FAQ Nixietubes – nixieclocks

FAQ Nixietubes – nixieclocks - You can download this file here.
General information about multiplexing:
Here's an explanation specific to using nixies - though it's applicable to any similar situation, with changes to the details :)

Multiplexing is the technique of using one wire to do the work of many - in our case, we might use ten wires to do the work of sixty - at the expense of a little more complication.

Consider a single nixie tube. High voltage, anode resistor to limit the current, and ten cathode wires, one of which must be connected to ground to illuminate a single digit. If you're driving this, using a direct drive you'd (usually) arrange to have the cathodes controlled using either a driver chip of some flavour (e.g. the 74141/K155) or with discrete transistors. The anode you leave connected through the resistor.

Which is fine. Drive the cathode you want and the digit lights up. It takes ten wires to control things.

But if you want two tubes, driving them the same way, you need twenty wires, four tubes forty wires, and so on. You also need as many drivers as wires... Even if you're using the K155 chip, you need one per tube, or you need a heap of transistors. Your circuit board has also become more complex and probably bigger, just to fit the bits on.

So what can we do to reduce this complexity, cost, and size?

If we fasten all the cathodes in parallel, we suddenly find we only need ten transistors (or one K155) but there's some bad news - we have to show the same digit on each display... and a clock which can only display 11:11 or 22:22 is probably of limited usefulness.

However, if we arrange somehow to switch the anode connections, we can make things happen differently: for example, if the time is 10.35, we would first switch the anode power to the hours/tens digit and drive it with a '1'. After a short pause, we do the same with the hours/units digit and send a '0'. The same for the minutes, sending a '3' and '5'.

If we do this at the right rate, persistence of vision persuades the eye that all the nixies are lit at the same time, and we've replaced forty transistors with about 14 (depending how you've switched the anode voltage); we've reduced the number of output wires from the processor - you don't really want to do this with a non-processor design, since that would generally already have the data in a non-multiplexed form which you'ld have to multiplex before you displayed it - and we've reduced the circuit board component count and real estate and cost.

Hope this helps

1. How do I power a nixie tube?
(A) With current-limited high voltage 120 to 250 volts DC depending on tube type. 180 volts is a typical value which works with most common types.

2. How can I generate the high voltage required for driving nixie tubes?
(A) With current-limited and rectified mains [if you have 230 volt mains or similar]. (B)With high-voltage transformers such as those which were installed in equipment which originally used nixie tubes. You did save the transformer, nixie sockets, driver ICs and HV transistors when you took the tubes out of that old piece of gear, didn't you? (C) With "back-to-back" transformers. [see next question] (D) With a custom step-up switch mode power supply. (E) With a capacitor-diode multiplier. (F)

3. What's this about "back-to-back" transformers?
(A) You can get nixie drive voltage using a pair of low-voltage transformers in series, with their secondaries connected together; the second [output] transformer will then be powered in the reverse of the way it would usually go. If you use transformers with the same output voltages [turns ratios], this forms a slightly inefficient isolation transfomer but only puts out approximately the same voltage as the mains input. However, if the output transformer has a lower secondary voltage rating, dual primary windings, or higher primary voltage rating, the output voltage of the pair can be higher than the input voltage. This is useful for those living in "low voltage land" [North America and Japan].

4. How do I current-limit the power to a nixie tube?
(A) Using a resistor in series with each tube's anode supply connection. The value sets the current. Normal values for direct drive are 33k to 82k, normal values for multiplexed drive are 4k7 [= 4.7k] to 27k. Calculate the value needed by R=E/I, where I is the desired current in milliamperes, E is the difference between your supply voltage and the tube's maintaining voltage, and R is the needed resistor value in kilo-ohms. With direct drive displays [see below], do not attempt to take the shortcut of using a single resistor for multiple nixies!

5. How can I control the high voltage signals needed to operate a nixie tube?
(A) Using high voltage transistors, optocouplers and/or vintage 7441, 74141 or similar IC drivers. (B) Using recently-made special high voltage driver ICs made by Supertex, Dionics, or others.

6. Where can I find data for nixie tube type "XXXX"?
(A) We have in our Links section available via the navbar on the left side of most pages, links to several sites which feature significant amounts of nixie tube data [Links > Tube Data Resources]. An index is available which tells what data are at each site. (B) There are probably data for other types available online. Try a web search with your choice of search engine, using a few variations of the type number [with and without hyphens, spaces, slashes, etc.] and brand name.

