Testing wiring of a null model cable

Sunny Daniels
e-mail: sdaniels@lycos.com

Abstract:

Dr Keith Wansbrough (an Auckland University Computer Science and Mathematics graduate, with a PhD from Cambridge, who now works in the IT industry in Scotland) looked at my earlier report [1] and concluded that:

a) The DTMF approach would be “fun”, but not necessary. Using the serial port of the old computer to extract the data would be much easier than sending DTMF tones through the sound card and capturing and then decoding them.

b) Using a normal (modern, reliable) computer with a serial port (not common nowadays, it seems, unfortunately) to receive the data from the old computer would be easier than using a data logger. However, flow control will be necessary, so a null modem cable with the flow control wires present and connected correctly will be necessary.

I bought a null modem cable from Jaycar, but unfortunately Jaycar do not claim to know the exact wiring of the cable. Given the possible historical value of the data on the old computer, I felt that it would be important for me (or someone else) to carefully check the wiring of the null modem cable (to check that it is correct for this application, and in particular that it has the required flow control wires) before attempting to use it with the old computer in question. I have nearly completed building a reasonably simple apparatus for checking the wiring of the null modem cable, from cheap, readily-available parts. I describe this apparatus here.

Introduction:

Acknowledgements:

I am very grateful to Dr Keith Wansbrough (an Auckland University Computer Science and Mathematics graduate, with a PhD from Cambridge, who now works in the IT industry in Scotland) for his ongoing technical assistance with this project.

I also appreciate the ongoing interest of Professor Tava Olsen in this, and her financial support (just the cost of some of the parts so far, bit still greatly appreciated).

Introduction itself:

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I presumed that a ready-made (with the actual cable “moulded in” to the plugs) null modem cable would be more reliable than a cable built by hand from connectors with solderable terminals and raw cable, so I bought one from Jaycar[2]. If I remember rightly, its catalogue number was WC7511.

However, Jaycar do not claim to know the exact wiring of the cable, so I am unsure of, among other things, whether or not there are flow control wires in the cable. Given the, if I am not mistaken, historical value of the data that I am attempting to recover, I believe that it would be wise to somehow determine the exact wiring of this cable from Jaycar, and ask others for confirmation that the wiring is correct for this application, before attempting to use it. Both ends of the cable from Jaycar are DB9 connectors.

In principle, it would be possible to test all 9*9=81 possible pairs of pins with a continuity tester (one probe on each DB9 connector) or even just a battery and a (low voltage) light bulb. However, I think that the probability of human error when doing this would be high, even if the results of this “experiment” were manually typed into a computer and analysed with the aid of software (which would not be trivial to write). Hence, I think that a more automated solution would be better.

I think that there is a well-known historical precedent for this: I recall reading somewhere that when Herman Hollerith’s famous electromechanical “tabulating machine” was used (in the early 20th century I think) to process the results of the census, not only did it save a lot of time (in comparison to the previous manual system) but also the accuracy of the results was noticably improved (again, in comparison to the previous manual system: I presume that the counting process was done more than once, both before and after Hollerith, as a safeguard against human error and safeguard against mechanical problems after Hollerith). I believe that Hollerith’s company evolved into IBM. However, for the record, I don’t expect this project to evolve into anything as big as IBM!

I know that this project (reverse-engineering a null modem cable) is not very technologically advanced, and certainly could not be described as a “breakthrough”. However, I am publishing the details of it, in the hope of getting feedback from others on it, and in the hope that my experience with this could useful for others working in two areas:

1) Recovery of valuable or historically significant data from old computers, like myself.

2) Building or maintaining systems for which reliablity is very important for the safety of people or the protection of the environment: It would seem to me that checking the wiring of all purchased (particularly from ordinary retail electronics shops, who I think usually do not know the exact location of the factory that originally manufactured the cable) data cables before using them for such applications would be important. I would be happy to have feedback from others working in these areas on this. The following applications come to mind, although I am not an expert on this:

a) Railway signalling systems.

b) Anything medical, particuarly connected with life-support systems and equipment used during surgery.

c) Commercial aircraft, particlarly ones carrying large numbers of passengers.

d) Nuclear power stations.

Incandescent bulb solution:

The most immediately obvious solution to me was:

1) Buy two DB9 connectors of the opposite gender to the ones on the ends of the null modem cable (sorry, I don't remember which gender: I don't have the cable in front of me at the moment). Let's call the two DB9 connectors "A" and "B".

