41C Flexible Hardware Module

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Agenda

- A Little History
- The Hardware
- Limitations
- Currently Implemented Modules
- Other FHM possibilities
- A Potential Upgrade
- Questions?

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A Little History

- 2010: first version of the 41CL
- 2011: first version of the Time clone
  (direct implementation of specification)
- 2012: second version of the Time clone
  (implemented in three Xilinx CPLD devices)
- 2015: third version of the Time clone
  (implemented in a Lattice FPGA)
- 2017: fourth version of the Time clone
  (different Lattice FPGA, PCB designed)
- 2018: converted design to Flexible Hardware Module

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The Hardware

- Lattice iCE40Ultra FPGA
  - 2048 LUTs + 2048 FFs in a 48-QFN package
  - Twenty 4096-bit block RAMs
  - 48MHZ, 10KHz oscillators, PLL, 4x DSP, 2x SPI, 2x I2C
- 1.2V, 2.5V, 3.3V sequenced power supplies for FPGA
- 3.3V -> 6V bus drivers (ISA, DATA, FI)
- Resistor-based 6V -> 3.3V translators
- 32768Hz oscillator
- POR chip
- 8-pin FFC programming connector (4 I/O available)

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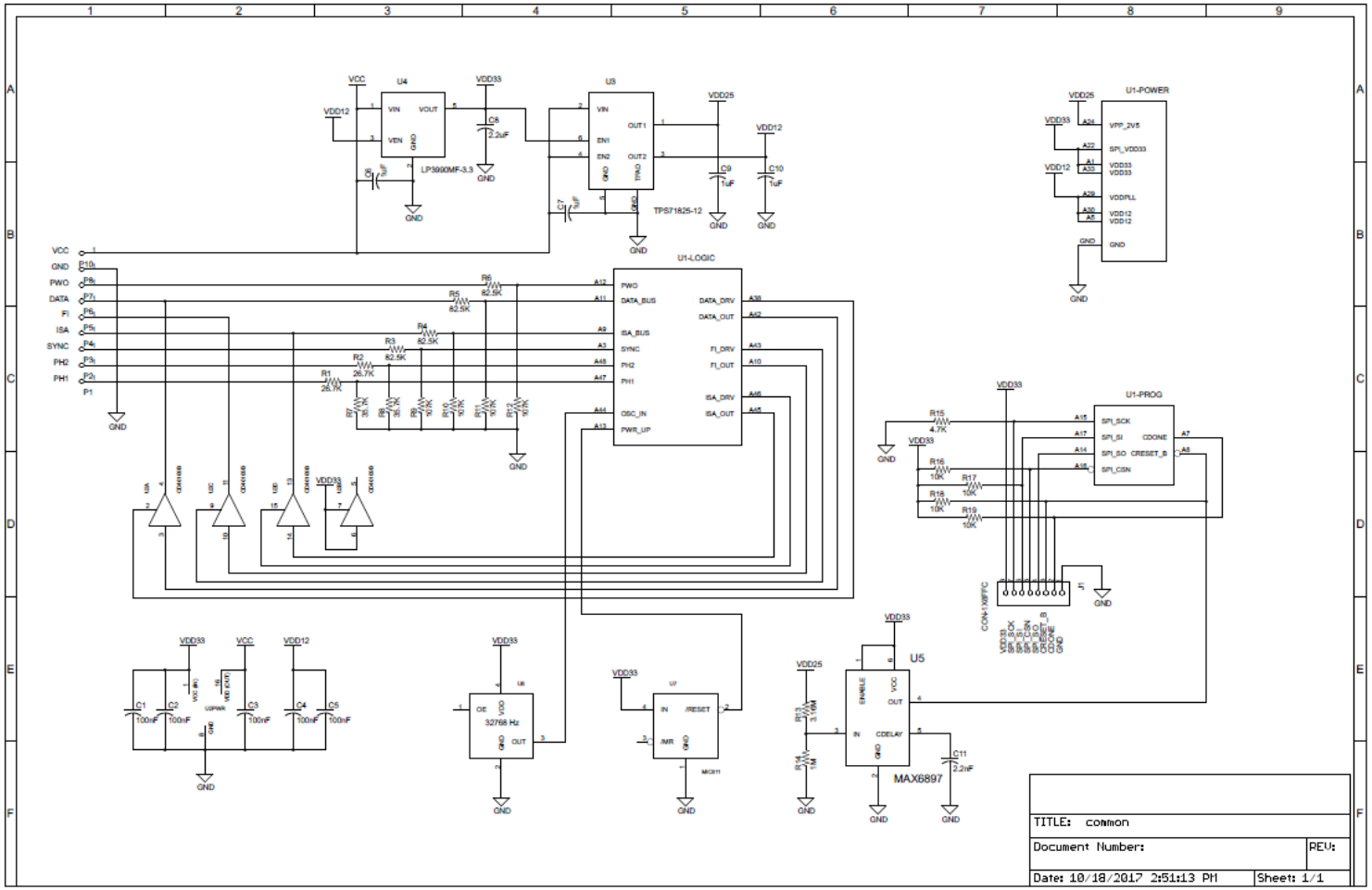
FHM Schematic



