"SoundSocket"

By

April 14, 2014

Meet the Team

- Josh Ancill
- Andy Cheng
- Daman Dhillon
- Kim Izmaylov
- Laura Wiggins

Technical Responsibilities

Firmware & Software Engineers:

Laura Wiggins and Daman Dhillon

Digital Hardware (FPGA) Engineers:

Josh Ancill and Andy Cheng

Analog Electronics Engineer:

Kim Izmaylov

Overview

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    b. Problem
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Background

- Wireless-centric age
  - WiFi, Bluetooth
- Portability: no wires!
- Recent development: Wireless Audio Streaming

Existing Solutions

- Bluetooth: 
  - low range
  - expensive for high-end models ($300~600+)
- WiFi and Bluetooth both use 2.4 GHz 

- Example service: AirPlay 

  - Locked to Apple devices

Problem: Interference

Spectrum interference is introduced by:

- Microwaves
- Wireless phones
- Routers/WiFi networks

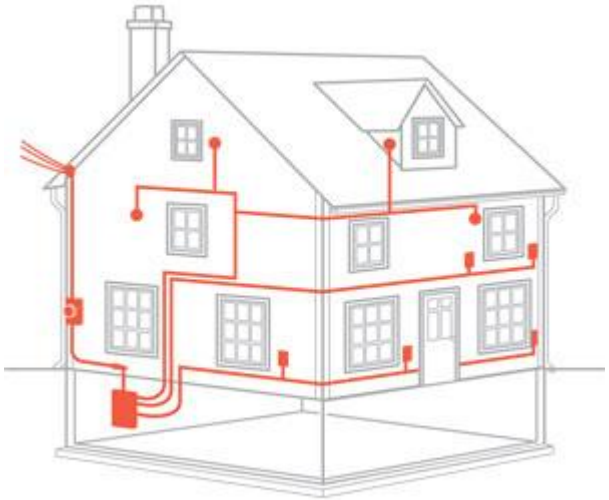
More devices = More interference

Problem: Interference

- Oversaturation of the 2.4 Ghz channel
- Dropped signals and distortion

Is there a way to bring the best of both worlds?

Consider a typical home...



- Existing network of copper wiring
- Idea: use this network of wires to transmit audio

Market Analysis

Direct Competition:

- IOGEAR Powerline Stereo System ($740)
- Simple Audio Roomplayer (UK only)

Indirect (non-powerline):

