

Microcontroller Framework for Radar Module Control

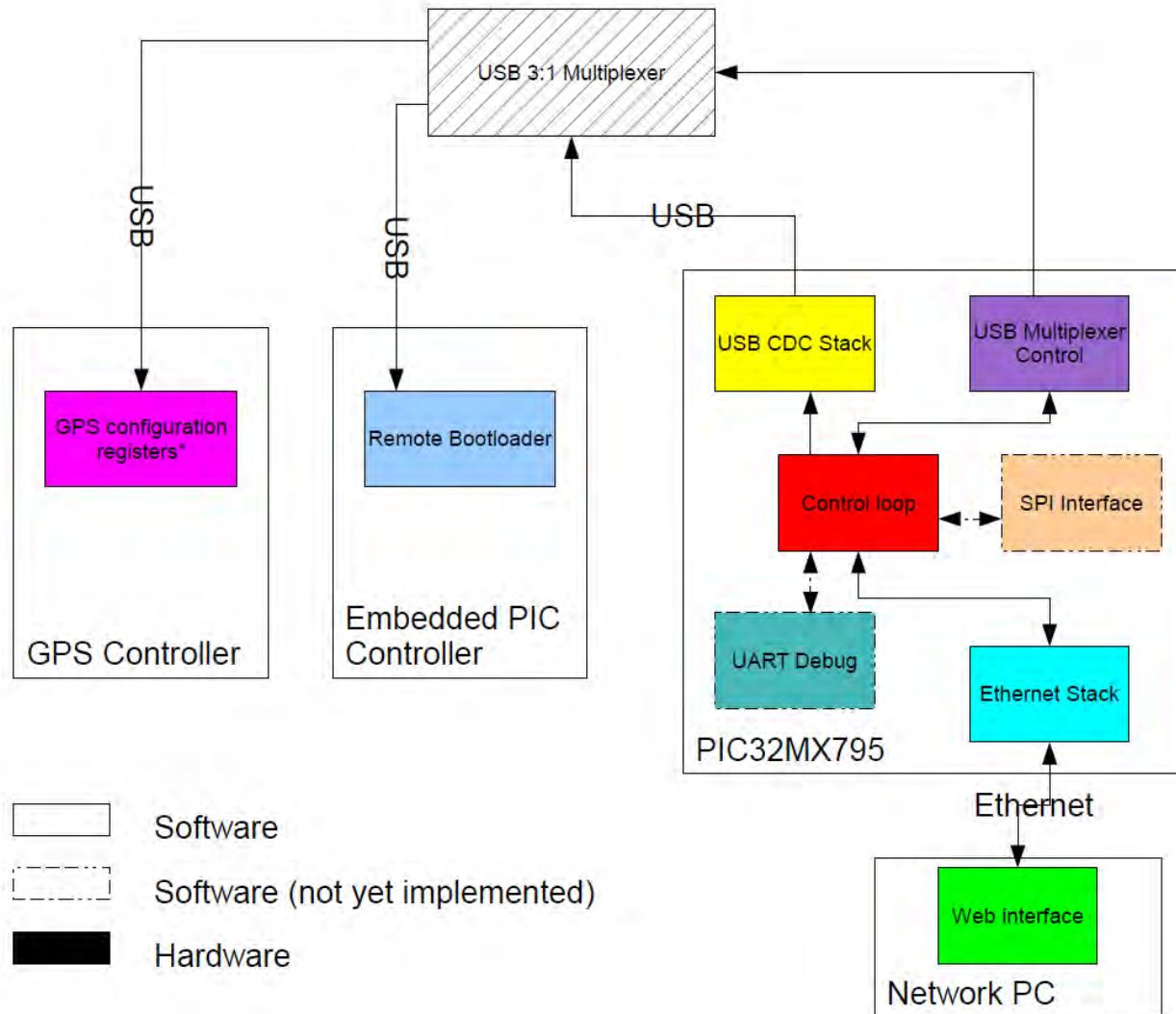
MIT Haystack Observatory

Elias Wilken-Resman

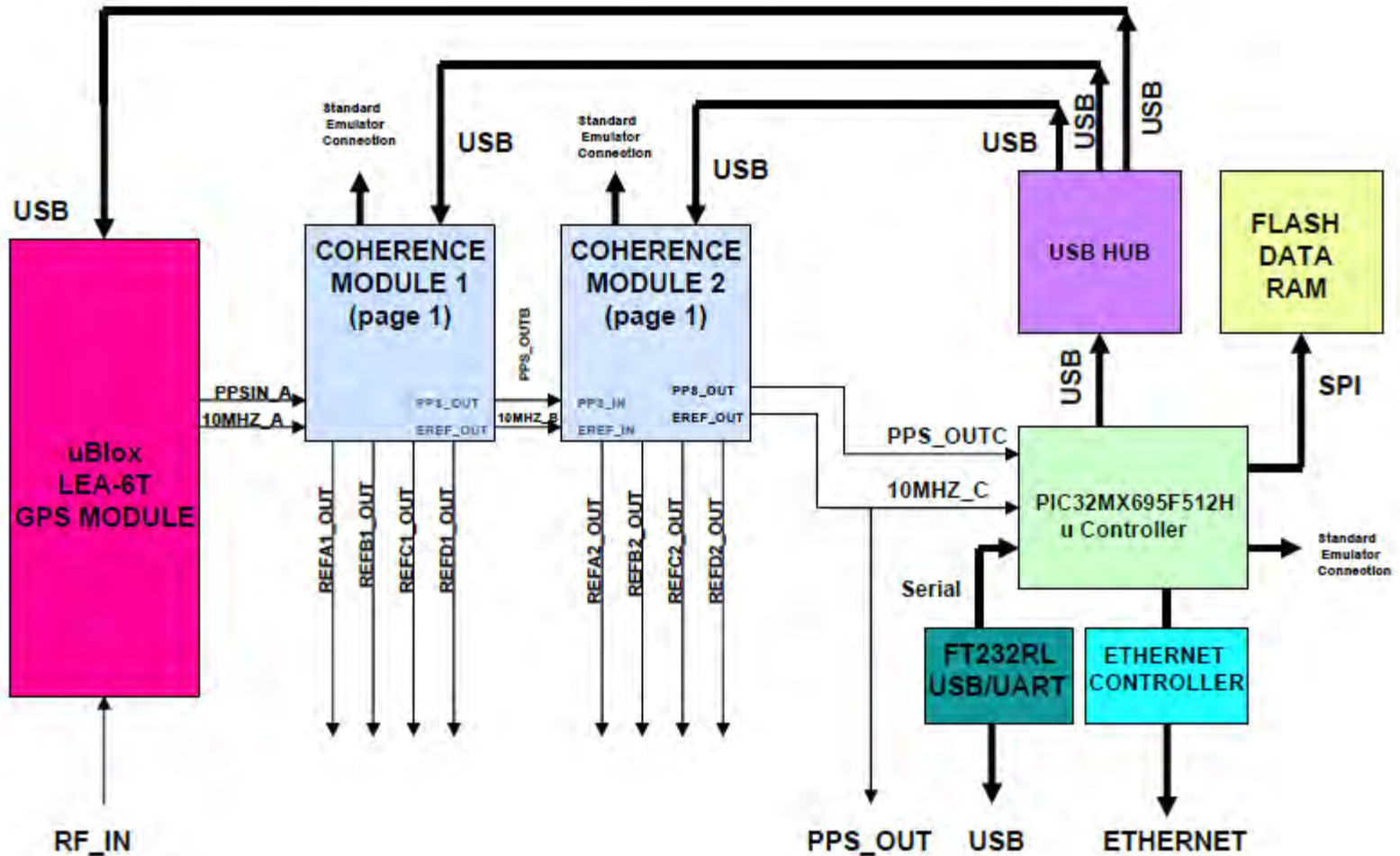
Mentors: James Marchese

Robert Schaefer

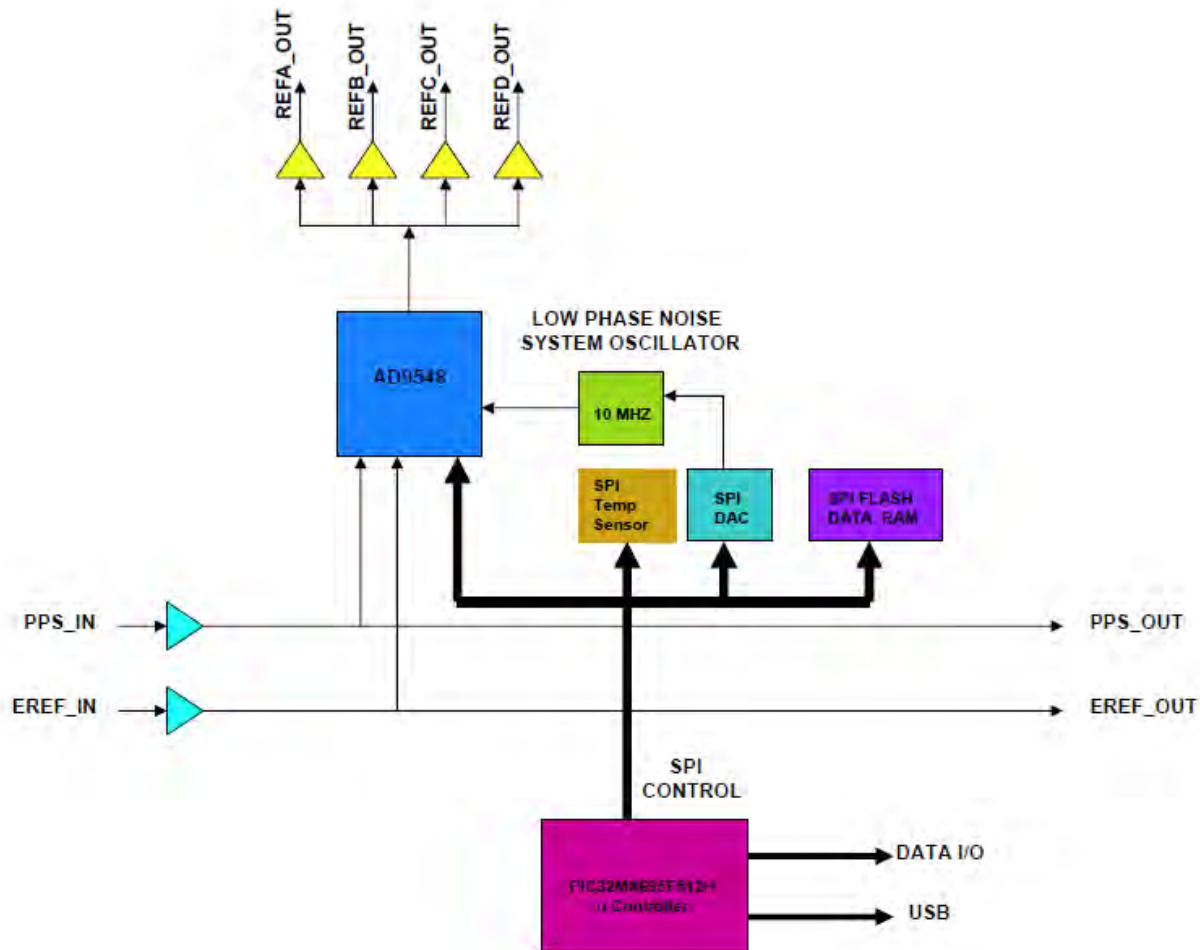
Microcontroller Software Framework



Example Platform: GPS Coherence

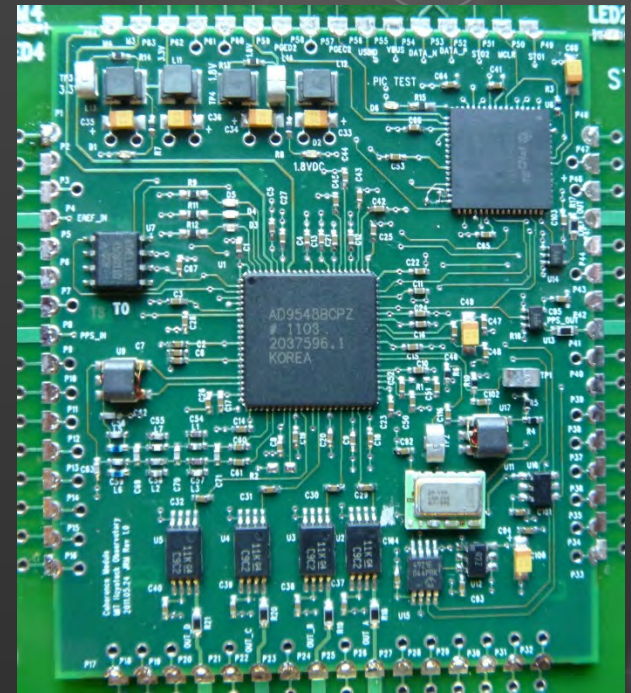


Coherence Module



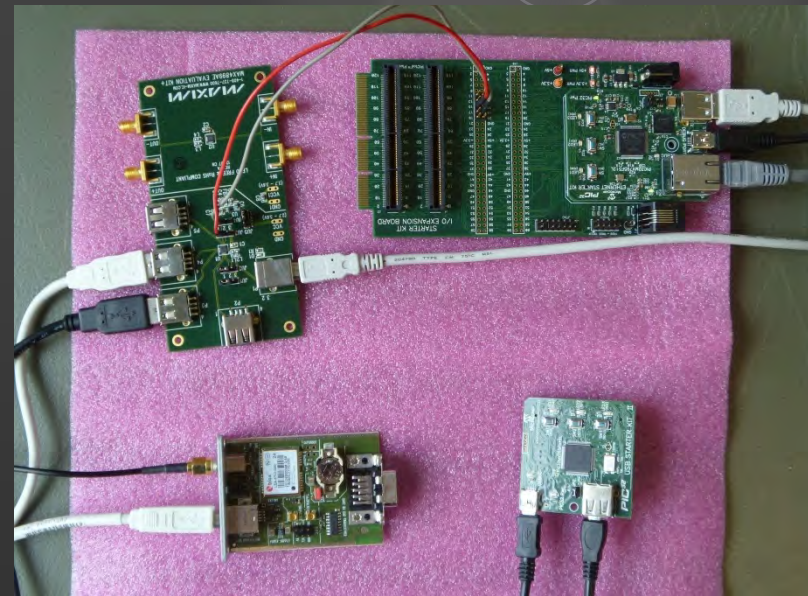
Coherence Module

- Design by Frank Lind, James Marchese
- Features
 - PIC32MX695 microcontroller
 - Analog Devices AD9548
- Now under electrical test



Carrier Board Emulation

- The carrier board microcontroller and Ethernet controller were simulated using the Ethernet Starter Kit
- An evaluation board for the Maxim USB multiplexer was used to route commands to selected modules
- A u-blox LEA-6T evaluation kit provides timing functionality
- A Microchip USB Starter Kit II was used to simulate a coherence module



Carrier Board Firmware

- The carrier board firmware makes use of the Microchip TCP/IP stack and USB Host stack, as well as components from the Microchip TCPIP Demonstration Application
- The Ethernet Starter Kit is used to implement an HTTP server for web-based configuration of attached modules
- Commands and new firmware may be sent to add-on modules
 - Passed from web browser to carrier board via HTTP POST
 - Passed from carrier board, through multiplexer, to modules via USB transfer
- The carrier board firmware configures the GPS module for PPS and 10MHz timepulse operation

Microchip Ethernet Starter Kit

- PIC32MX795
 - 512KB Program Memory
 - 128KB RAM
- USB debugging support
- 10/100 Mbps Ethernet
- PIC32 selected due to low cost
 - Less than \$7 in large qty.