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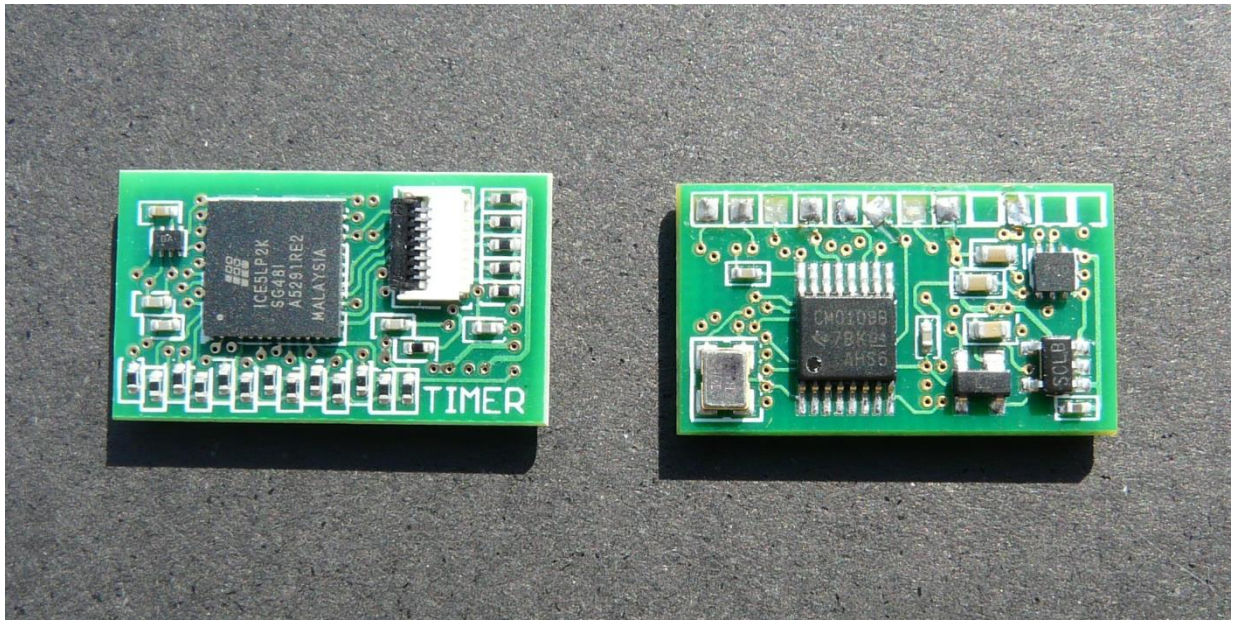
23mm x 13.2mm



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Limitations

- One-Time-Programmable FPGA
  - Internal NVCM for programming
  - Means that all designs must be breadboarded
- No Port decode hardware
  - Fixed page decode (can be made programmable)
- 230uA typical current drain
- Only four I/O available
  - Default is three inputs, one output
  - Inputs have resistors on the board (can be removed)
- Resistive level shifters optimized for 1x bus speed

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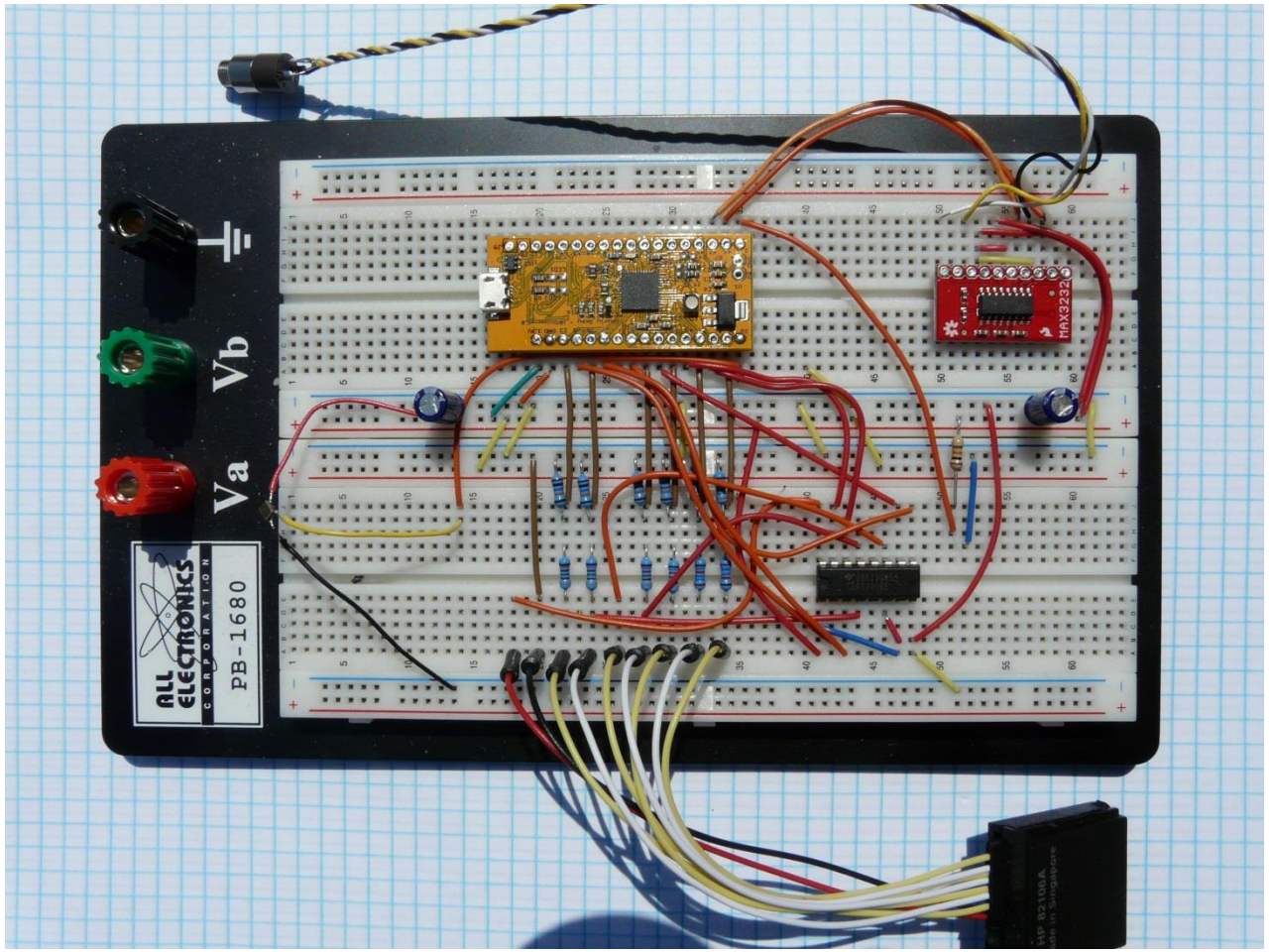
UPDuino Breadboard



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Time Module

- 834 out of 2048 LUTs
- 627 out of 2048 FFs
- 10 block RAMs for ROM

Fully functional (as far as I know)