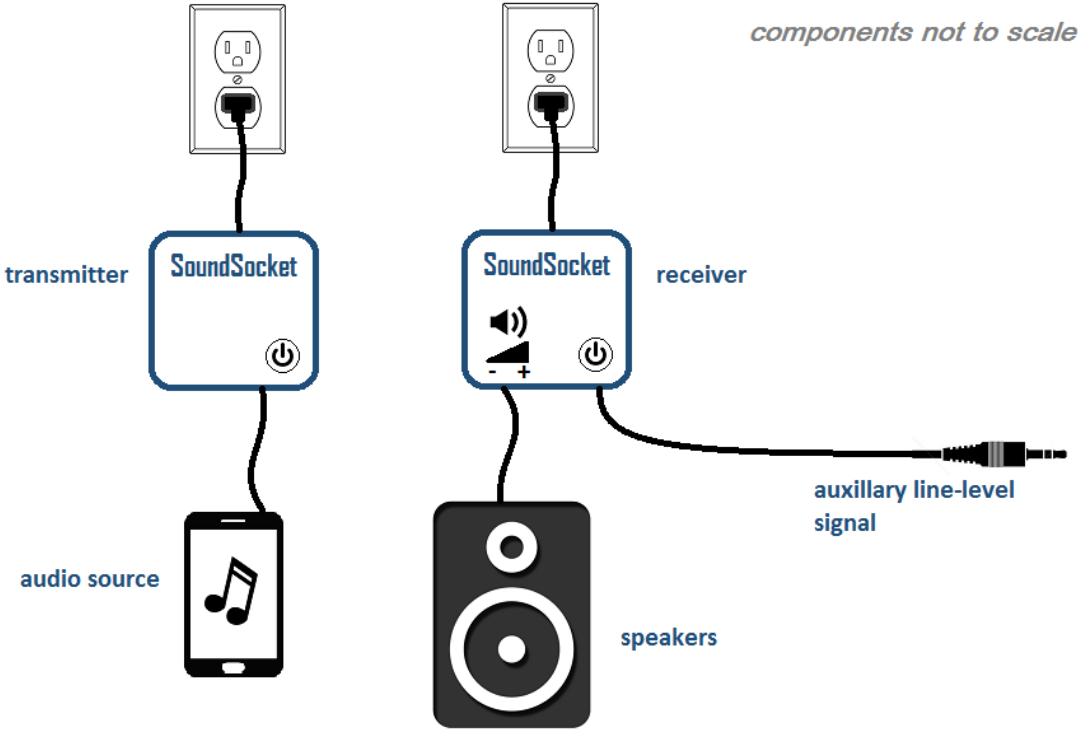
- Apple AirPlay, Bluetooth speakers

Major Design Obstacle

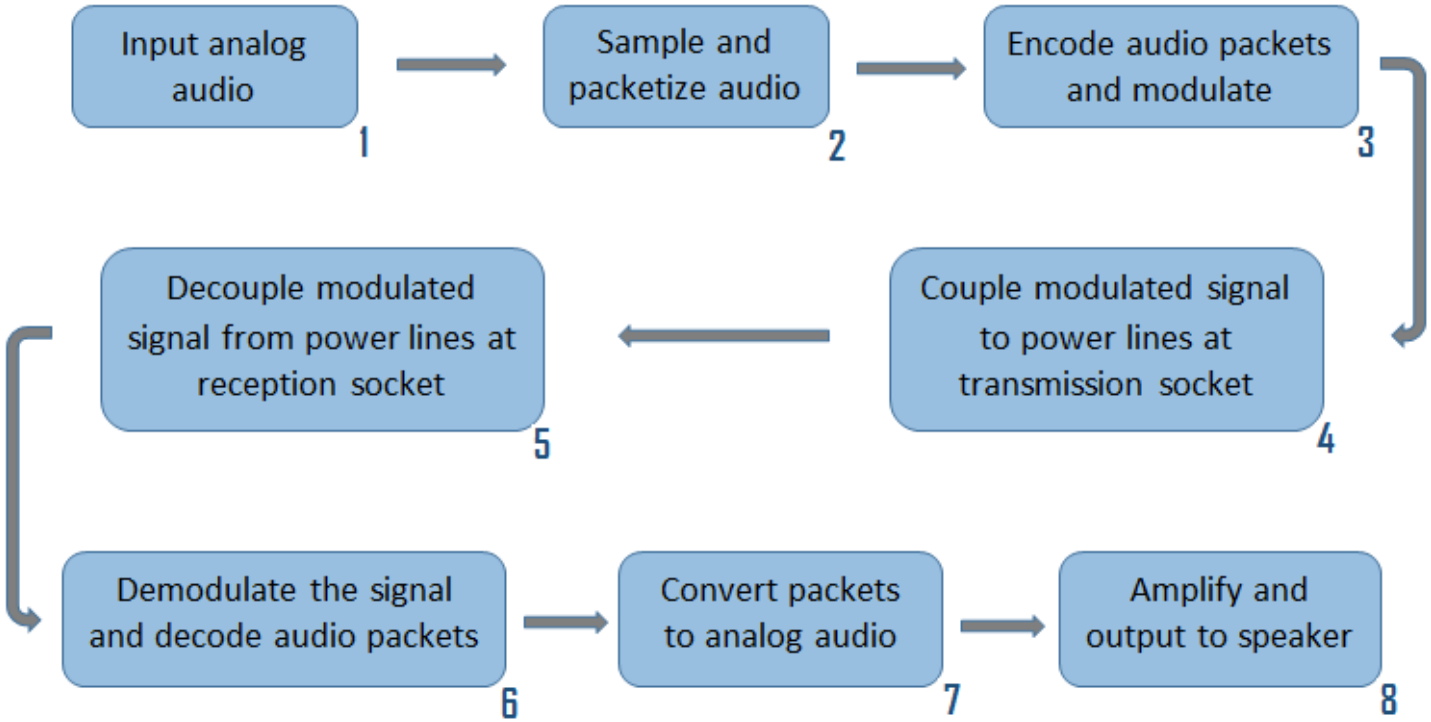
Home wiring:

- Designed for power transmission
  - Lossy wires
  - 120V 60Hz existing signal
- Cause of most design requirements
  - Packetizing
  - Modulation

