Modular Synthesizer

6.111 DESIGN PRESENTATION

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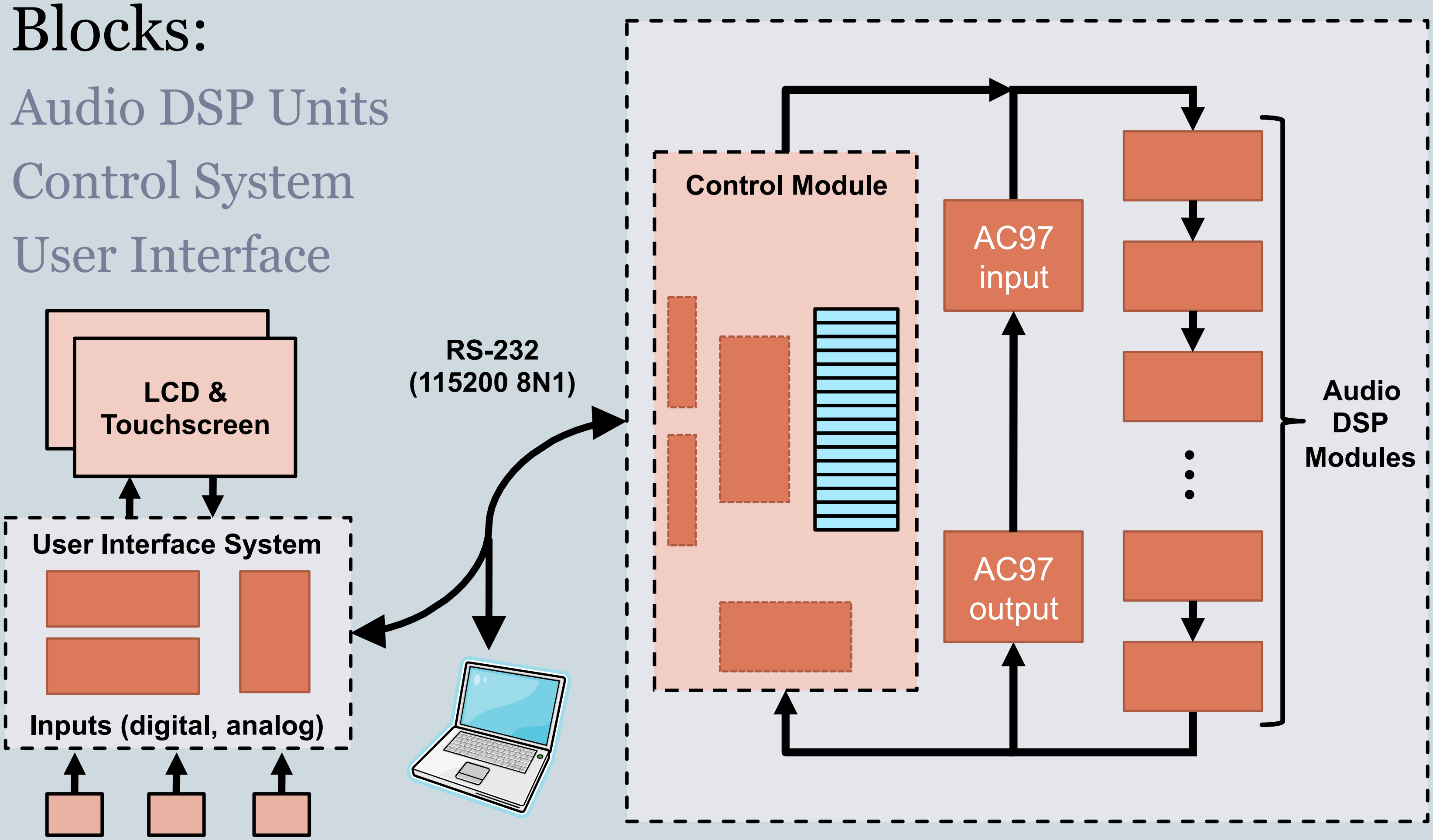
Concept Overview

- What is a synthesizer?
  - Electronic instrument that generates output tones from user-controlled inputs
  - *Modular Synth:* break audio processing into discrete units for arbitrary routing

- Why a synthesizer?
  - Highly modular design
  - Easy to implement in DSP → 48kHz refresh frequency
  - Interesting routing/UI needs
  - Fun to demo!

