Comparch Final Project Proposal

Lisa Hachmann & Anisha Nakagawa

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1 Introduction

Anisha and Lisa are setting out to the moon in the final project of making an Apollo Guidance Computer! This historic computer features 16-bit instructions and memory, very specific architecture and two versions of an instruction set (block I and block II). We will create a version of the Apollo Guidance Control with behavioral verilog that can implement this set of instructions.

1.1 Architecture specifications

We will build the verilog modules based on the documentation of the Apollo system. The main components include:

- Four 16-bit central registers: the accumulator for general computation, the program counter, the remainder from divide and the return address, and the lower product from multiplication.
- Thirteen other registers for internal use.
- A clock that was divided to half frequency and one-fourth frequency
- Erasable memory made of 15-bit words, with 1 kiloword of memory
- Fixed memory with 24 kilowords
- Interrupts (stretch goal, as the planned instruction set does not rely on this)
- DSKY interface (stretch goal, rather than taking use input we will start by pre-programming the instructions)

We will be able to re-use many modules from our single cycle CPU, and some of the control logic. We will have to modify most to be 16-bit instead of 32-bit. See Figure 1 on the following page for a high level block diagram.

1.2 Instructions

We will start by implementing the original eleven instructions from the first iteration (block I) used in Apollo 4-6. These instructions are: transfer control (TC), count compare and skip (CCS), retrieve data at an address (INDEX), return from interrupts (RESUME), exchange contents of memory and register (XCH), clear and subtract (CS), transfer to storage (TS), add (AD), bitwise and (MASK), multiply (MP), divide (DV), and subtract (SU).

2 Deliverables

The Apollo Guidance Computer had two different instruction sets that were used for different missions. Block 1 includes only 11 instructions and was used only on unmanned missions. We set our minimum deliverable to be the Block 1 instruction set. Block II was used for manned missions, was considered incredibly robust

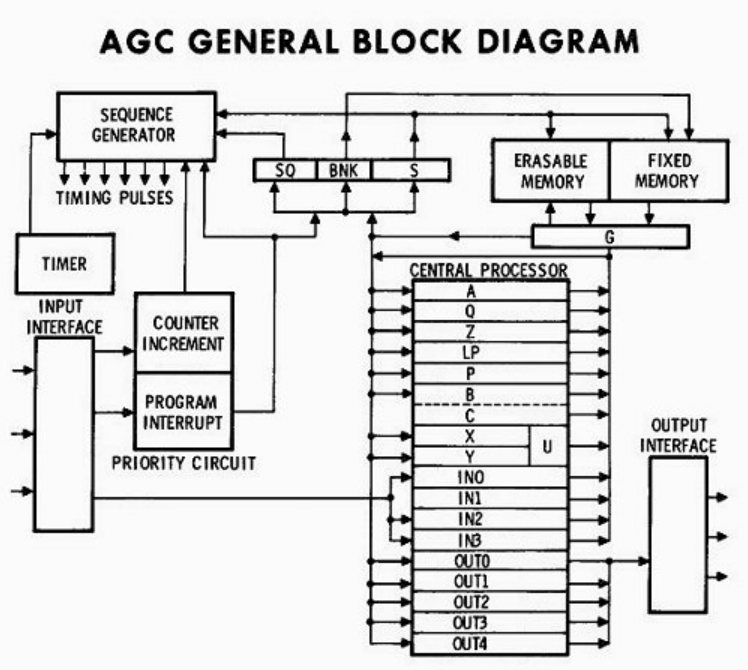

Figure 1: Block Diagram of the AGC

software, and contains 34 instructions (including the original 11 from Block I). While Block II retains the same architecture, its increased memory and instruction set are considered the final version of the AGC.

Our planned deliverable is the instruction set of Block I and the instructions necessary to run a simple source code file from the original apollo missions. For example, we could use the instructions to compute sine and cosine, as shown in the last reference. This would only require five additional instructions: TCF (jump to fixed memory location), DOUBLE (adds the accumulator to itself), COM (bitwise complements accumulator), EXTEND (take next instruction from extracode), and DDOUBL (adds a double precision value to itself).

A stretch deliverable could be implementing more of the Block II instructions so that we can run a more complex assembly code file. We could also focus on dealing with user input with the DSKY keyboard.

3 Work Plan

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**** WORK PLAN FOR GOING TO THE MOON ****

11/28/16 Work Plan and Proposal

Encode the 11 types of instructions: Estimated 2.5 hours

We need to build the following modules by the midpoint check in date: (estimated 5 hours)
Erasable and Fixed Memory
4 16-bit "central" registers
13 "other" registers
Clock module with clock, 1/2 clock and 1/4 clock.
Control Logic Unit

Begin test benches with DUT passed: Estimated 1.5 hours

General Confusion Part 1 Estimated: 5 hours

Make sure first 11 instructions work properly: Estimated 8 hours

Total Work Time Part 1: 22 hours

12/7/16 Midpoint Check In

Encode 5 extra instructions for sine/cosine: Estimated 1 hour
Make sure extra 5 instructions work properly: Estimated 4 hours
Test benches for all modules made and overall: Estimated 3-4 hours
General Confusion Part 2: Estimated 7 hours
Visual - either Slides or Poster depending on presentation format TBD. Estimated: 1 hour
Documentation: Estimated 3 hours

Total Work Time Part 2: 19 hours

12/15/16 Final Project

Total Work Time (Part 1+ Part2): 41 hours!!

**** WORK PLAN FOR GOING TO THE MOON ****
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References

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https://www.ibiblio.org/apollo/hrst/archive/1717.pdf

[2] Block I Apollo Guidance Computer (AGC): How to build one in your basement,
http://klabs.org/history/build_agc/

[3] Apollo Guidance System Documents,
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[4] Block 1 Documentation,
https://www.ibiblio.org/apollo/Block1.htm

[5] Block II instruction format,
https://www.ibiblio.org/apollo/assembly_language_manual.html

[6] Full source code of instruction sets from Apollo 11,
https://github.com/chrislgarry/Apollo-11

[7] Apollo 11 Github,
https://github.com/chrislgarry/Apollo-11

[8] Single Precision Sine and Cosine Instructions
https://github.com/chrislgarry/Apollo-11/blob/master/Comanche055/SINGLE_PRECISION_SUBROUTINES.agc