Being shipped mounted on 41CL boards

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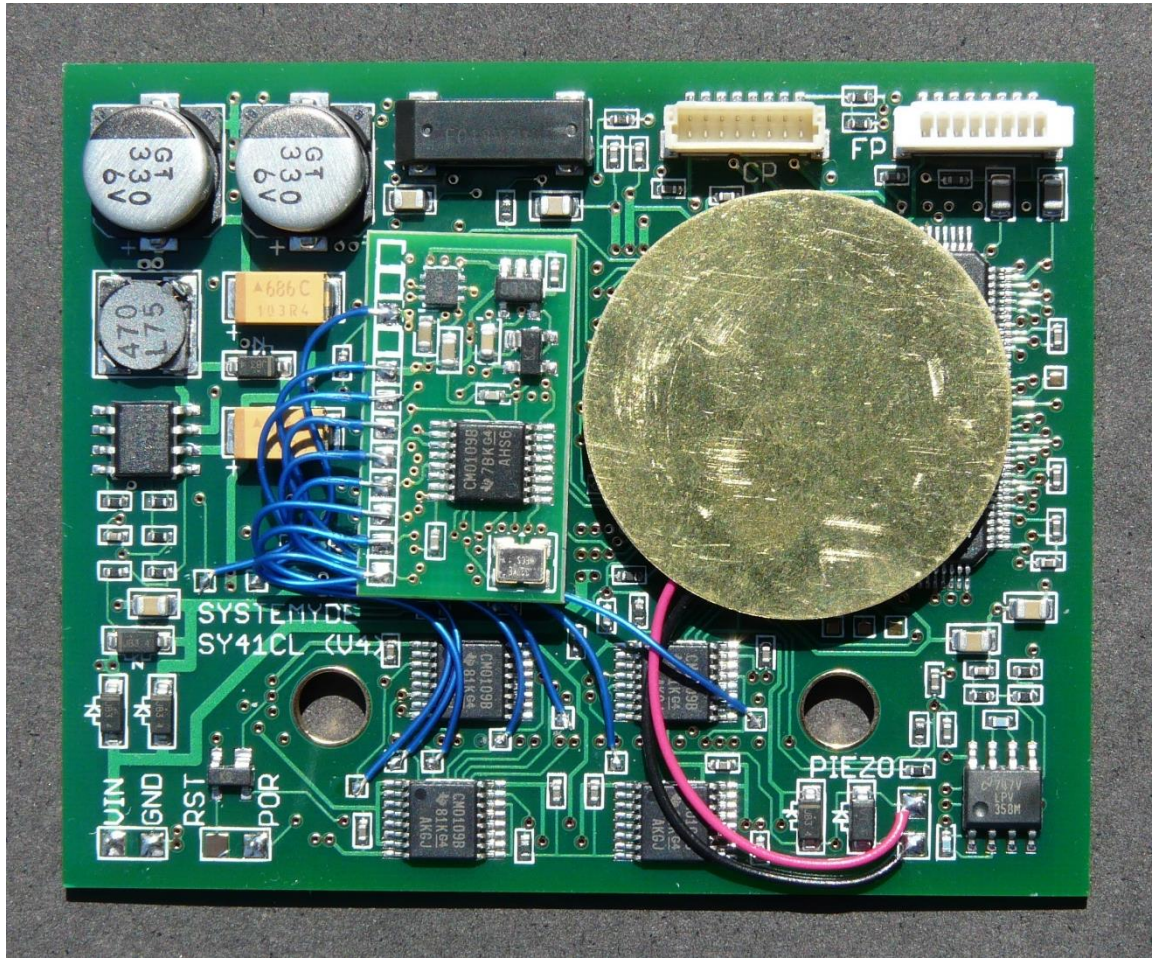
41CL + Time Module



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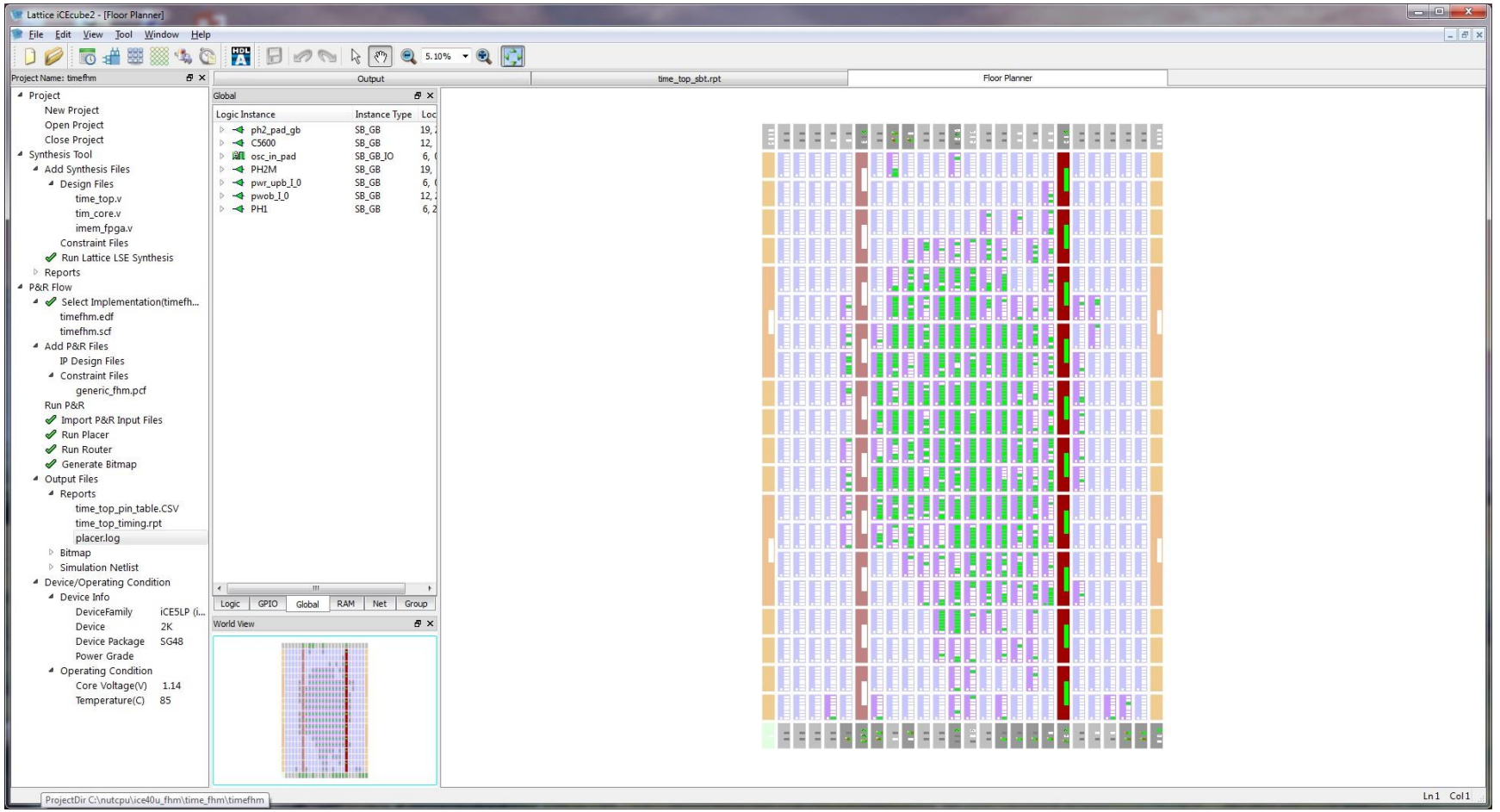
Time Module



