip EEPROM (or an external EEPROM) and execute it. Choices for a language include a robot-control language (e.g. Logo) or a BASIC-like language (perhaps the old HP calculator language which uses three-letter commands).

A Sinewave Inverter
Using the high-speed PWM capability of the chip generates two out-of-phase signals to drive an "H" bridge inverter used for motor control and power conversion. Requires an algorithm to correct the pulse width based on output amplitude.

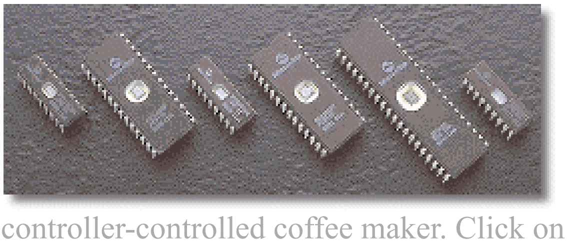
A Programmable Robot
Allows the user to download a simple program via a serial connection (e.g. Fwd, Turn Left, Fwd, Turn Right) to control a small robot. A requirement of this project is to add sensors to each motor to ensure they run at equal speeds to keep it running forward in a straight line.

Disk Controller
Using the on-chip UART a basic floppy disk controller can be constructed which allows data to be written-to and read-from a floppy disk. The student must design a storage format (e.g. FAT or otherwise) and must research how the floppy disk interface works. Note that _old_ computers from the 1980's frequently used simple hardware consisting of a discrete UART and I/O chip to perform floppy disk interface ... the professor can provide an example of this type of circuitry (e.g. an Ohio Scientific 470 floppy controller).

A Frequency/Event Counter
A multi-function instrument capable of acting as a frequency counter, event counter, count to n and stop, and count to n and recycle modes.

A Programmable Relay
Similar to products on the industrial market this 'relay' is actually a micro-PLC which can execute simple logic and timing functions. Review a few commercially-available products (e.g. Logotron from Entrelec) to see what can be done.

An Intelligent battery charger
By monitoring the current flowing into a rechargeable battery this charger can accurately charge a cell to it's full potential. Allows the user to enter the capacity (in Amp-Hours) of the cell.



In class I often joke about a microcontroller-controlled coffee maker. Click on this image to see more about this idea.

Course Notes

NEW! Midterm Examples (WORD DOC) A few (more) examples for study purposes.

NEW! Midterm Examples A few examples for study purposes.

NEW!2001F Midterm In it's entirety ... in WORD format. Great for study purposes.

Sample Project Specification an example from a previous project showing what is expected.

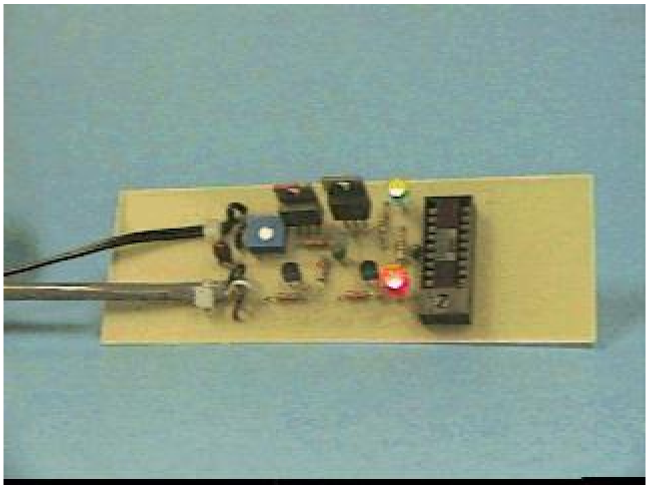
State Machine Design This is a good starting point -- you must now add (i) Config file capability at startup and (ii) triggered mode to allow lights to switch only when a vehicle is waiting.

Interrupt Usage Example as covered in the lectures. This example uses TMR0 to generate interrupts for a clock at 15Hz.

Tutorial: Using the On-Chip EEPROM Notes from class on using the on-chip 64-byte EEPROM

Software UART on a PIC An example of how to receive a serial character on a PIC by programming a UART in software. Contains code snippet and explanation of operation.

Using a Serial ADC with a PIC An example of how to read a byte from an ADC0831 serial ADC using a PIC.



Build your own PIC PROGRAMMER A description of how to construct a simple PIC programmer. At one time this was supplied as a kit to students in this course however our new proto boards have built-in programmers so this is no longer required. PCB's and parts kits are no longer available so you'll need to scrounge the parts yourself. Compatible with the PICPROG.EXE utility on this page.

Links (Serious Course-Material Type)

The following are LINKS to web sites which feature microcontrollers. Some sites allow the downloading of code and designs which may be useful to students in this course.

Homebrew Computer FAQ Contains information as well as an ENORMOUS list of resources available to build computers,programmers, etc.

Microchip Inc. ... The company which produces the PIC controller This site features datasheets and maintains a download library of code for PIC microcontrollers.

Links to PIC Enthusiasts Sites This site features projects, code, and tips from PIC enthusiasts worldwide.

PIC Toolbox A list of links to PIC sites. FTP sites, suppliers .... a wealth of information.