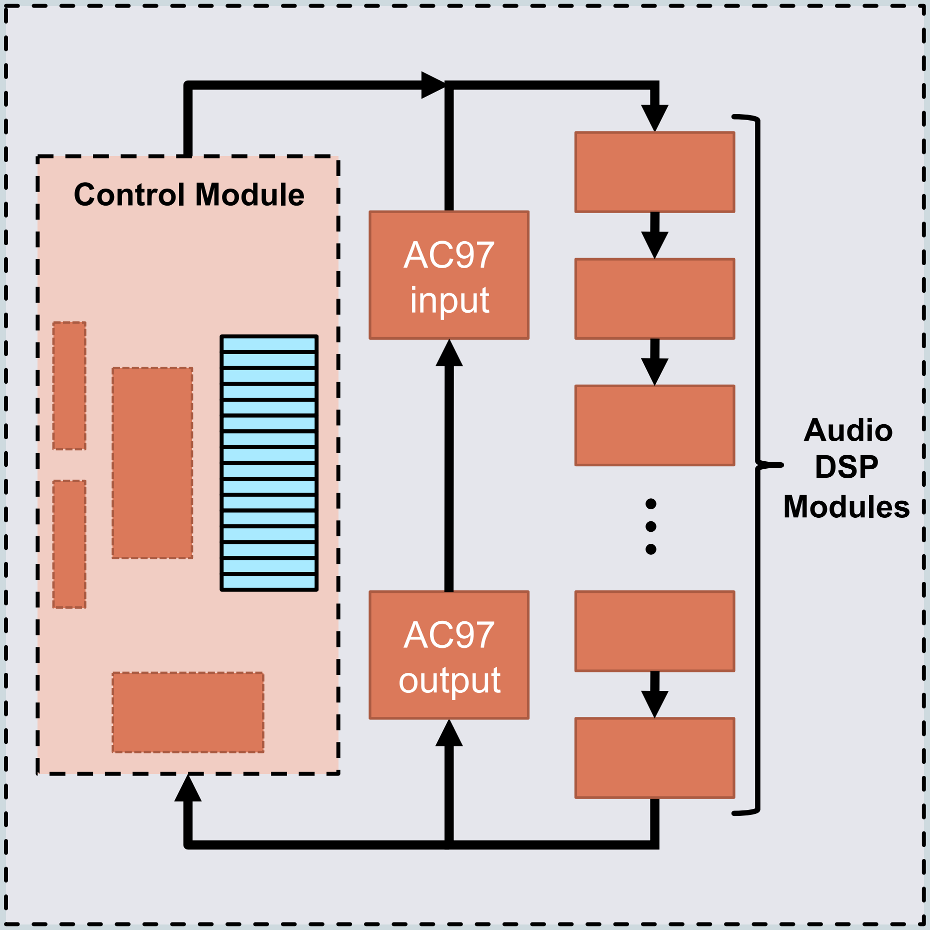
System Block Diagram

- 3 Blocks:
  - Audio DSP Units
  - Control System
  - User Interface



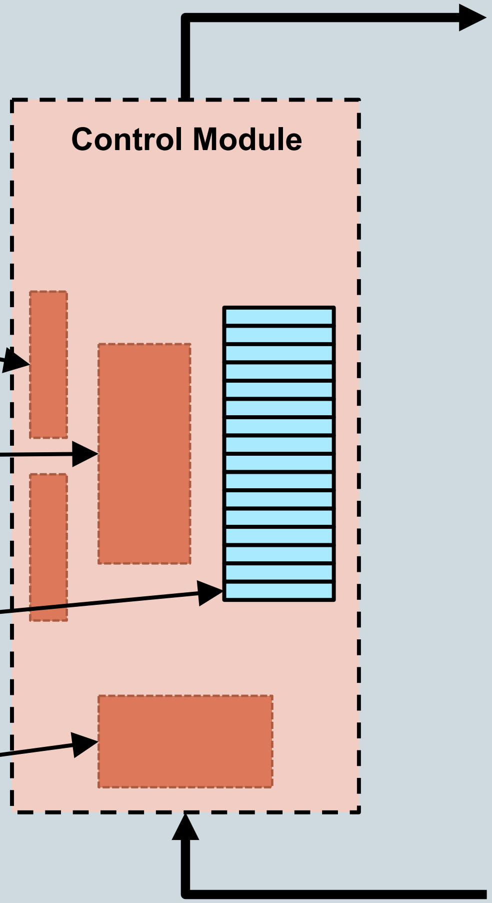
Control System

- 2 Parts:
  - Control Module
    - Serial parsing
    - DSP control
    - DSP setup
    - System memory
  - Routing Network
    - "Ring" topography
    - 2 Loops
      - Audio Data
      - Control Data