Module Emulation/Firmware

- Microchip USB Starter Kit II used to simulate an add-on module
- USB interface
- Runs a modified Microchip bootloader
 - Accepts USB-CDC commands
- Remote firmware update through carrier board's web interface



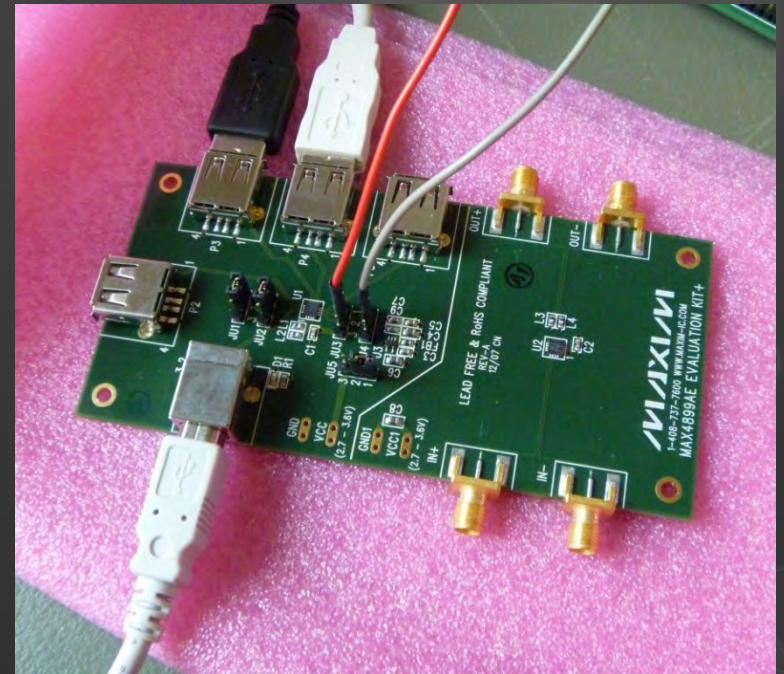
u-blox LEA-6T GPS receiver

- Two independently configurable timepulses—1Hz to 10MHz
- Fixed mode operation
 - Superior timing accuracy
- ARM7 microcontroller
 - USB communication
 - On-the-fly reconfiguration