Parallax Inc. This company sells development tools for PIC controllers

Micro Control Journal This journal covers control technology employing microcontrollers

PIC Resource Links David Tait's link page to many PIC resources including homemade programmer designs and software, assemblers, and code

Getting Started with PICs Page Steve Marchant's PIC resource page. Cheap homemade programmers, design examples, etc.

An Ultra-Simple PIC programmer Stephen Nolan's simple 8 component PIC16C84 programmer. The simplest I've ever seen. Our class programmer is based on this original design. Schematic and code included as well as an excellent description of the PIC programming process. Requires new programmer utility (in the section below) to use INTEL-HEX files from our MPASM assembler.

MAXIM Semiconductor Inc. This site features datasheets for the MAX232 RS-232 transceiver chip

National Semiconductor Corp. This site features datasheets for ADC and DAC products

Circuit Cellar INK The folks who give us the class set of magazines each month. Features an ftp site with code from magazine articles available for download, etc.

Myke Predko's Guide To Interfacing Hitachi 44780 Based LCDs Most LCD displays are based on this chip which has many programmable features. This author shows how to connect and use the LCD.

Hitachi 44780 LCD Controller Data Sheet Complete DataSheet (PDF) for the LCD's we use.

Seiko LCD Modules Loads of information on interfacing and using standard LCD modules such as the ones we use on our PICPROTO II boards.

Links II (Not-So Serious *Gee Whiz* Type)

The World's Smallest Web Server Running on an 8-pin PIC processor in about 0.5K words of program memory.

The Furby Autopsy Site A fine example of a microcontroller application

The Road Runner Show Page Featuring Wile E. Coyote, 'Patron Saint' of Engineers (No apparent reason for including this link ... just a diversion).

Bob Blick's Propellor Clock Which uses a PIC ... you've got to see it!

HackWatch The name says it all. The information is presented for 'educational use only', of course :). This is where the PIC16C84 security bug was first outlined.

Downloadable Code

DISCLAIMER: All code and examples are copyright Niagara College 1997-2002. This information is intended for suggestion only and may be superseded through updates. Use of this code in any commercial application is forbidden. Code and examples are provided without warranty and Niagara College and the author assume no liability whatsoever with respect to accuracy of information, use of such information,or infringement of patents arising from such use or otherwise. No licences are conveyed implicitly or otherwise under any intellectual property rights.

- MPASM for the PIC (PKZIP Format) The MPASM Assembler for DOS Get the latest from Microchip for free (see LINKS above)

- PROGRAMMER UTILITY for the PICSTART-1B (PKZIP Format) The programmer utility for use with the commercial IN-LAB programmer only, not the PICPROTO boards

NEW! PICPROG.EXE Programmer executable for the PICPROTO-II board used in our labs. Version 1.7 - supports command-line arguments as well as 16F87x devices. Type 'PICPROG /?' to see argument list. Sixteen bit version runs only under Windows 9x. Use '/O' option for 20MHz devices

- Picprog.BAS QBASIC Source Code for the PICPROTO-II Board programmer (Version 1.7) above. Also supports the old separate programmer board. This is a modified version of Stephen Nolan's code which allows the direct use of INTEL-HEX files (as produced by the Microchip MPASM assembler). See the link to Nolan's site for hardware details. If you modify and improve it, send me back the code!

- TEST.ASM PIC Assembler Code for the single blinking LED example used in class.

- TEST2.ASM PIC Assembler Code for the LED and pushbutton example used in class

- LAB3.ASM PIC Assembler Code for lab 3

- LAB3B.ASM PIC Assembler Code for lab 3, part B

- LCDTEST.ASM Assembly Code for the LCD Test program which is used in Lab #3

- COMP630_TEST.ASM PIC Assembler Code for the LCD, Keypad, and Button example used in class

PIC PROTOBOARD II SCHEMATIC (in AUTOCAD .DXF Format) The complete schematic for the PIC proto board used in labs

PIC PROTOBOARD II SCHEMATIC (in AUTOCAD .DWG Format) The complete schematic for the PIC proto board used in labs

PIC PROTOBOARD II SCHEMATIC (in JPEG Format) The complete schematic for the PIC proto board used in labs

PIC PROTOBOARD UPGRADE SCHEMATIC (in JPEG Format) Showing the PIC16F877

- EEPROM.ASM An example program which uses the on-chip 64-byte EEPROM. Also demonstrates the use of the B2_BCD binary to BCD converter routine

- INTERRUPT DRIVEN CLOCK An example real-time clock which counts in seconds and minutes and is fully interrupt driven to relieve the main program of having to check the RTCC at any time. Also shows the use of the string and binary-to-BCD converter functions.

- Using an external Serial EEPROM with a PIC Complete working example program which writes a string to a 24C04 serial EEPROM then reads back the results from the SEEPROM to display it. A good test program for SEEPROMs.

- BCD to Binary Converter An example of how to read 3 keypresses and convert them into a binary value.

● SCOPE UTILITY PC-side utility to allow download of images from the TDS digital scopes used in the lab. Password Protected ZIP

● New String Example As used in class.

NEW! Paging Example As used in class.

MAIL

E-Mail the Professor

Please: No questions regarding past individual student projects. These are the responsibility of the student involved.

Back to the Technology Web Server Main Page

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