Control Module

- Control Module
  - Transmit & Receive instructions from PC or User Interface unit
    - Serial interface
    - 115200 8N1
  - Control Logic
    - Drives synthesizer DSPs with RUN, SET, BYPASS lines
  - System State Memory Buffer
    - (*n* x *m*) registers @ 8 bits wide
  - Ring Network I/O
    - For DSP state setting/updates

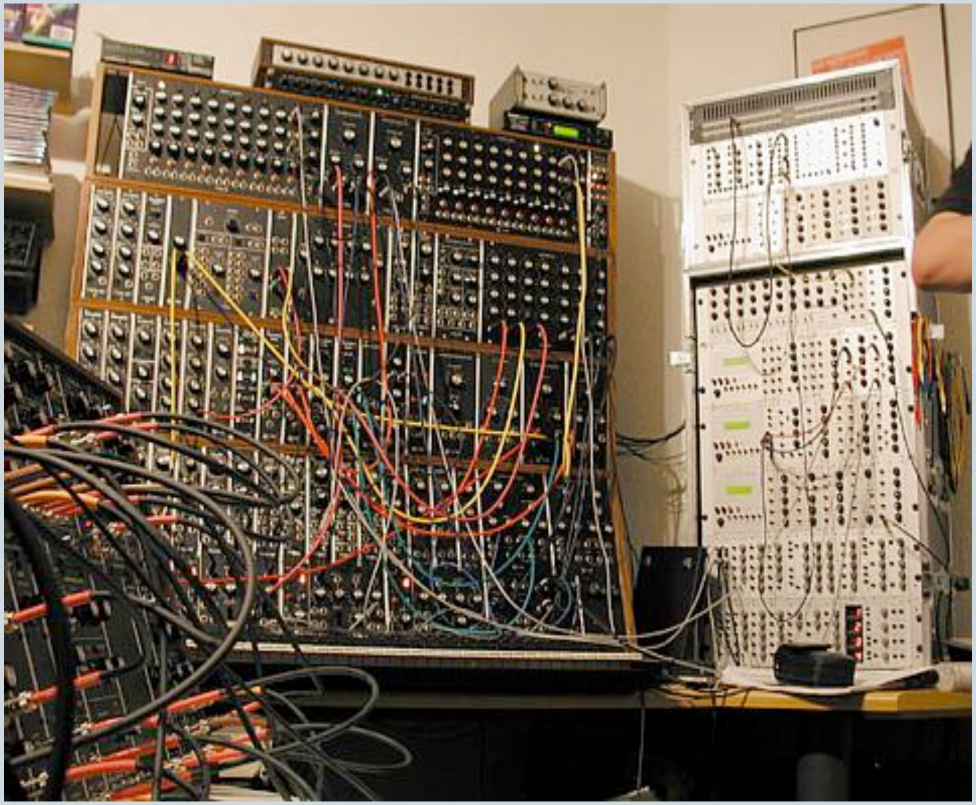


n – number of DSP modules implemented
m – number of control registers needed by DSP module *n*

Inter-Module Routing

- The Problem:
  - Inter-module signal routing should support arbitrary configuration
  - Should be on-the-fly configurable
- Previous Solution:
  - Analog signal routing between jacks on synth board:

an audio “*patch panel*”



The "Digital Patch Panel"

- Our Solution:
  The "Digital Patch Panel"
- Parallel data streams
  - 16-bit PCM audio
  - 8-bit control values
  - Bin(*n*) address lines