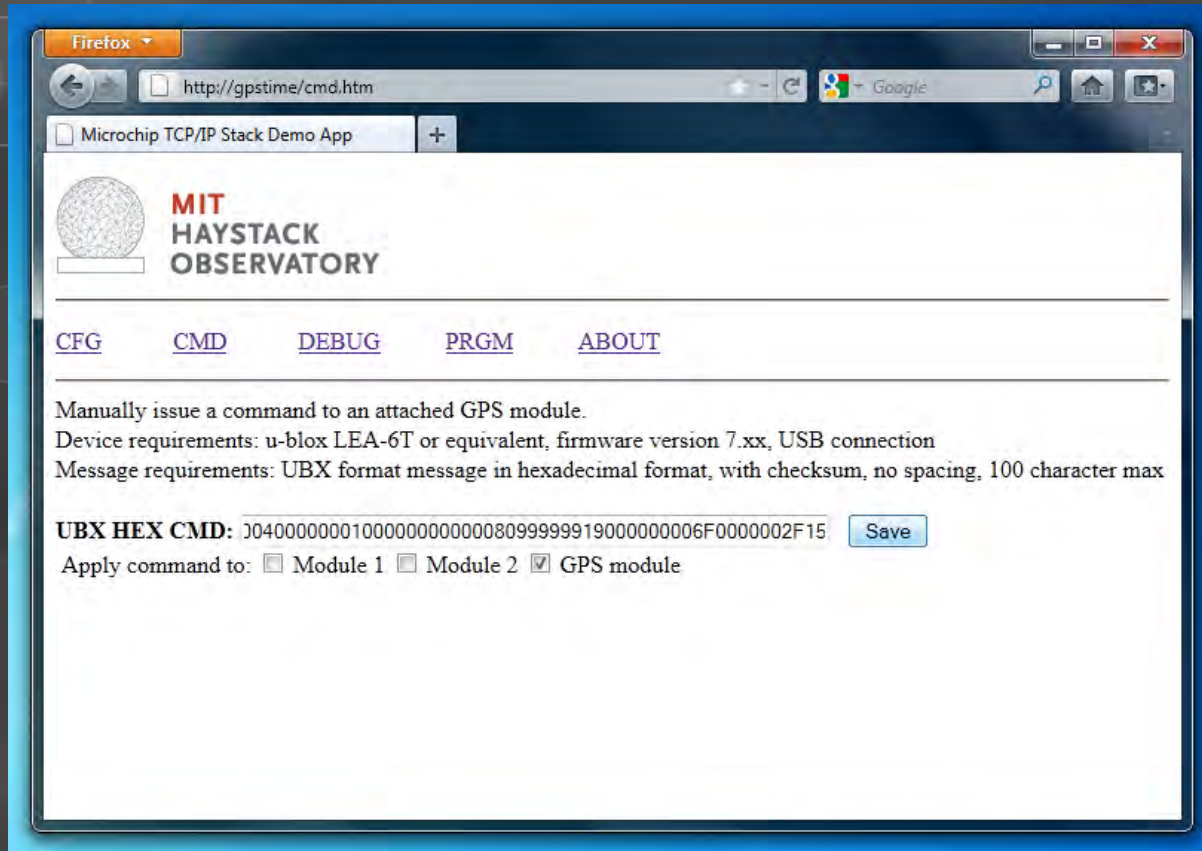


Maxim USB Multiplexer

- USB hub initially used in carrier board design
 - Not supported by Microchip USB stack
- Analog 3:1 multiplexer
 - One upstream host
 - Up to three attached devices
 - Only one device connected to host at a time
- All devices powered simultaneously



Command Interface



The screenshot shows a Firefox browser window with the address bar displaying `http://gpstime/cmd.htm`. The page header includes the MIT Haystack Observatory logo and navigation links for [CFG](#), [CMD](#), [DEBUG](#), [PRGM](#), and [ABOUT](#). The main content area contains the following text:

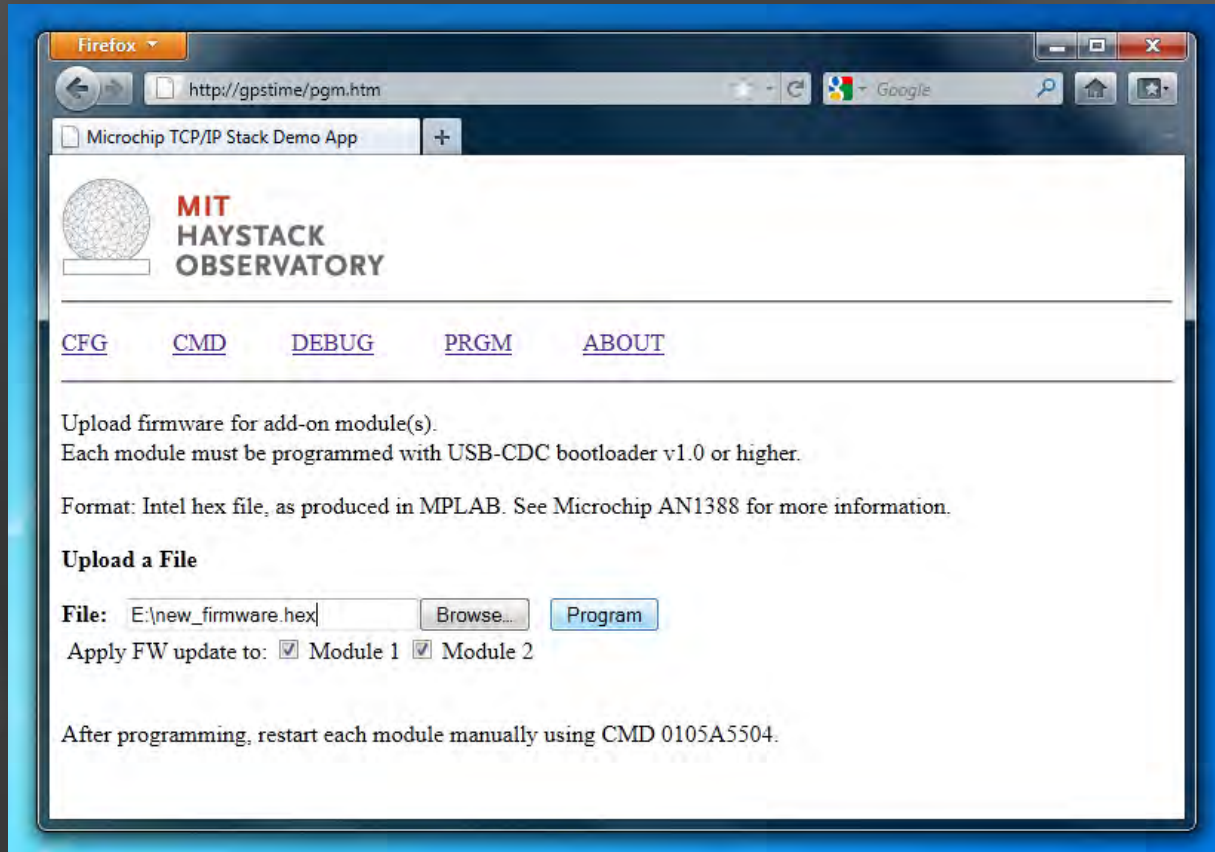
Manually issue a command to an attached GPS module.
Device requirements: u-blox LEA-6T or equivalent, firmware version 7.xx, USB connection
Message requirements: UBX format message in hexadecimal format, with checksum, no spacing, 100 character max

UBX HEX CMD:

Apply command to: Module 1 Module 2 GPS module



Programming Interface



The screenshot shows a Firefox browser window with the address bar displaying `http://gpstime/pgm.htm`. The page title is "Microchip TCP/IP Stack Demo App". The main content area features the MIT Haystack Observatory logo and a navigation menu with links for [CFG](#), [CMD](#), [DEBUG](#), [PRGM](#), and [ABOUT](#).

Upload firmware for add-on module(s).
Each module must be programmed with USB-CDC bootloader v1.0 or higher.

Format: Intel hex file, as produced in MPLAB. See Microchip AN1388 for more information.

Upload a File

File:

Apply FW update to: Module 1 Module 2

After programming, restart each module manually using CMD 0105A5504.

Future Work

- Further testing and validation
- Firmware for coherence module PICs
 - SPI devices, AD9548 control
- Host side improvements
 - USB to USART, flash data storage
- Support for additional modules
 - Tuners (upconverters/downconverters)
 - Calibration sources
 - ADC/DAC Serial Control

References

- Analog Devices Application Note 1002
- Axelson, Jan. *USB Complete, Third Edition*
- Esterline, John. Oscillator Phase Noise: Theory vs. Practicality.
- Microchip Application Notes 833, 1247, 1388; microchip.com
- u-blox GPS Compendium

Thanks

- My mentors, Jim Marchese and Bob Schaefer
- Phil Erickson and Frank Lind
- Ching Lue
- Will Rogers
- Atmospheric Science Group
- KT Paul and Haystack Observatory
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