CMOS VLSI Lab
Fall 2014

Final Project
User Documentation

Today's Date:	**12-12-14**
Team Name:	***TEAM RAJ***
Group Members and Work Distribution:	**John Gangemi** – Designed logic for ASIC, Created layout components, Integrated components into padframe (Floorplanning & Routing) **Alex Holst** - Padframe I/O buffering, Assisted with layout and circuit testing **Raj Patel** - Wrote Reports, Assisted with Layout , and Coordinated Meetings
No. of Hours Spent:	~100 hrs
Exercise Difficulty: (Easy, Average, Hard)	**Hard**
Any Other Feedback:	Power routing proved to be the most difficult part of this project.

I. BUILDING A DIGITAL THERMOMETER

Functionality

The Digital Thermometer ASIC is designed to work in conjunction with Texas Instrument's TMP121 Analog-to-Digital Temperature Sensor through SPI (Serial Peripheral Interfacing) communication protocol. The custom ASIC functions as the 'Master' device therefore providing the 'Slave' TMP121 with the appropriate signals (system clock and chip select) in order to generate a serial data link through the 'SPI' I/O pin of the TMP121.

Application of voltage to either or both I/O pins Mode1 and Mode0 will generate the following signals routed to the output pin sections 'Out0, Out1, and Out2'...

Mode 1	Mode 0	Out1 (0-6) & Out2 (0-6) [*7 Segments*]	Out0 (0-7) [*Test Pins*]
0	0	Celsius-to-Fahrenheit module	Celsius-to-Fahrenheit module
0	1	SPI module	SPI module
1	0	Celsius-to-Fahrenheit module	SPI module
1	1	SPI module	Binary-to-BCD module

It should be noted that I/O pins Out1 (0-6) are for the ones digit 7 segment display and I/O pins Out2 (0-6) are for the tens digit 7 segment display.

To apply a system reset to the custom ASIC one must assert the 'RST' pin high, this will in effect restart the 8-bit Asynchronous Counter and clear all data in the 6-bit Parallel In/ Parallel Out Shift Register. With regards to the output pin sections the data transmitted will reflect a celsius value of 0 degrees (SPI holds 000000 binary).

Specifications

Supply voltage (Vdd):	5v
ASIC operating temperature:	*See MOSIS TinyChip datasheet
Functional celsius temperature:	0 - 37°
Functional fahrenheit temperature:	32 - 98° (+/- 1°)
Operating frequency:	500 Hz
Duty cycle:	50 %
Minimum conversion time (CS' = 1):	320 ms (*See Texas Instrument TMP121 datasheet)
Clock cycles per conversion time (CS' = 1):	160 cycles (operating frequency / minimum conversion time)
Clock cycles for SPI I/O (CS' = 0):	9 cycles
Clock cycles per ASIC conversion:	169 cycles (clock cycles per conversion time + clock cycles for SPI I/O)
Circuit update frequency:	2.96 updates per second (operating frequency / clock cycles per ASIC conversion)

* ASIC has been simulated at operating frequencies up to 2 microsecond cycle time (2 MHz) with a 50% duty cycle, however to maintain sufficient functionality of the ASIC it is recommended that the user implement the operating frequency listed in the above chart.

ASIC Timing Diagram