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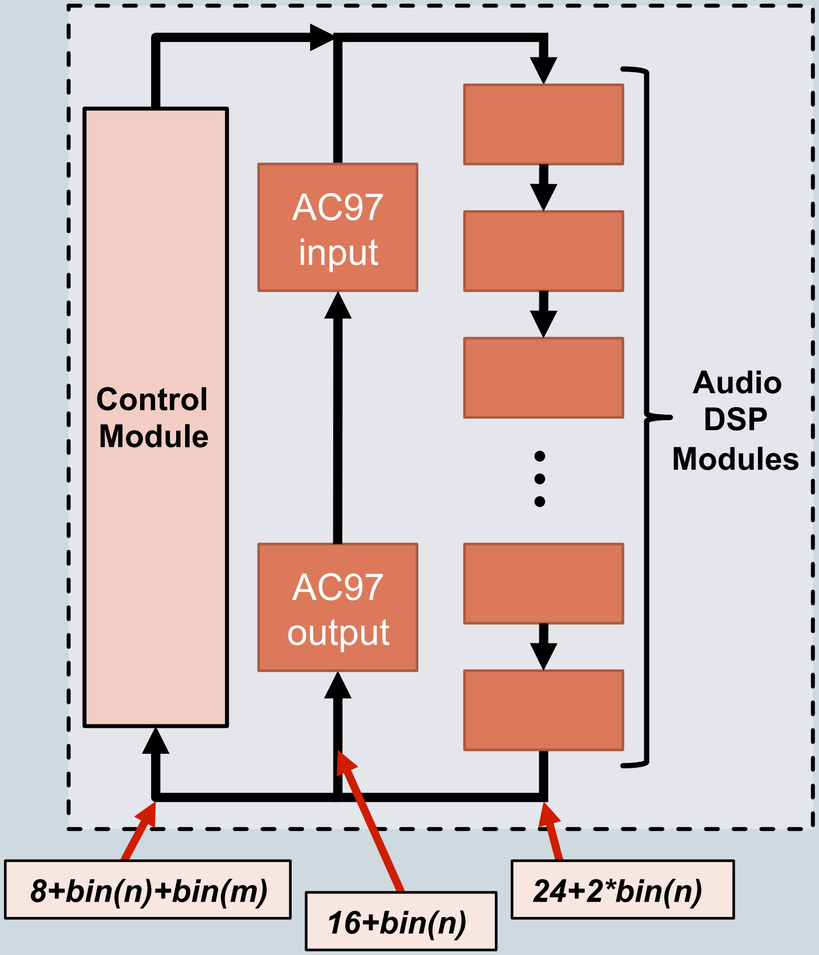
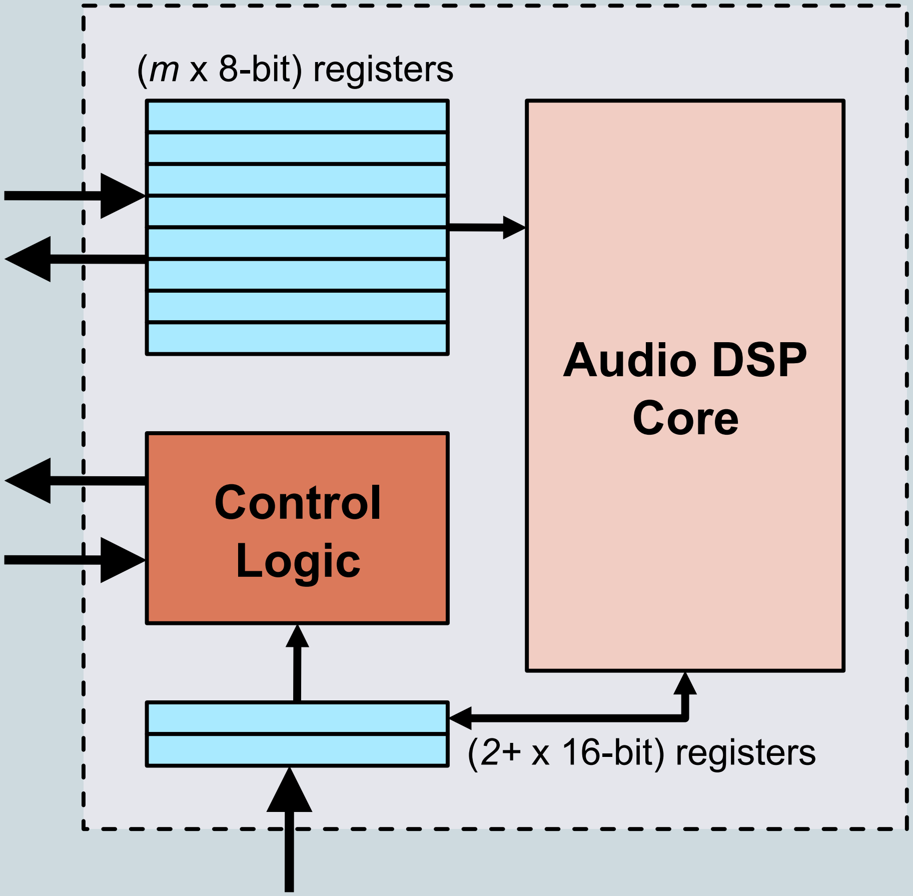
- Like an SPI bus:
  - Data rotates "through" each module
- Triggered on certain signals:
  - Audio: network rotates on every `<AC97 ready>` signal
  - Control: rotates on every command update via serial port

n – number of DSP modules implemented
m – max number of control registers needed by DSP modules