7. What does multiplex / direct drive mean? What are "muxing" and "time sharing"?
(A) Direct drive: all tubes have a constant supply and light at the same time. (B) Multiplex: only one tube [or a few out of many tubes] driven at a time. The updating/switching speed is so fast that all appear to be lit at all times. Multiplex is often shortened to "mux" [muxing, muxed], and sometimes called "time sharing" in vintage documents.

8. Why use direct drive?
(A) Can be made with standard logic parts, easy to understand, does not need a microcontroller or programming skills. (B) No high peak currents, no high voltage / high frequency switching noise. (C) Gives brightest display.

9. Why use multiplexing?
(A) Reduced component and signal conductor counts. (B) Compact and simple electronics; easier, faster and cheaper to assemble. (C) Dimmer display compared to direct drive, sometimes a desirable feature.

10. How can I generate a one Hz signal for my clock?
(A) Mains power at 50 or 60 Hz frequency is adjusted for good short-term and excellent long-term accuracy in most industrialized countries. Just divide it by 50 or 60 to get 1 Hz. (B) For portable / battery-powered clocks crystal control is the simplest way, but good accuracy is always a challenge. (C) See the next question.

11. Is there a way to keep a clock synchronized to a master time signal?
(A) GPS [worldwide; a.k.a. NAVSTAR], WWVB [continental U.S.A], DCF 77 [Germany/Europe], HBG [Switzerland], MSF [U.K.], RJH [Russia], JJY [Japan] and other radio transmissions are available for extremely accurate government-maintained timekeeping signals. Most or all commercial receivers of these signals also make available an accurate 1 Hz pulse.

12. My nixie doesn't glow pure orange, it's more pinkish, with a blue/purple haze. What's wrong?
(A) Probably nothing! The most advanced nixies, often called "Ultra Long Life" types, use quite a bit of mercury to prolong their life to 100K hours or more - this equals *decades* of continuous operation. In some tubes, this produces the strange coloration described at normal operating current. In other tubes, the effect is only objectionable at higher than normal currents [as might be used in a multiplexed display]. In original use, these tubes typically either had an orange/amber/red filter coating, or were placed behind a similarly tinted window or lens to block the blue colour and greatly improve readability.

13. How can I remove cracked, damaged, or undesired orange/red coloured filter coating?
(A) Just place the tube in hot tap water for several seconds to a few minutes, and you can easily rub it off. Unfortunately, tube markings stamped on top of the coating will also be lost, so you may want to re-label with at least the type number in case you [or your heirs] need to replace tubes after a few decades.

Other questions
I have all the components soldered on the boards. I now want to start connecting the tube sockets. I am using National 900 tubes, and don't know which pins are for what.

You need to test that by using a 47k resistor in series with the hi voltage supply, that is your anode supply and then a wire from ground from the powersupply, then you find the anode of the tube by looking into the glass when that is found you try to connect it to the resistor with hi voltage on it. Then test all digits with the ground wire, and write it all down. if you can light up all 10 numbers the tube works, if not if is maybe defective or you have not connected the anode supply to the right anode pin.

Also I don't really understand the schematic. It looks like each wire connects to 3 tubes (I am building the 6 tubeclock). How can this work? Won't all 3 tubes display the same digit? I'm sure I'm missing something, but it seems like each tube should have its own wires.

Please see on the schematic that those 3 tubes has seperate anodes and they are connected to 3 different anode drivers. So imagine only one of them is lit at a time, then it will work fine if all numbers are connected together. That is called multiplexing. the same thing happens in the other 3 tubes, so 2 numbers is lit at a time, and then switched through all 3 tubes.
this clock uses 2 x 3 muxing to display 6 numbers, like hr, min and sec.

> The component that goes in the X1 spot is different than the one shown in
the diagram. Does it matter which way it goes in the board?

Not at all.

> I put it in with the writing facing the outside of the board. Is that ok?

The components are placed into the boards at that side with the text, some components will maybe cover some text, but that is fine. Please have a look at the webpages with the nice closeup pictures, they will make it much more easy for you to make it right.

> On the 4-wire connection between the boards, do the wires run straight across, or cross over (square hole to square hole)?

Square hole is pin 1 on both boards. pin 1 is connected to pin 1 and 2 to 2 and so on..
so you are right, square hole to square hole.