Visual System Overview



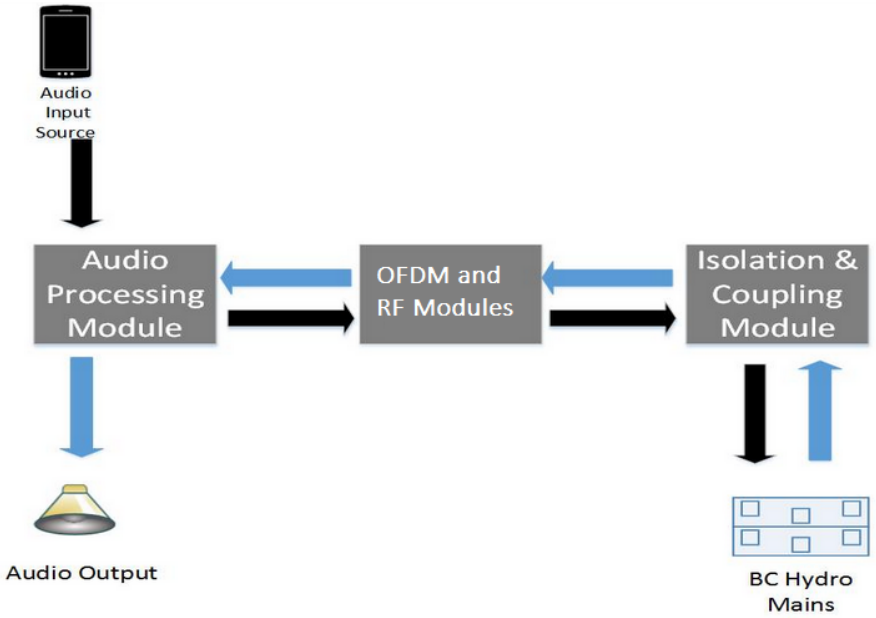
Functional Block Diagram



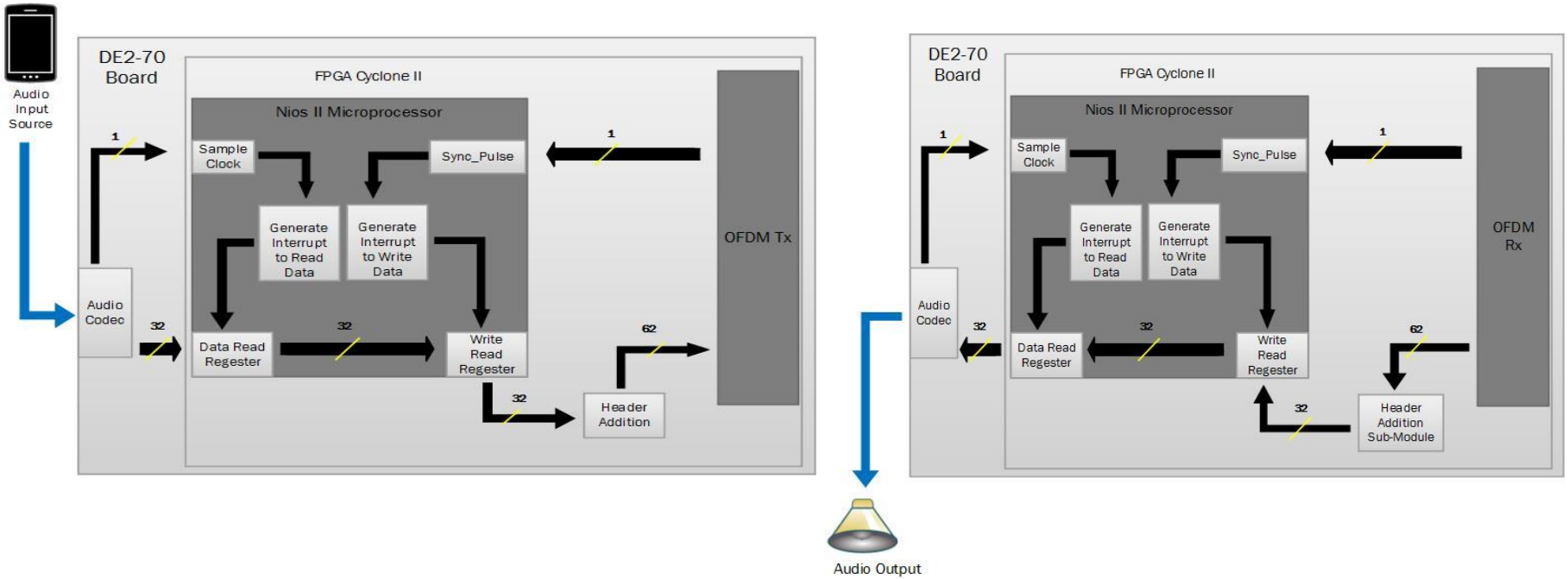
System Overview

4 modules:

- Audio processing module
- OFDM module
- RF module
- Isolation & coupling module