Audio Module Design

- Standard DSP layout:
  - State Registers
  - Control Logic
  - Ring Network I/O
    - Audio (16+ bits)
    - Control (8+ bits)
  - Audio DSP
- Standard I/O interface
  - Ring Networks
  - Control Signals



Audio Modules

- 11 (13) Digital Audio modules

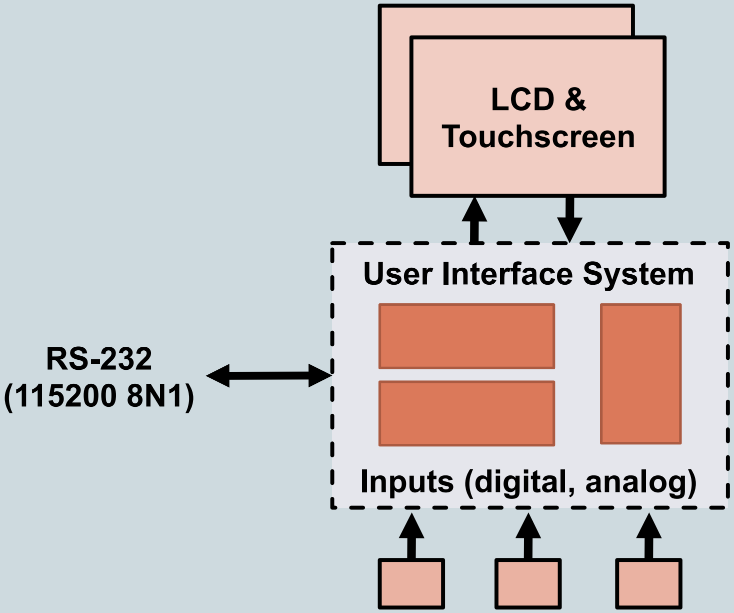
- Basic DSP modules:
  - Oscillator
  - Filter
  - Sequencer
  - Slew Limiter
  - Amplifier
  - Envelope
  - Noise
  - Ring Modulator
  - Delay
  - Reverb
  - N-to-1 mixer

- "Reach" DSP modules
  - Vocoder
  - Pitch Corrector

- Peripheral Audio modules
  - AC97 - Input
  - AC97 - Output

User-Interface Component

- 2 Issues:
  - Module settings
  - Audio path routing
- Previous Solution:
  - Knobs, Sliders, Switches
  - Point-to-Point wiring
- Our Solution:
  - Buttons & Switches
  - 2-axis analog joystick (SPI)
  - Resistive touchscreen (serial)



LCD & Touchscreen

User Interface System

RS-232 (115200 8N1)

Inputs (digital, analog)

Display Module

- Output Display:
  - Custom LCD system – Sharp 4.3” Widescreen (PSP)
  - 480 x 272 pixels @ 8bpp, RGB
    - 391,680 image bytes/color/frame @ 8bpp
  - 24+4 driver pins
    - 8 bits x R,G,B data bus
    - HS, VS, VCLK, DISP
  - 2.5V interface logic levels
  - LED backlight driver onboard

- Fallback Plan A:
  - VGA LCD drive (a la Lab 5)
- Fallback Plan B:
  - PC Software/Human-Readable commands via serial terminal

Input Modules

- Main Input - Touchscreen:
  - Custom touchscreen for 4.3” Widescreen LCD
  - Resistive 4-wire interface
  - Touchscreen Controller: AD7843 12-bit touchscreen ADC
  - TTL serial interface

- Aux Inputs – Joystick:
  - 2-axis (XY) joystick
  - 10-bit ADC with SPI interface
- Aux Inputs – Buttons:
  - 6 buttons, momentary
- Aux Inputs – Switches
  - 8 switches, SPST

U/I "Wrapper" System

- Based on NEXSYS2 board
  - Spartan 3E-1200k Xilinx FPGA
  - 16 Mb SRAM
  - 128 Mb Flash
  - RS-232 UART
- Serial comm link between U/I unit and Synth
  - Computer replacement during testing
- Offloads display control, refresh, user input from master FPGA

Milestones & Timeline

Sun	Mon	Tues	Weds	Thurs	Fri	Sat
			Design Presentation		Oscillator – basic functionality	AC97 input, output – basic functionality
	Audio Ring Network – basic functionality		Design Meeting Control Logic – basic functions		Basic Audio DSPs - implemented	
		Design Meeting		Thanksgiving, Mike & Muth travelling		
Cont'd	Design Meeting			**New Features END DATE** Design Meeting		
Design Meeting	**Checkoffs**					