2) Connect (with wire and solder, for a reliable connection) each pin of connector "A" to a low voltage incandescent light bulb, mounted on some sort of board, labelled with the pin number.

3) Connect (again, with wire and solder: reliability is important IMHO) the other ends of the bulbs to a common terminal, which we will call "Earth".

4) Connect (again, with wire and solder) each pin of connector "B" to some sort of terminal on a board (can be just a screw screwed into a block of wood, provided that the wood is reasonably dry) labelled with the pin number on "B" to which it is connected.

Then all we have to do is screw the null modem cable into "A" and "B", connect one end of a power supply (or battery) of the appropriate (matching the light bulbs) voltage to "Earth", then touch (a wire from) the other end of the power supply to each terminal (in the board mentioned in step 2 above) from 1 to 9 in sequence, seeing which bulbs light up in response to power on each terminal!

Problems with incandescent bulb solution:

Unfortunately, using incandescent bulbs was not as simple as it sounds. I was given a collection of seven (if I remember rightly) low-voltage incandescent bulbs by a friendly security guard here in Auckland (I don't know his name, but I thank him for this). However, they were not labelled with their voltage. By trial and error (luckily I did not blow any with the trial and error) I found the voltage that looked (from the colour of the filament, but I am not an expert on this) right for them, which I have now forgotten. But I think it was about three volts.

But I had no power supply of this voltage, and I didn't feel like either buying an expensive professonal benchtop power supply or trying to build a power supply circuit of my own for these bulbs. Also, I would need to buy another two bulbs (to have nine of them) of the correct voltage and resonably low wattage (to avioid damaging the cable with excessive current) in order to have the required nine of them.

I had some spare twelve volt power supplies, so I considered buying nine 12 volt bulbs (of reasonably low wattage to void damage to the cable) but I quickly realised, if I remember rightly, that a 16 segment starburst LED display (of which I would not use all of the segments), with the required series resistors, would be cheaper. The segments of the display would take the place of the light bulbs!

If I remember rightly, the two other obvious alternatives:

a) two seven-segment displays

b) nine discrete LEDs

also turned out to be more expensive than the starburst display, at least if purchased from Jaycar. Also, the starburst LED display in question requires much less current per segment than any commonly-available incandescent bulb (AFAIK), and so reduces the risk to damage to the null modem cable from putting excessive current through it.

<u>Another false start: display from microwave oven control board:</u>

Another solution, which initially seemed promising, but turned out to be impractical, was use of an LED display module (obtained for free) from the control board of an old microwave oven. I have a 12 volt Halogen desk lamp with exposed 12 volt AC terminals (bad design, IMHO, but not my fault). The microwave oven display had four digits, a colon, and a collection of symbols (grill, full power, or some things like that) that light up below and above the digits. However, I could not find any documentation for it on the Internet. It appeared to be branded “Galanz”.

The most obvious way to reverse-engineer it seemed to be to find the appropriate series resistor value by trial and error, and then try putting 12 volts AC, through the series resistor, between pairs of terminals on the display until something on the display lit up! The LED segment itself provides the required rectification of the AC.

However, Dr Wansbrough alerted me to a problem with this plan: apparently putting 12 volts (actually more than 12 volts, since the power supply is 12 volts RMS) across an LED in reverse can damage the LED. As soon as I became aware of this “reverse breakdown” issue, I decided that designing the extra circuitry required to enable the display to be reverse-engineered in this way withough damaging it was more hassle than it was worth. As this point, I decided to buy a display and use a switchmode power supply to power it.