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Time Module + 2x X-MEM

- 1058 out of 2048 LUTs
- 720 out of 2048 FFs
- 10 block RAMs for ROM
- 8 block RAMs for X-MEM

Fully functional (as far as I know) breadboard version

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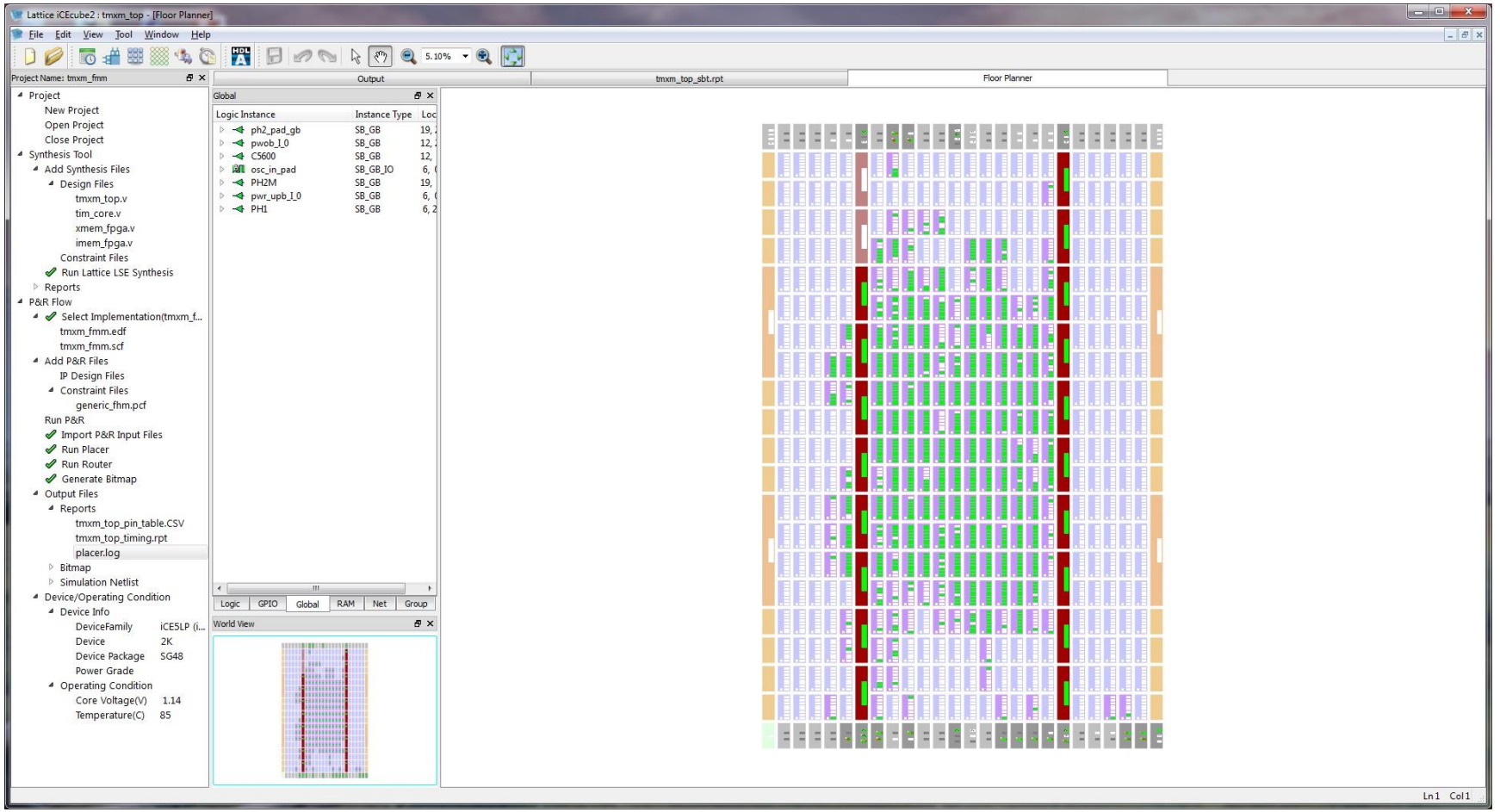
Time Module + 2x X-MEM



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X-FNS + 2x X-MEM

- 375 out of 2048 LUTs
- 189 out of 2048 FFs
- 10 block RAMs for ROM
- 10 block RAMs for X-MEM