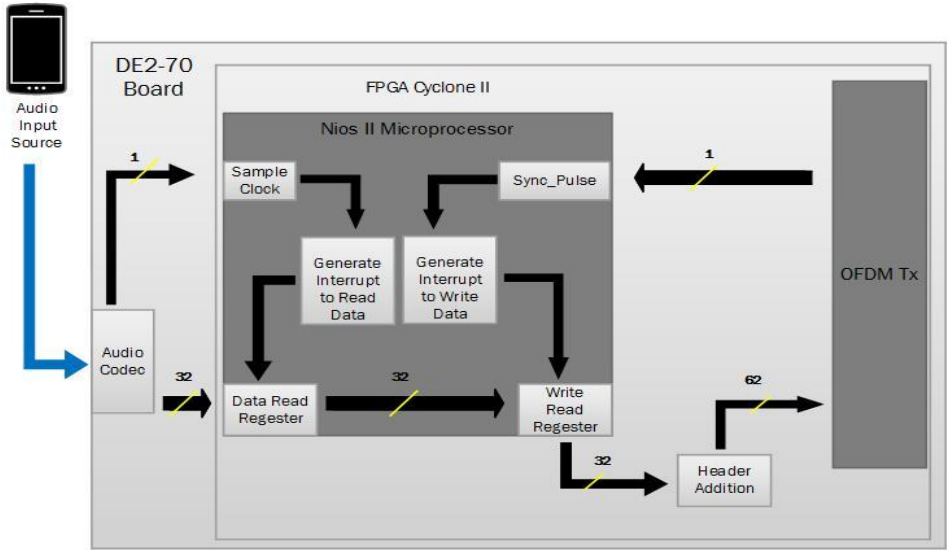


Transmitter/Receiver Pair (RF and isolation/coupling omitted)



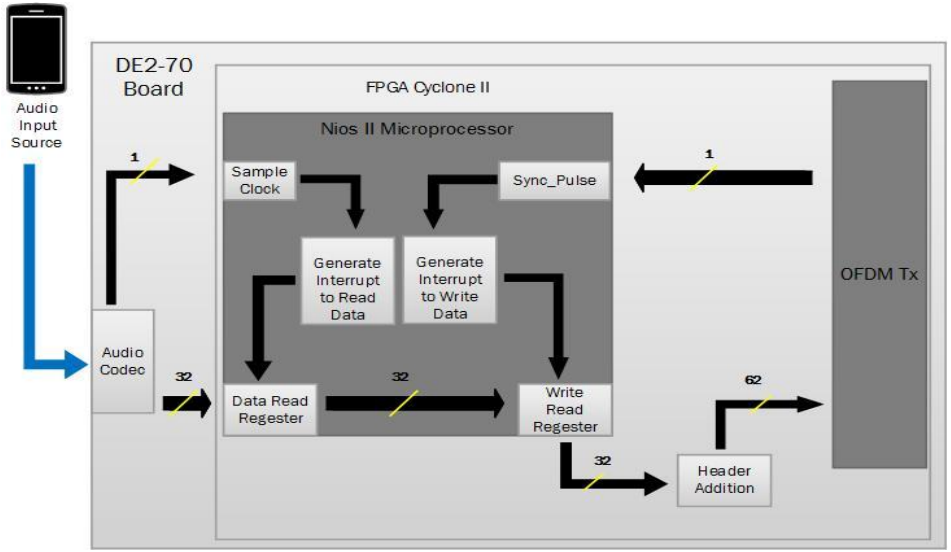
Input and Output Specifications

Sub Module	Input	Output
Audio CODEC	Analog audio signal	32 bit digital data (16 bit left and right channel)
Nios II Processor	32 bit digital data	32 bit digital data
Header Addition	32 bit digital data	62 bit digital data



