Nixie Tubes

Timothy Holmes

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1 Purpose

The nixie tubes name can be dated back to the first experiment with these displays. During research, these tubes were labeled as Numeric Indicator Experimental No. 1, or NIX I for short. The team later started to refer to the tubes as "Nixie" and the name remained. The nixie tubes prime usage was back in the 1950's but later to be passed by cheaper and better technology. Vacuum fluorescent displays (VFDs) replaced the nixie tube and soon after light-emitting diodes (LEDs) replaced (VFDs). While there are no real advantages anymore, one reason they were sought after was for their unique round digits. While digits with LEDs and VFDs have box digits that are harder to read especially in dark labs. Nixie tubes are also reliable and will last a very long time. These tubes manufactured in large quantities in the Soviet Union. It's easy to confirm their reliance since these tubes work fine today 60 years after their manufacturing date. These tubes have been out of date for a while and can not be used with modern equipment since they require high-voltage. An low-voltage integrated circuit would have no use for a nixie tube. LEDs are cheaper to manufacture, are abundant, and overall a very useful light source with endless capabilities due to their design. While nixie tubes are outdated, they do make great electronics projects. People have created interesting projects such as clocks, calculators, and even a speedometer. However, the technology we have today is drastically better for many reasons. Makes these nixie tubes obsolete and rendering them only to serve an aesthetic purpose.

2 How they work

A nixie tube is a cold cathode display used for displaying numbers or other scientific symbols. This tube is called cold cathode because despite having a lot of voltage run through it, the tube will never heat passed the temperature of a human body. Inside the numerical tubes, contains ten digits 0-9 that act as the cathodes (-) and a mesh wire that surrounds the digits that acts as the anode (+). Inside the tube contains neon (sometimes mercury and argon too) at low pressure, hence the reason they are called vacuum tubes. A voltage of 170 - 180 applied to the anode and one of the cathodes for the low-pressured gas to

ionize. In the ionization process gas molecules turn into positively charged ions and negatively charged electrons. These ions are attached to the metal atoms of the cathode (digits) while the electrons are pulled out to the anode (metal mesh). When the electrons eject off the cathode and hit an ion, it excites the ion enough to give of photons in the visible light spectrum, this process gives the nixie tube it's distinct glow. Observe closely and there is a dark space between the glow and the cathode. This space is called the Aston dark space and is created by the lack of electrons hitting ions. The electrons also won't have enough energy to excite an electron this close to the cathode; thus, a dark space remains. Applying the voltage to different cathodes is how different digits light up.

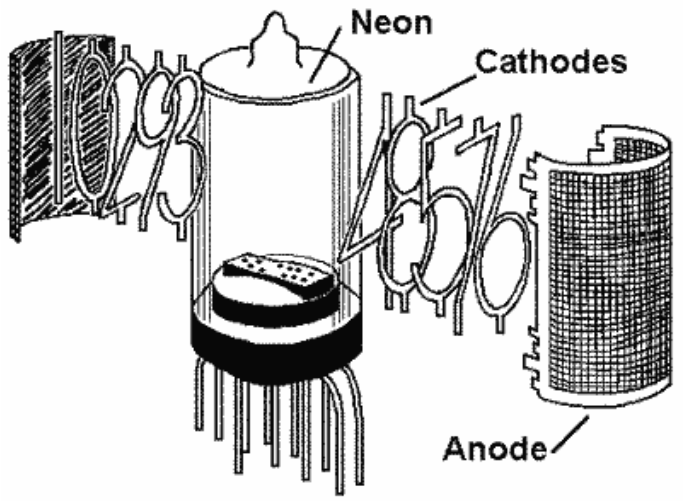

Figure 1: An expanded view of the nixie tube.

3 Components involved on the board

One of the most essential circuits on board is a boost converter, this is a DC-to-DC converter. The purpose of a boost converter is to take a low-voltage and to step it up to a high-voltage while stepping down current. When current flows through the circuit, the inductor stores energy in it's magnetic field. The transistor rapidly turns on and off. Some of the voltage then goes back into V_{in} while the other voltage goes to the load in the circuit. The capacitor then supplies the load where the output is $V_{in} + V_L$. The capacitor continues to drain but is refilled every time the transistor switches. In layman terms, think of the inductor filling up like a water ballon. the current travels down through the transistor, back into the voltage supply and back into the the inductor. Once the transistor switches off, the diode switches on allowing for the current to flow into the load into the capacitor. The current into the capacitor does not go back

into the voltage supply but the current through the load does. This is where we get $V_S + V_L$, which in return heads back to the electromagnetic field greater by the inductor and in return charges the capacitor. This process repeated over and over again is how we are able to receive more voltage on the output then we input. A sample detailing this circuits process is included in the figure below.