Fully functional (as far as I know) breadboard version

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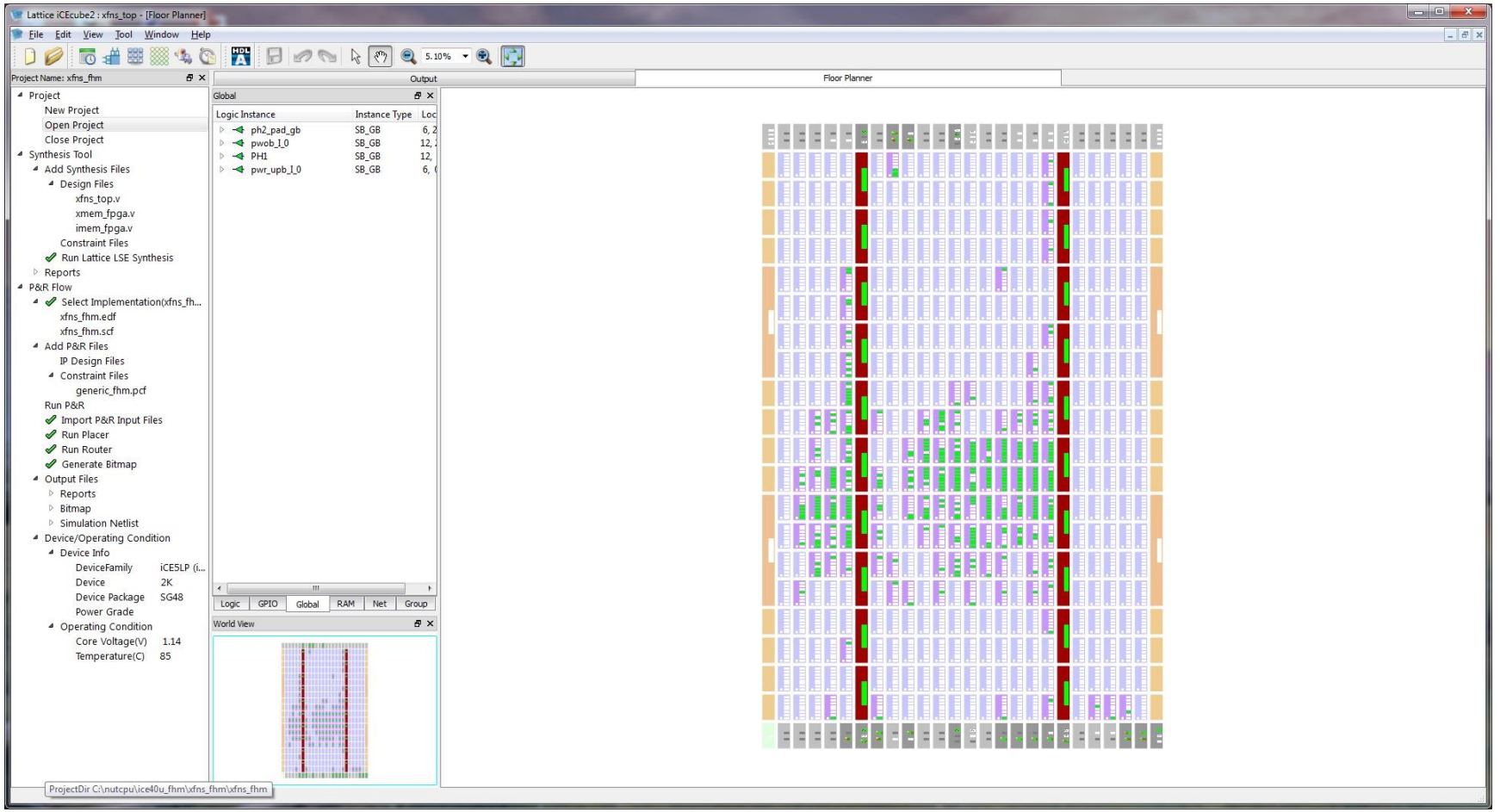
X-FNS + 2x X-MEM



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2x X-MEM

- 237 out of 2048 LUTs
- 103 out of 2048 FFs
- 8 block RAMs for X-MEM

Fully functional (as far as I know) breadboard version

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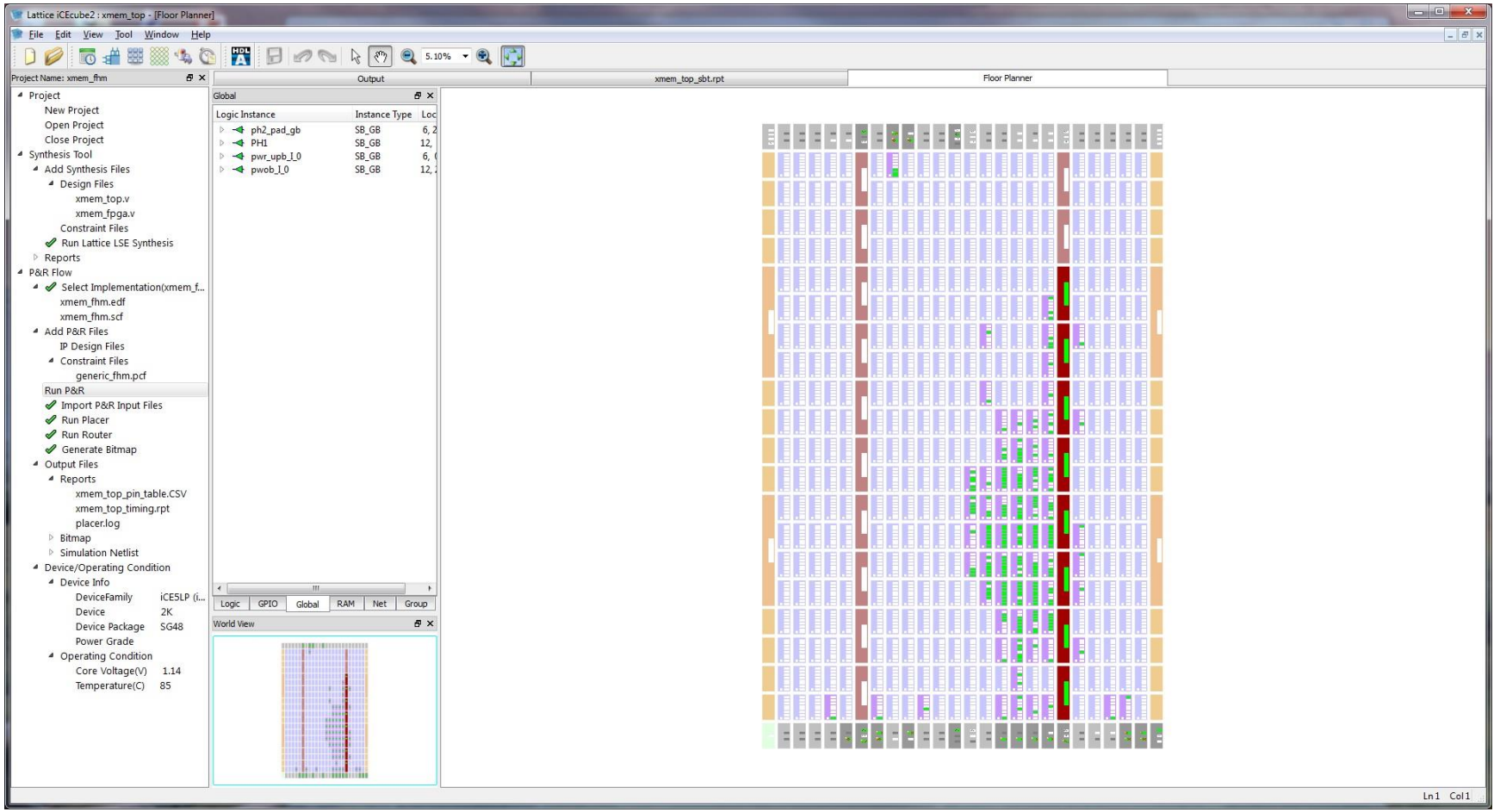
2x X-MEM