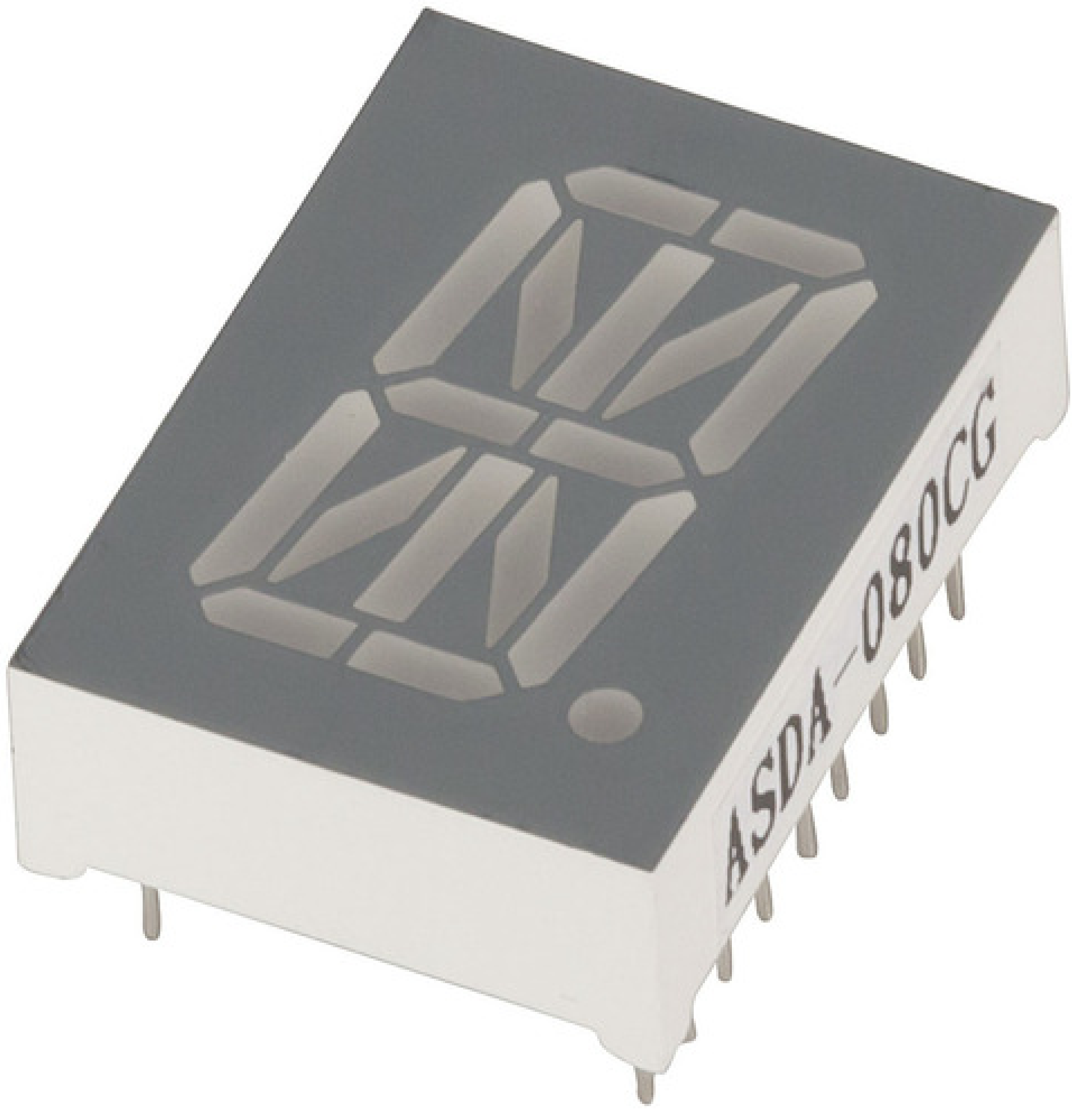
Also, I remember reading many years ago in an old Electronics Australia article (letter to the editor, I think) that half-wave rectified devices (at least in Australia) are prohibited, if the DC so generated exceeds a certain amount, in order to provent corrosion of the installation’s earth. However, Dr Wansbrough seemed to think that such a regulation, if it does still exist in any country, only applies to half-wave rectification on the mains side of a power transformer (or anywhere in the circuit if there is no power transformer): presumably DC flowing through the secondary of a power transformer does not propagate back to the primary of the power transformer; however, I don’t understand transformers very well myself. I would be happy to have feedback from others more knowledgable about this than myself.

However, I still think that designing a device (probably computer-controlled: there is also the issue of somehow determing the correct current to pass through each display segment: the symbols around the digits are of a different colour to the digits themselves) to safely and correctly reverse-engineer a microwave oven display would be an interesting and useful project. I imagine that hundreds of microwave ovens are thrown away in Auckland every day, and the displays from them could be very useful for building prototypes of embedded systems. Also, if the number of different models of such displays in the microwave ovens that are thrown away every day is not too great, then I imagine that some sort of cool low-cost large computer-controlled display could be made from a large collection of free microwave oven displays of the same model!

