Introduction

Have you ever wished you could have “been there” during the first manned space flights? Join me for a trip down “memory lane”, back to the heady days of the Apollo program and the first manned landings on the moon.

I was in high school during the Apollo 11 thru Apollo 17 missions. Indeed, I listened to (but didn’t get to view) the very first landing, from a tent at Boy Scout summer camp, via a transistor radio (another newfangled invention!) that one of my fellow scouts had smuggled in, several tents over, with the volume turned up. Like many youth of that era, I fantasized of being a real astronaut and going along to the moon. Remember that this was before personal computers were available, and indeed the very first video games such as “Pong” were introduced during this time frame. It was superbly “cool” to be able to move a control and make things move on a screen!

Like many teens of that era, I had little money available for such frivolous pursuits. However, my dad was an electrical engineer on electronic development projects for a large company. When a project wrapped up, his company would often have some excess parts left over and they would go in the trash – unless intercepted on the way there! Thus Dad had a pretty fair stock of electronic parts, and encouraged me to explore.

Dad also had an oscilloscope, which is normally used to display a high-speed graph showing changes in voltage over time. This particular ‘scope also had a terminal marked “External Sweep Input”, which got me thinking. I could drive the “External Sweep Input” with a signal to control the horizontal movement of the beam, and the normal input with a different signal to control the vertical movement. The result would be to draw a picture via X-Y coordinates, much like the Etch-A-Sketch that remains a popular toy even today, but with the ability to make the picture move.

I started brainstorming, and figured out a way to draw a picture of the Lunar Lander with the available parts. Cool, but it doesn’t DO anything. Hmmm, these newfangled “operational amplifiers” could sum two (or more) voltages, so I could sum the picture with voltages controlled by twisting a knob, and thereby move the “lander” around the screen!

Around this time I was taking high school Physics and Calculus, and learned that position is the integral of velocity, and also that an operational amplifier (“opamp”) could perform integration.

There's nothing magical about integration; don't let the term scare you off. Think of driving at 30 MPH for two hours and you've gone 60 miles. Integration does the same thing, but also handles non-constant speed.

Taking it a step further, velocity is the integral of acceleration. So by chaining two integrators together, we could make a realistic computation of motion based on "thrust", which we could input by twisting a knob! Remember, "computers" at this time were the stuff of SciFi – unless you were speaking of humans who did computations. Tah-dah….an analog computer, synthesizing a realistic "lunar lander" that could fly around on the screen! And this really is an "analog computer" – a concept that pre-dated the digital computers we use today. Remarkably in this day of "planned obsolescence", most of the parts we used are still readily available after the passage of many decades!

We continued adding features as you'll see during the assembly / theory of operation steps below, until we had a fairly full-featured game. It was actually built on a prototyping board, where we could plug in chips and connect them by poking wires into holes in the board. The actual unit did not survive the decades since then, but I saved a hand-drawn schematic of our fancy implementation, shown below.