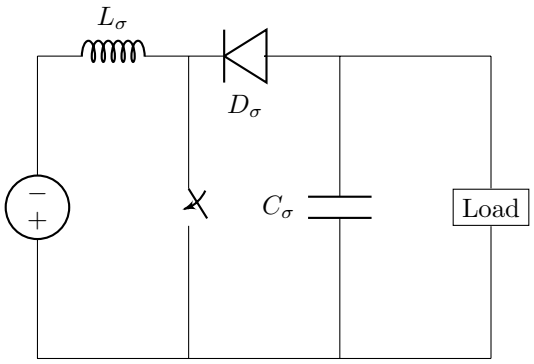

Figure 2: A simple schematic of a boost converter.

A 32-Channel serial to parallel converter takes low-voltage serial to high-voltage parallel. This register was used to control the which cathode received voltage. Using an Arduino, some code was written in C++ that talked to this chip and told it which cathode received high-voltage. The Ardunio was the head unit that was able to communicate and power the integrated circuit. Buttons on the board were programed in the firmware to be able to set up time, set up the date, turn on or off LEDs, and set alarms.

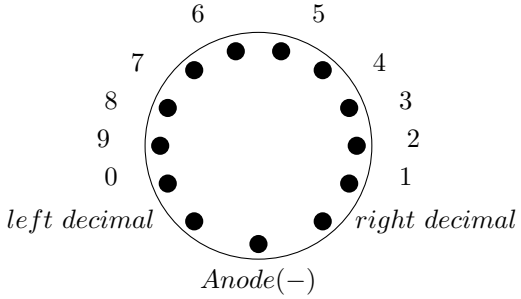

Figure 3: Nixie tube pins where the bottom pin is the anode(+) and the rest of the pins are cathodes(-) displaying digits corresponding number.

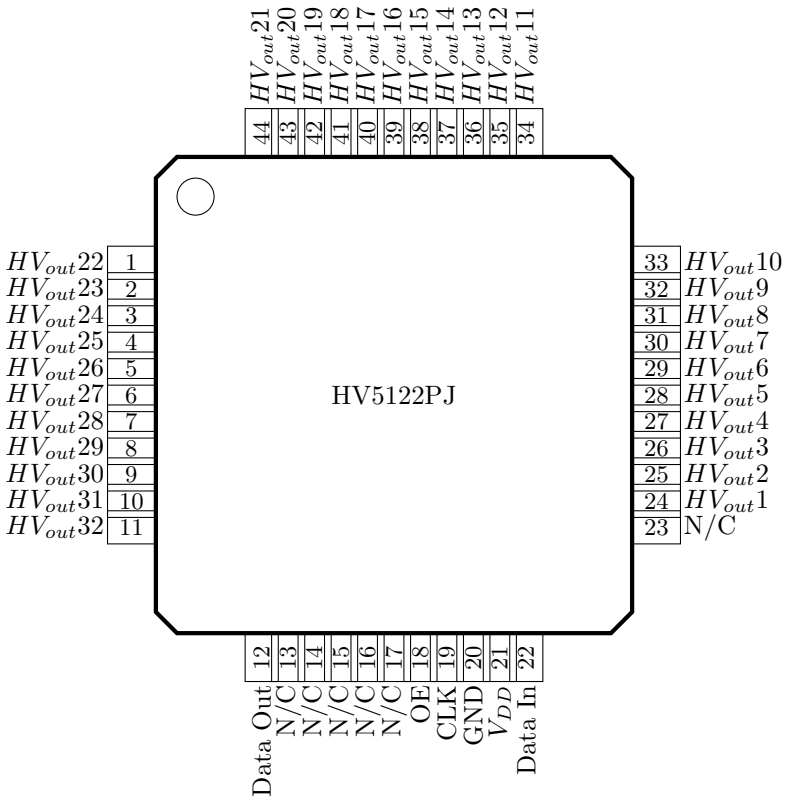

Figure 4: 44 pin chip used serial to parallel communication to send voltage to the cathodes illuminating the digits in the tubes.

The nixie tube has 13 different pin connectors. The model nixie tube used on this board is an IN-8. There are many different makes of nixie tubes serving various needs for old lab equipment. However, the style of nixie tube used on this tube is one of the cheaper, more abundant options. This nixie displays digits 0-9 and two decimals, one on the right side of the nixie tube and one on the left side of the nixie tube. For the purpose of the clock the left and right decimals were not connected. Instead, two other neon bulbs (IN - 3) were added to the board to act as colons. Each of the pins on the nixie tube is then connected to one of the high-voltage outputs. With power from the Arduino and some code we receive a working clock.