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GNSS Module

- 1259 out of 2048 LUTs
- 763 out of 2048 FFs
- 10 block RAMs for ROM (but it’s also writable)
- 6 block RAMs for ping-pong buffer (3 and 3)
- 1 block RAM for 41C peripheral registers
- 1 block RAM for receiver FIFO
- 1 block RAM for transmitter FIFO
- 3-wire connection FHM to GNSS receiver (rx, tx, enable)

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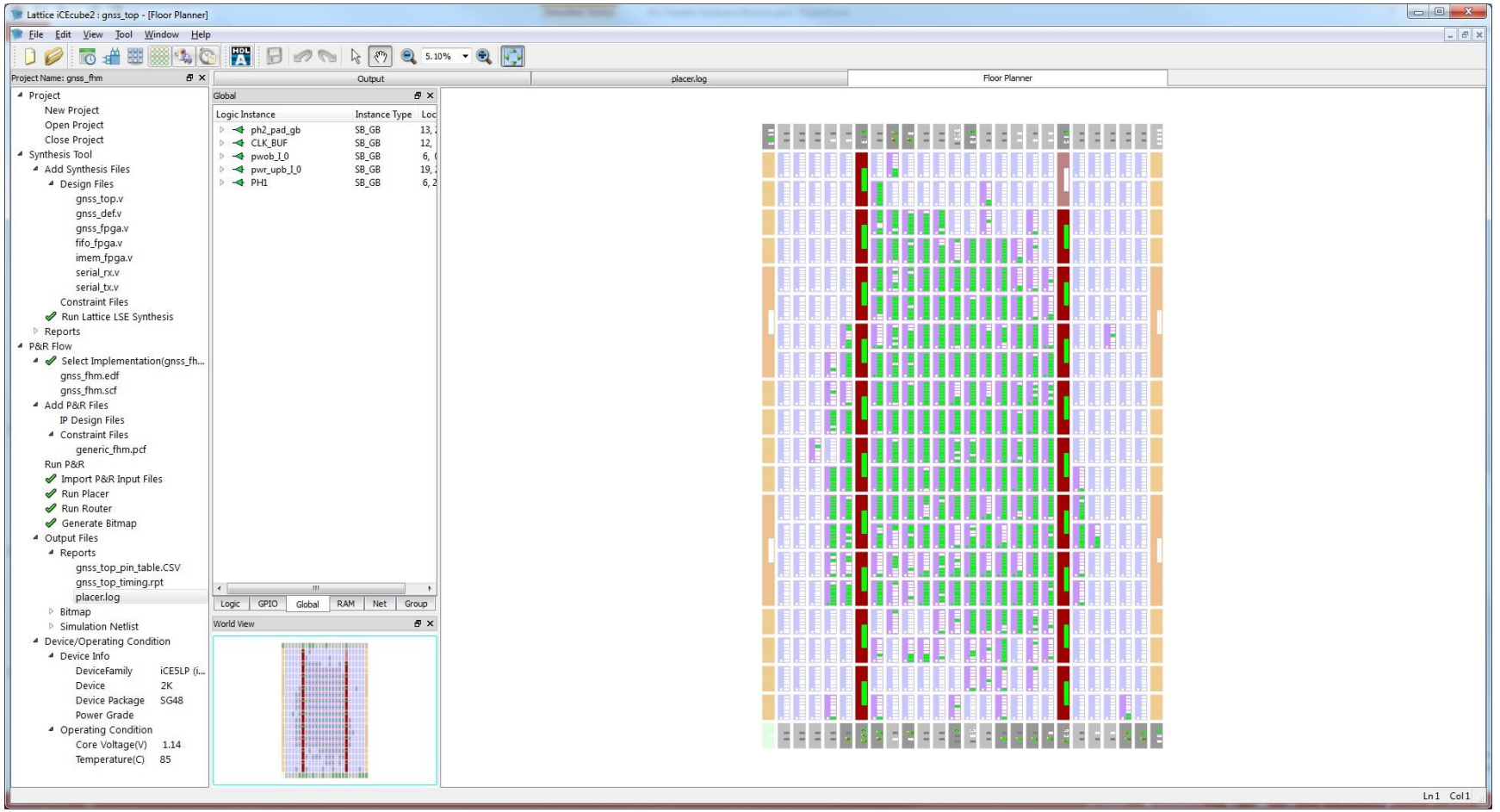
GNSS Module



