High Performance Digital Musical Synthesis using Arrow SoC

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Problem Description

Objective

To design and implement a high-performance music synthesizer system on the Arrow SoC Board

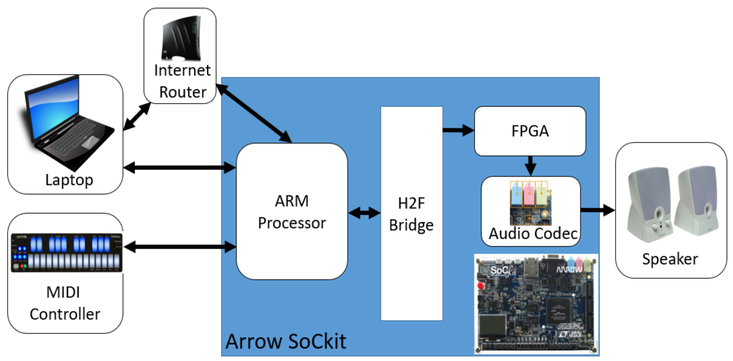
Main requirements

- User friendly interface for adjusting the synthesizer settings
- 88-note midi range
- Digital frequency modulation (FM) with 6 operators
- 45 FM algorithms
- Oscillator (sine, sawtooth, triangle, and square waves)
- Envelope generator (6 adjustable segments with looping)
- Polyphony (8 FM layers)

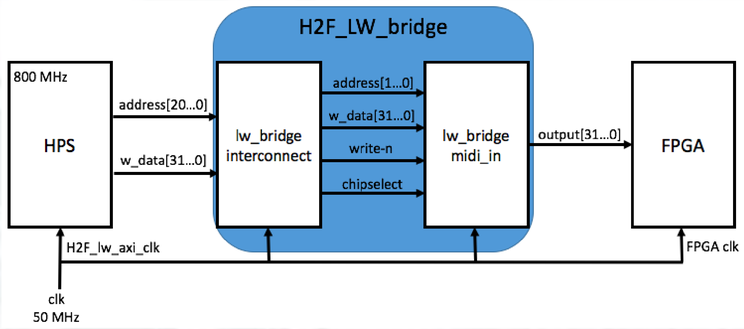
Challenges & Constraints

- Installation of Linux on the SoC
- Total number of programmable logic units on the FPGA
- Debug during software and hardware integration test phase

Overall System Design

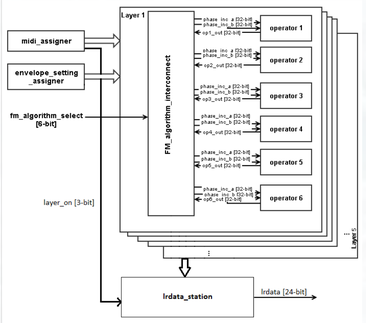


HPS to FPGA Bridge Interface

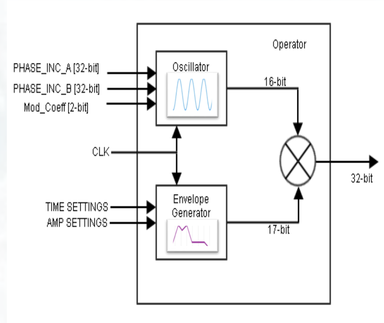


FPGA Design

Overall



Operator

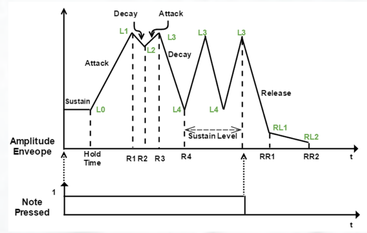


Oscillator

- Use the phase accumulator to store the phase of the waveform. The phase is then sent to a waveform LUT to generate the corresponding waveform

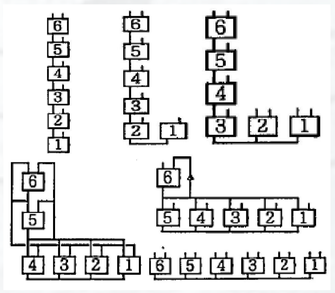
Envelope Generator

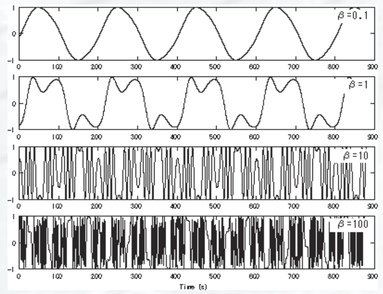
- Volume and modulation level
- 6 adjustable segments, 7 time settings and 7 amplitude level
- One-shot mode or loop mode operation



FM Algorithm

- 6 operators are connected in various configurations to achieve different FM algorithms.
- The FM coefficient controls the level of the modulation





Testing and verification

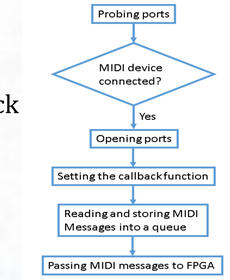
- FPGA - each component was tested thoroughly by using ModelSim to verify the required functionalities
- HPS – download the programs to the HPS and run them to verify whether the programs work correctly

Hard Processor System Design

MIDI Controller

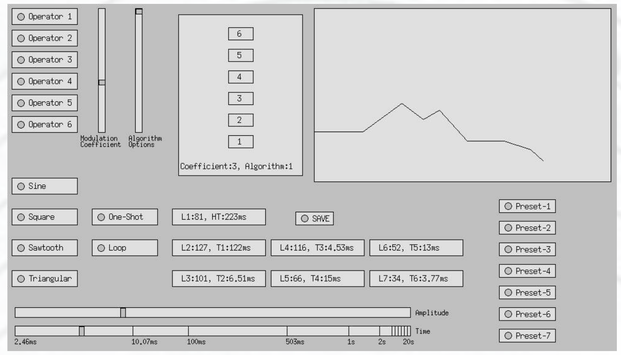
- Receive MIDI information from the keyboard
- Transmit MIDI data to FPGA with callback interrupt

Status Byte	Data Byte 1	Data Byte 2
1001 1111	0011 1100	0111 1111
Note	Note Number 60 (C3)	Note Velocity 127
MIDI Channel 16		



Graphical User Interface

- Xming (X Server for Windows)



Linux Image

- Debian 8 “Jessie” – a basic root file system for ARM
- ALSA (Advanced Linux Sound Architecture) – an API for MIDI input/output across Linux
- X11 – a communication protocol between an X client application and an X sever
- Xlib – one of the libraries in the X Window System

Conclusion

- Gained knowledge on musical synthesis techniques, digital signal processing, software and hardware integration design
- Gained knowledge on ARM processors, the Linux kernel, C programming
- Future improvement: multi-timbrability, sequencer, and user interface on LCD touch screen

Division	FPGA Group		HPS Group	
Name	Sijie Chen	Tianming Zhang	Xiao Huang	Wei Wang
Total Hours	320	320	320	320