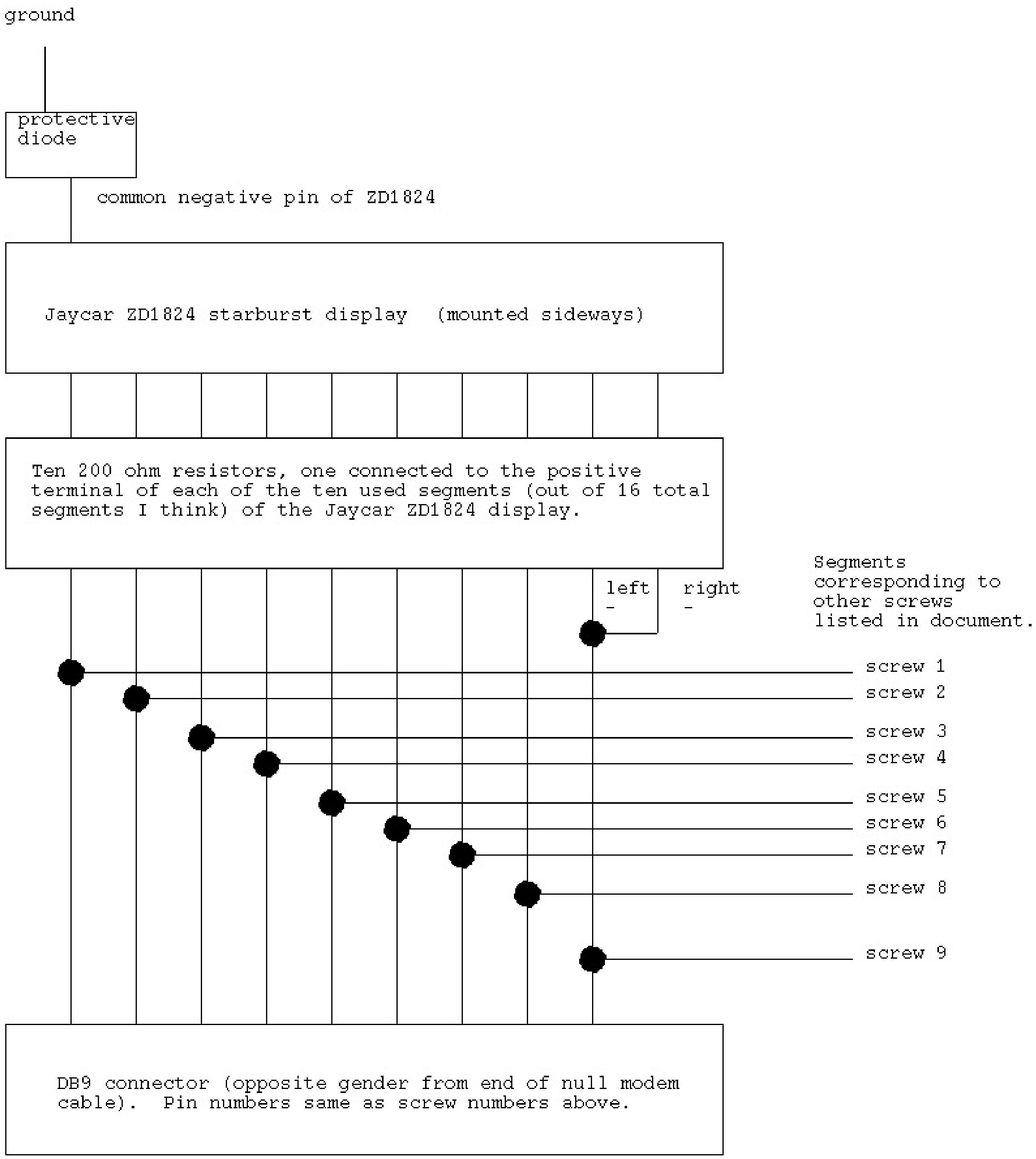
Better solution: Starburst LED display from Jaycar:

(For the record Jaycar is probably not the cheapest source of such displays, but I don't have unlimited unpaid time to devote to this project; my work on this project has been almost completely unpaid so far, and I am committed to trying to continue working unpaid on it, except maybe for the cost of parts, until I either succeed or hit a major technical obstacle).