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GNSS Module Hardware

- Double-length module housing
- U-blox 7 GNSS receiver (8mm x 35mm x 6.5mm)
- 38.4K bit/s UART for communication
- Does as much processing as possible in hardware
    - Ping-pong buffer for NMEA messages
    - Tracks and sorts NMEA messages
    - Tracks fix status (1-d, 2-d, 3-d)
    - 41C peripheral registers for converted values
- Software in ROM provides full feature set

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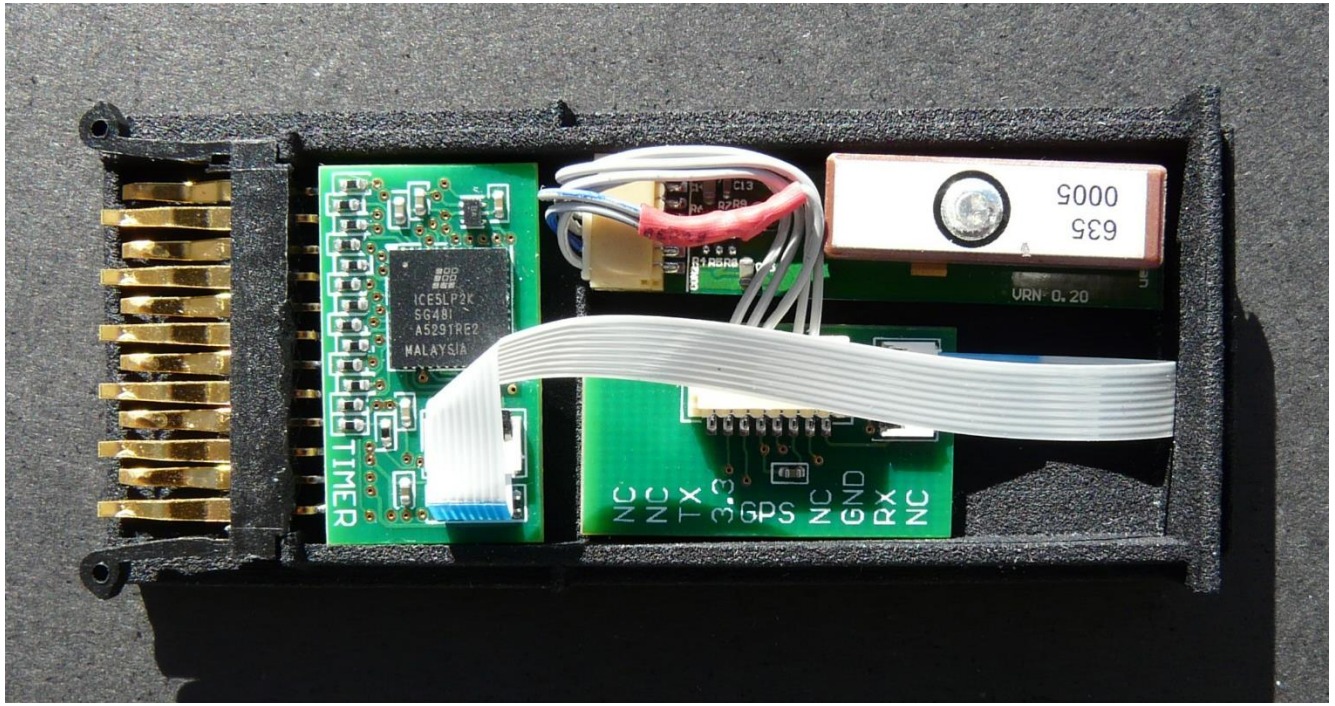
Inside the Module Housing



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GNSS Module Software

- Receiver Control functions (on, off, sleep, etc.)
- Individual GNSS Data functions (lat, lon, alt, vel, dir, etc.)
- Waypoint functions
    - Lock ping-pong buffer and read fix data
    - Write selected fix information to 41C registers
    - Optional alpha header to identify fix information
- Waypoint Housekeeping functions (register pointers)
- Miscellaneous functions (display formats, conversions)
- ROM Option functions (disable, relocate, write)
- Possible upgrade is clock display like Time Module

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GNSS Function List

ROMID
GNOFF
GNON
GNON?
GNTRK?
DATUM
LAT
LON
ALTI
HEADING
SPEED
UTIME

UDATE
SATS
SATIV
GEOID
HDOP
VDOP
AC
ACX
ACT
ACTX
ACTD
ACTDX

CT
CTX
CTD
CTDX
LL
LLX
LLA
LLAX
LLAC
LLACX
LLACT
LLACTX

LLACTD
LLACTDX
LLC
LLCX
LLCT
LLCTX
LLCTD
LLCTDX
LLT
LLTX
LLTD
LLTDX

RCLWBR
STOWBR
RCLWPR
STOWPR
RCLRNG
WPR+X
DMT
GMODE
GMODE?
DISROM
ENROM
RELROM
WRROM

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GMODE Identifiers

Functions affected	Default	Options			
Waypoint Functions	TAG	RAW			
Individual GNSS Functions	ALP	NOA			
LAT, LON	DEG	DMS	DMT		
ALTI	M	FT			
SPEED	KT	MPH	KM/H	M/S	F/S
Power Control	AUTO	GOFF	GON		
Communication Speed	384	192	96	48	
Interrupt	NOW	WAK			

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Other FHM Possibilities

- SD card controller?
- Multi-protocol serial (UART, SPI, I2C) interface?
- Printer controller?
- IR printer controller?
- General-purpose IR?
- Remote display controller?
- Machine Language Development Lab?
- Barcode wand controller?
- HP-IL controller?
- What else?