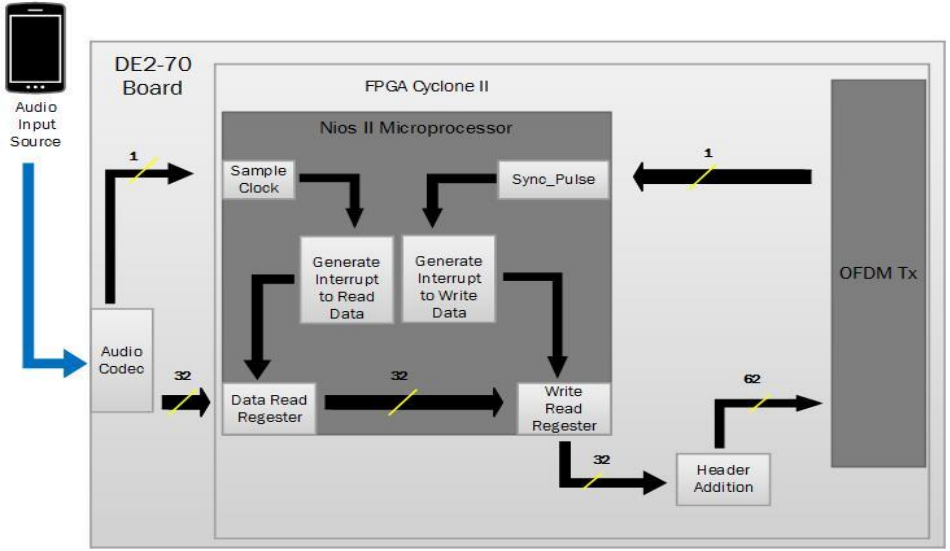
Audio CODEC Sub Module

- Wolfson WM8731 Audio CODEC
- Data sampling rate ~40 kHz
- Implemented in VHDL



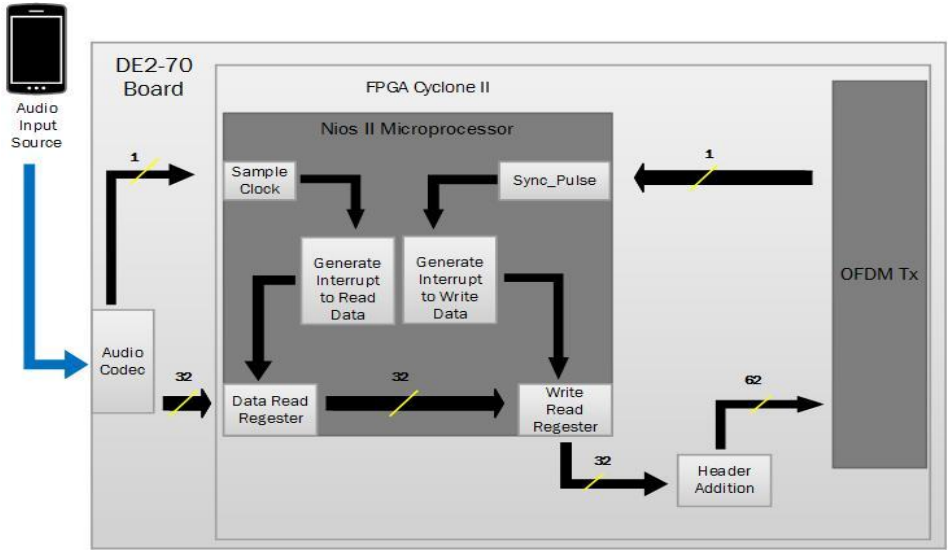
Nios II Processor Sub Module

- Used Nios II embedded processor
- Implemented functionality via interrupt service routines
- Used different clocks for data read and data write registers