If I remember rightly, this is the cheapest starburst display that Jaycar sell, and its catalogue number is ZD1824 (a data sheet for this display can probably still be downloaded from the Jaycar web site):



The overall circuit diagram for the more complicated end of my proposed testing device (under construction, but nearly finished IMHO) is:



I apologise for the slight crudeness of this diagram, in particular the use of rectangles instead of the proper circuit diagram symbols for the protective diode and resistors. I had only a limited selection of drawing programs installed on my Linux laptop at the time that I drew this, and I didn't have the patience to try to install one that was better suited for drawing circuit diagrams. I used "tgif". I am happy to try to obtain a proper circuit diagram drawing program and redraw this diagram if necessary.

This apparatus (which we will call the "smart end", for want of a better name) will be connected to one end of the cable under test. The apparatus at the other end of the cable, which we will call the "dumb end" for want of a better name, (for which I can't be bothered to draw a schematic, at least at this stage) will be just a DB9 connector (of opposite gender to ones at ends of the cable) with each of its nine pins connected to a screw in a block of wood labelled wth the pin number.

Sorry, I have been sloppy with my terminology in this diagram. The terminal that I call “Earth” earlier (when discussing the incandescent light bulb solution) is called “ground” in this diagram. The function is essentially the same.

At the moment, I am using a “Logitech” switchmode (if I am not mistaken: it is quite light for its power output) power supply which, if I remember rightly, is labelled “5.8 volts” (DC) but seems to be outputting 6.0 volts. If I understand Dr Wansbrough correctly, this level of inaccuracy is normal for such small power supplies, i.e. it the power supply is probably not faulty. I don’t clearly remember what the power supply was originally intended to power. If I remember rightly from last time I looked at it, it is designed to deliver at least one ampere, which I think in more than enough for this application.

The protective diode in this above circuit (taken from an old microwave oven control board: I don’t know its exact speciications) is to protect the starburst display from ruin in case I accidentally use the power supply the wrong way around.

So the idea is that:

1) the negative terminal of the power supply would be connected to “ground” in the above circuit diagram (the smart end).

2) one end of the cable under test would be mated with the associated DB9 connector on the smart end.

3) the other end of the cable would be mated with the DB9 connector on the dumb end.

4) the positive terminal of the power supply would be touched to each of the nine screws on the dumb end in sequence. The pattern that appears on the starburst display (the subset of the segments that light up) in response to each such dumb end screw being powered up in this way indicates which pins at the smart end are connected to the corresponding screw on the dumb end. I hope that this should be fairly obvious to any reader with a reasonable knowledge of electronics.

Testing smart end without dumb end.

Basically, I have built all of the smart end apparatus except for the DB9 connector itself and the wires connecting its pins to screws, and, I believe, successfully demonstrated that it works.

My intended mapping of smart end screws to display segments (with the starburst display mounted sideways, as it is in my partially completed device, is, if I have got everything right:

screw number	**segment(s)**
1	top left -
2	left \
3	left /
4	bottom left -
5	top right -
6	right /

7	right \
8	bottom right -
9	both middle left – and middle right -

Screw 9 is the only screw connected to two different segments. Since pin nine is effectively the “odd pin out” after all of the others have been divided into two subsets of four (with a hopefully easy to remember mapping between pins and segments for the two subsets of four), it seemed aesthetically more sensible to have it light up segments on both the left and right hand sides rather than arbitrarily assigning it to a single segment to the left, right, top or bottom of the centre. Each of the two segments connected to screw 9 has its own series resistor: I think that otherwise the current would be unlikely to be shared evenly between the two segments in question.

The whole smart end apparatus, in its current state, looks like this:

A few comments on the above photograph:

1) The breadboard (PCB with grid of holes in it and a pre-determined pattern on the back from Jaycar: I don’t remember the catalog number but I could probably find it again if anyone is interested) is hanging from two white wires that go into screws near the top of the block of wood. These two wires are connected together by the breadboard tracks, and both serve as the “ground” terminal in the circuit diagram.

2) The other screws are all labelled (sorry, might not be clearly visible from the photo) with the number of the DB9 connector pin to which they are intended to connect and also a crude sketch of the orientation of the display segment (s) with which they ara associated.