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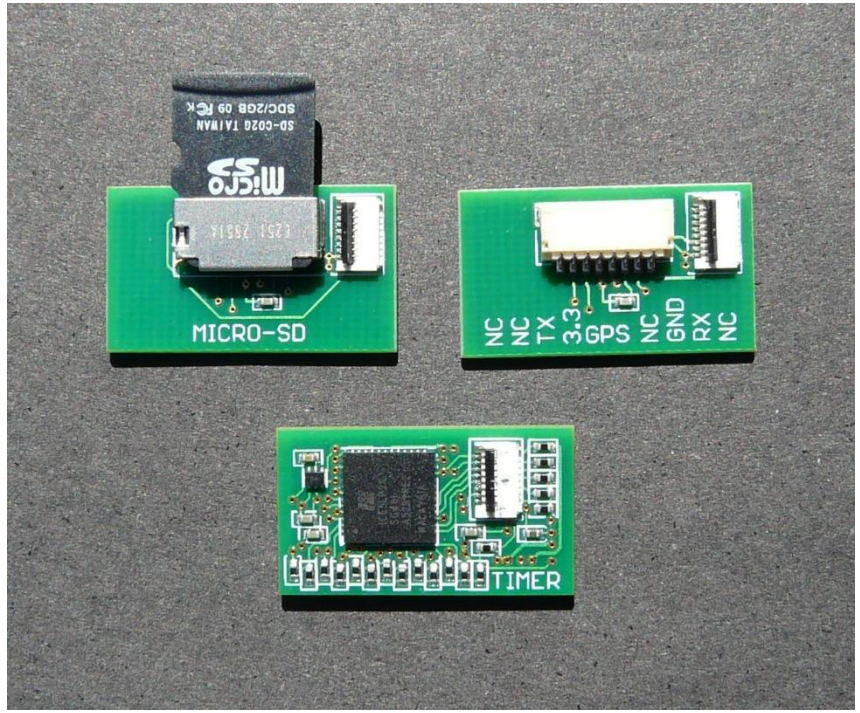
FHM and Adapter Boards



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Potential Upgrade

- **Lattice iCE40UltraPlus**
  - **5280 LUTs + 5280 FFs in same 48-QFN package**
  - **Thirty 4096-bit block RAMs**
  - **48MHZ, 10KHz oscillators, PLL, 8x DSP, 2x SPI, 2x I2C**
  - **Four 16k x 16 SPRAM blocks**

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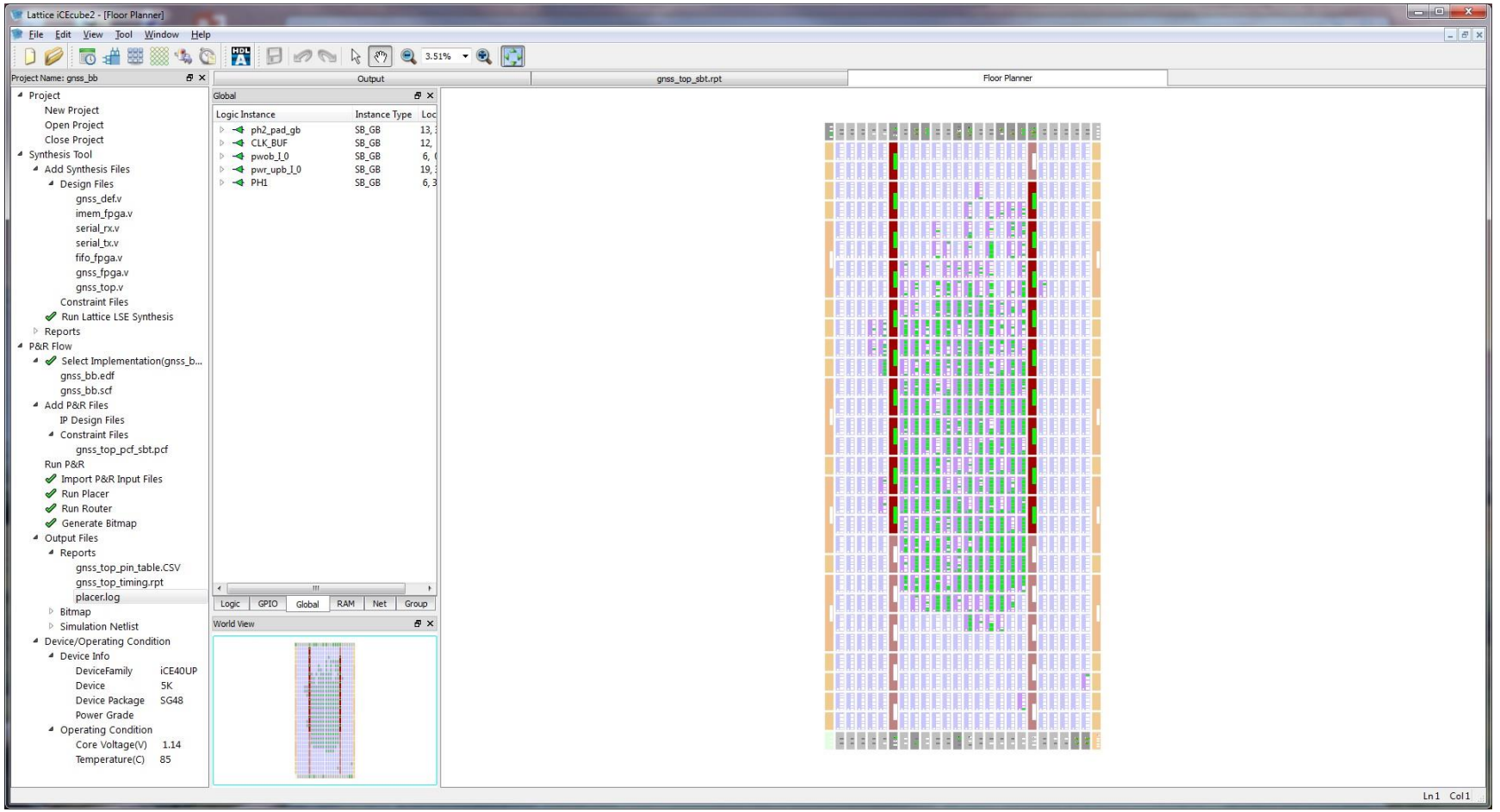
GNSS in UltraPlus



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Questions?

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