Header Addition Sub Module

- Implemented in VHDL
- Uses a 10 MHz clock to facilitate synchronization

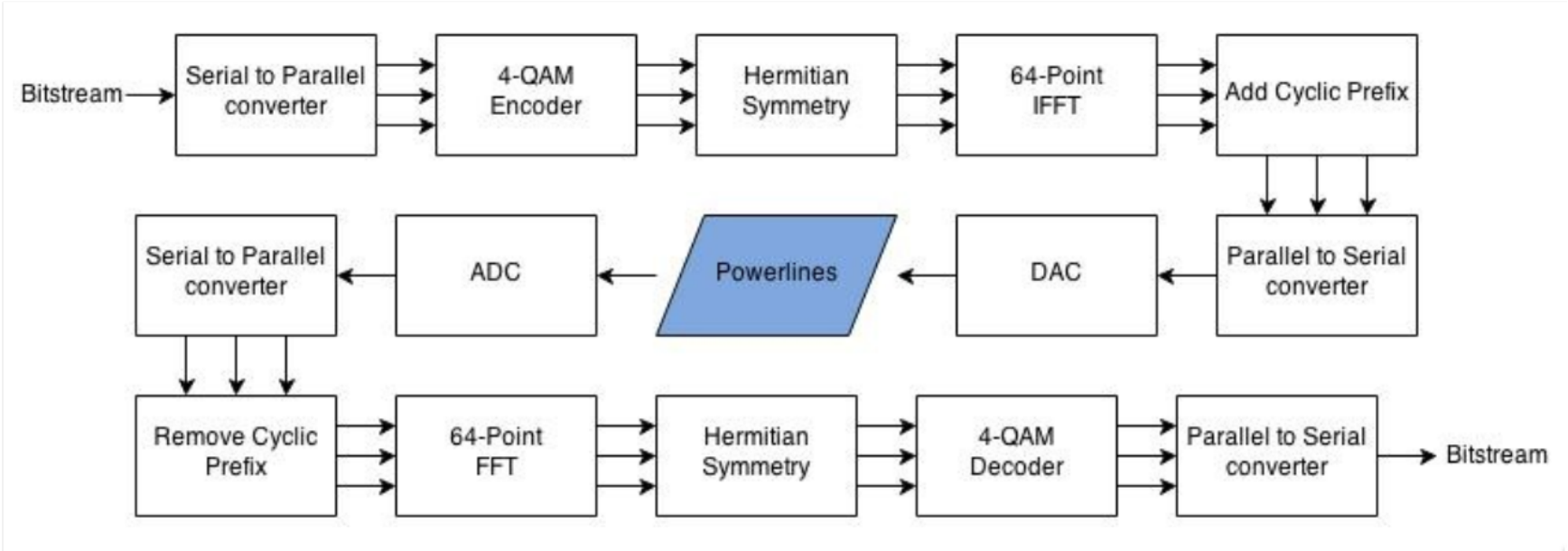


22 1's	L (15-12)	...	0	L (7-4)	0	L (3-0)	0	R (15-12)	...	0	R (7-4)	0	R (3-0)	0

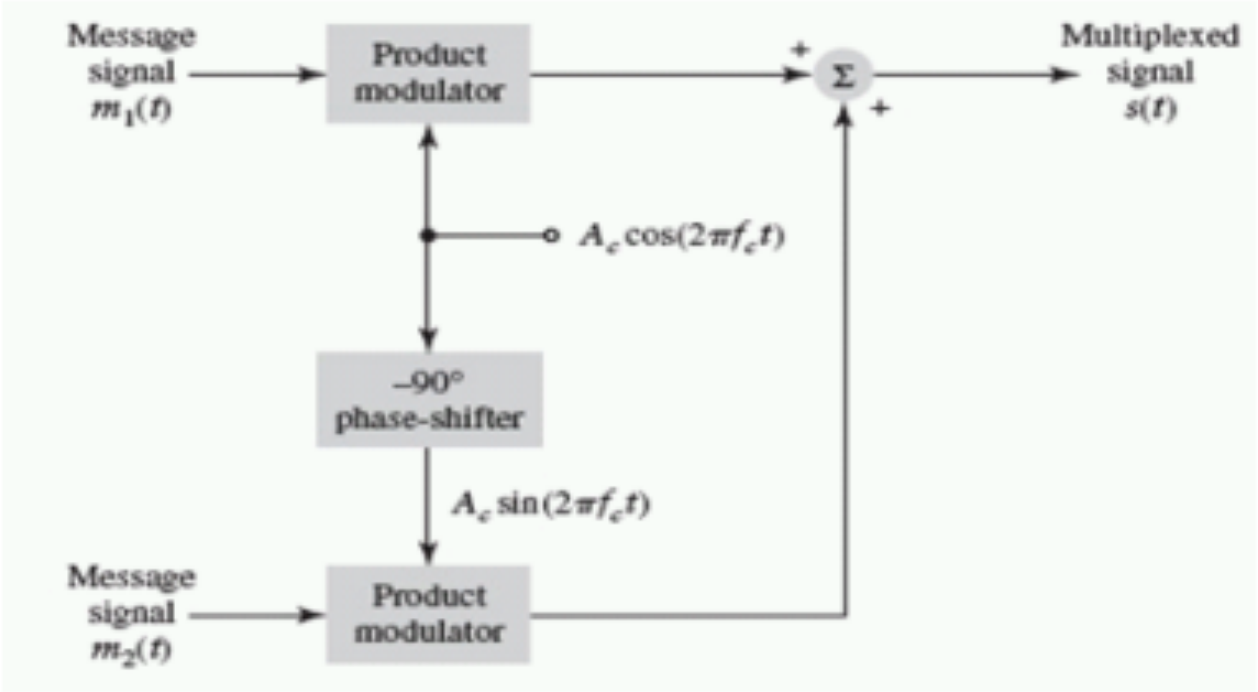
Why OFDM?