3) The breadboard is only about 10cm wide by 5cm high. At the time that I bought it from Jaycar, it seemed like a good solution (cheap). However, soldering eveything onto it correctly was a pain in the backside, to put it politely. In retrospect, I should have used a much bigger breadboard (also available from Jaycar, I think). Of course, a custom PCB would have been much better, but I don’t

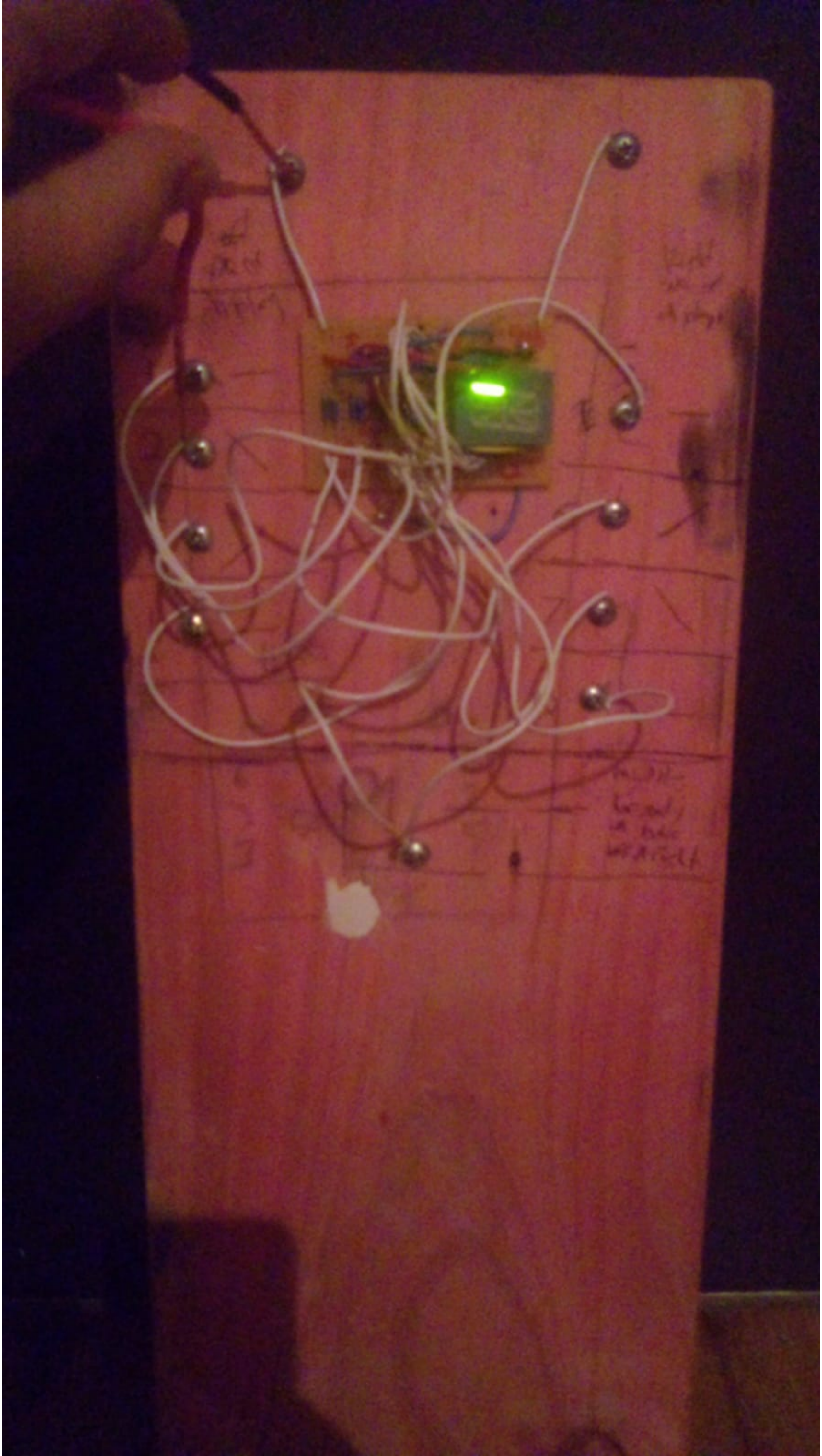
have any experience of using PCB design software, and I don't know how much it would cost to get a custom PCB fabricated. I am happy to try to re-design and re-build the whole thing with a custom PCB if anyone is interested in this.

4) If I remember rightly, I chose the series resistor values (by a combination of rough calculation and trial and error: they are 200 ohms) such as to put a current of 15mA through each illuminated segment of the LED display. This, IMHO, lights them up with more than adequate brightness while still leaving a 5mA margin for error: the data sheet recommends using 20mA. I have confirmed this by putting an ammeter in series with the power supply when doing the tests described (and photographed) later in this document,

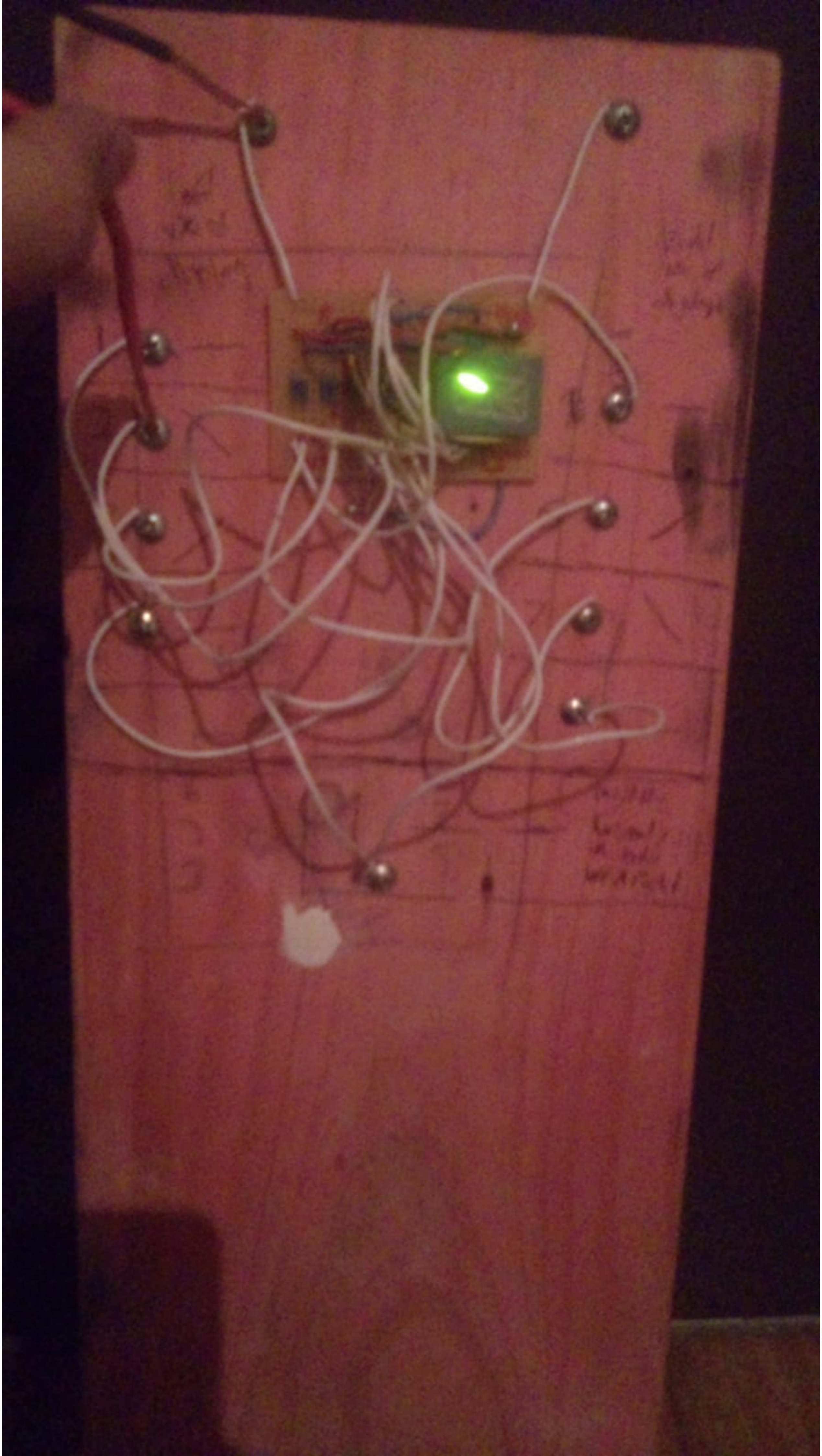
Photos of the actual testing process:

(In all four photos below, you should be able to see both the red wire from the positive terminal of the power supply being touched to the screw in question and the correct segment(s) lighting up in response).