- Bandwidth efficient (overlapping orthogonal signals)
- Resistant to channel fading
  - Probability is lower than single carrier
  - Better audio quality
- Robust against Intersymbol Interference (ISI)
- Robust against Subchannel Interference (ICI)

OFDM Module High Level Diagram



RF Module (QPSK)

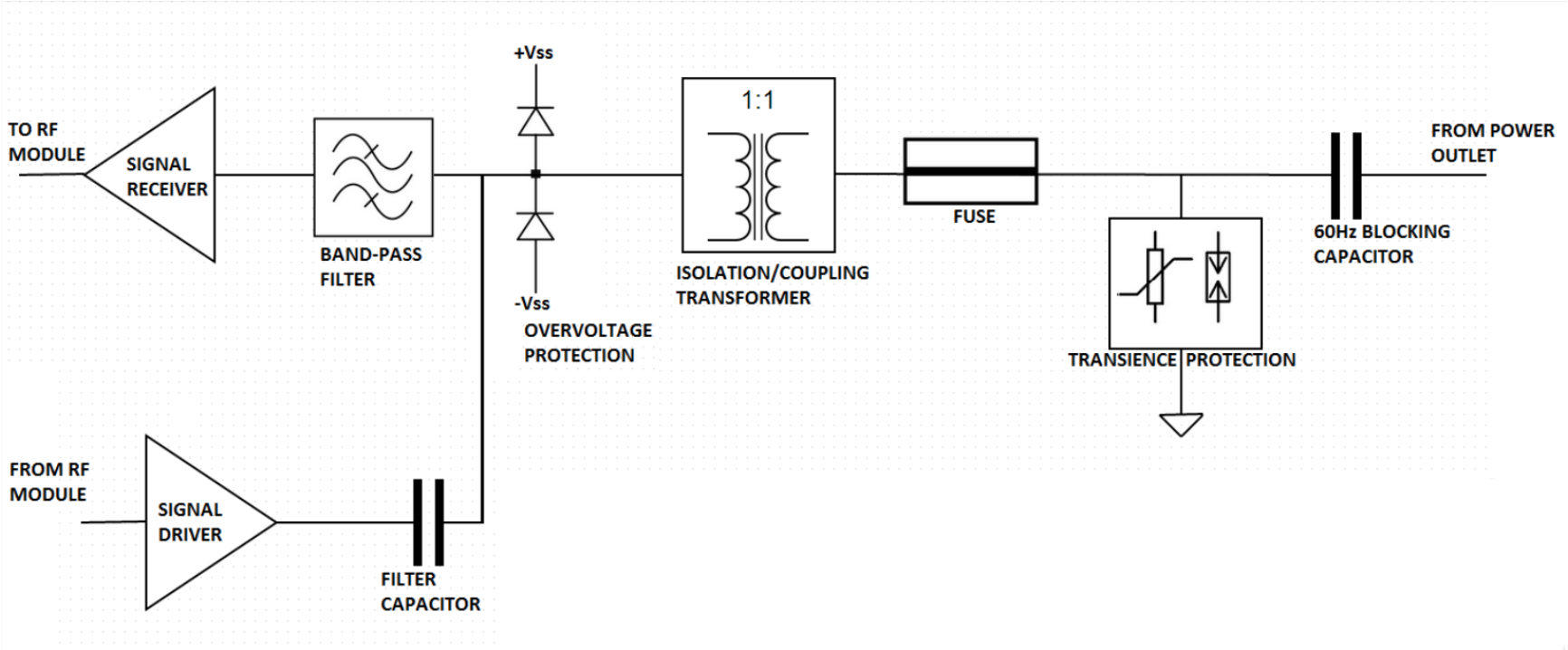


Isolation & Coupling Module

Unusual communication medium

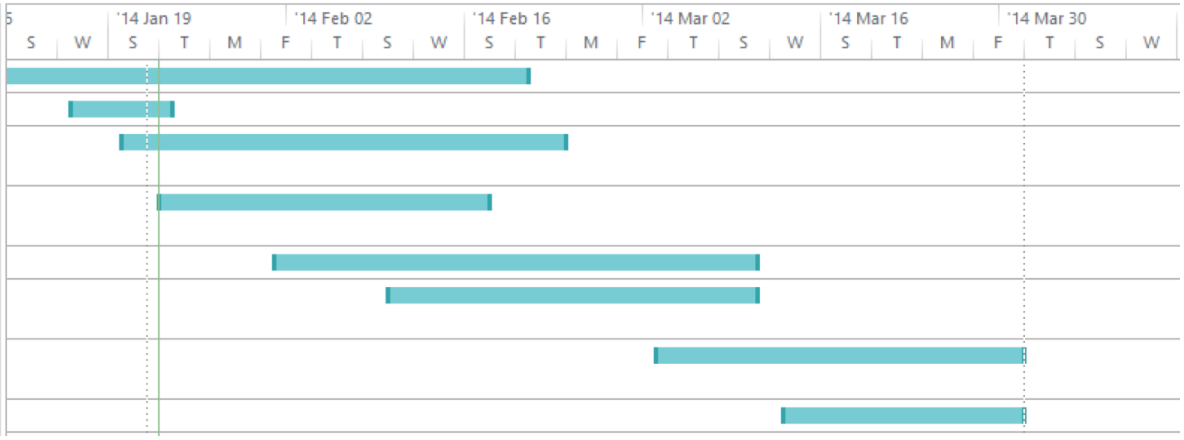
- Protect from 120V @ 60Hz
- Drive and couple the signal

Isolation & Coupling Module



Projected Timeline

Task Name	Duration	Start	Finish
Primary Research	35 days	Fri 14-01-03	Thu 14-02-20
Proposal	6 days	Thu 14-01-16	Thu 14-01-23
Sourcing/Ordering Parts	26 days	Mon 14-01-20	Sun 14-02-23
Functional Specification	18 days	Thu 14-01-23	Mon 14-02-17
Design Specification	27 days	Sat 14-02-01	Mon 14-03-10
Assmebling and Testing Modules	21 days	Mon 14-02-10	Mon 14-03-10
Integration and Prototype Testing	21 days	Mon 14-03-03	Mon 14-03-31
Debugging	13 days	Thu 14-03-13	Mon 14-03-31



Deviations from the Timeline

- Ongoing R&D
- Ongoing parts acquisition/replacement
- Assembly of modules mostly complete
- Integration not fully complete

Initial Projected Costs & Funding

Parts List	#	Cost
DE2-70 FPGA Board	2	$0 (ESSEF Parts Library)
AFE7225 Evaluation Module	2	$998
Miscellaneous	-	$100
Subtotal		$1098
Tax		$131.76
Total		$1229.76

Funding:

ESSEF Fund: $700

Anticipated Remaining Cost: $529.76

Final Project Cost (approximate)

Parts List	#	Cost
DE2-70 FPGA Board	2	$0 (ESSEF Parts Library)
ASLK Pro Boards*	2	$0 (Part of ENSC 425 Lab)
ADC/DAC Boards	2	$350.00
Miscellaneous Parts**	-	~$250.00
Subtotal		$600.00
Tax and Shipping		$100.00
Total		$700.00

New Design:
Significantly Lower Costs

* Not used in final design
** Mostly isolation/coupling circuit and powerline model

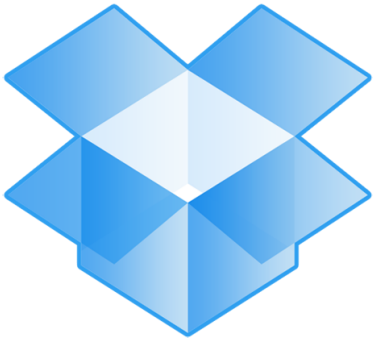
Production Costs

- ASIC chips (no FPGAs)
- Enclosure
- Hard to estimate overall cost
  - Exactly what/how much resources used in FPGA?

Team Dynamics & Workflow

- Engineering work divided by modules
- Non-engineering tasks:
  - Documentation: overseen and finalized by Kim
  - Scheduling: Laura
  - Budget & finances: Andy
  - Purchasing: Josh and Kim

Communication tools



Communicate and collaborate
through the cloud

Things we learned

- Difficult to integrate new members
- Large ambitions
  - Address member concerns early and with care
- Make use of time spent together

Future Plans

No current plans for the overall project

Individual plans:

- Transmission over actual power lines
- Lossless transmission over OFDM + RF modulation

Sources

[1] G. Zhou, J. A. Stankovic and S. H. Son, "Crowded Spectrum in Wireless Sensor Networks," *IEEE,* pp. 4-5, 2006.

[2] Wolfson Microelectronics, "Portable Internet Audio CODEC with Headphone Driver and Programmable Sample Rates," 2004. [Online]. Available: http://www.altera.com/education/univ/materials/boards/de2-70/unv-de2-70-board.html. [Accessed March 2014].

[3] P. P. Chu, Embedded SOPC Design with Nios II Processor and VHDL Examples, John Wiley & Sons, Inc., 2011.

[4] P. m. Tmsiqueira, "OFDM modem :: Overview," OpenCores, [Online]. Available: http://opencores.org/project,ofdm. [Accessed 28 January 2014].

[5] Wikipedia, "Orthogonal frequency-division multiplexing," [Online]. Available: http://en.wikipedia.org/wiki/Orthogonal_frequency-division_multiplexing. [Accessed February 2014].

Acknowledgements

- Fred Heep
  - Modifying the ADDA circuit
- Lucky One
  - DE2-70 board and consulting
- ESSEF
  - Second DE2-70 board
- Jameson and Guinness
  - Therapeutic and relaxation aid

QUESTIONS