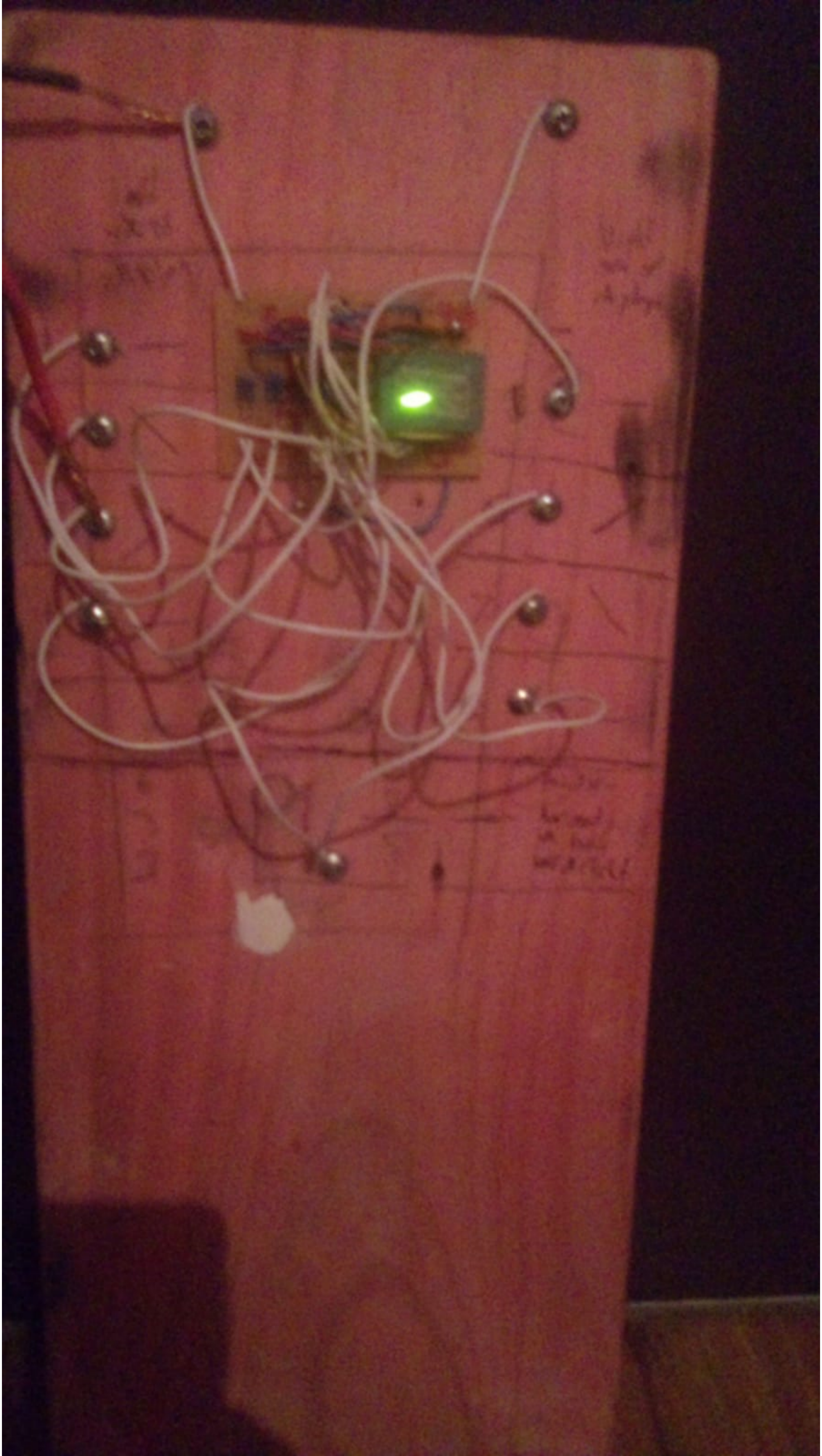
Testing screw one (negative on ground, positive on screw one):



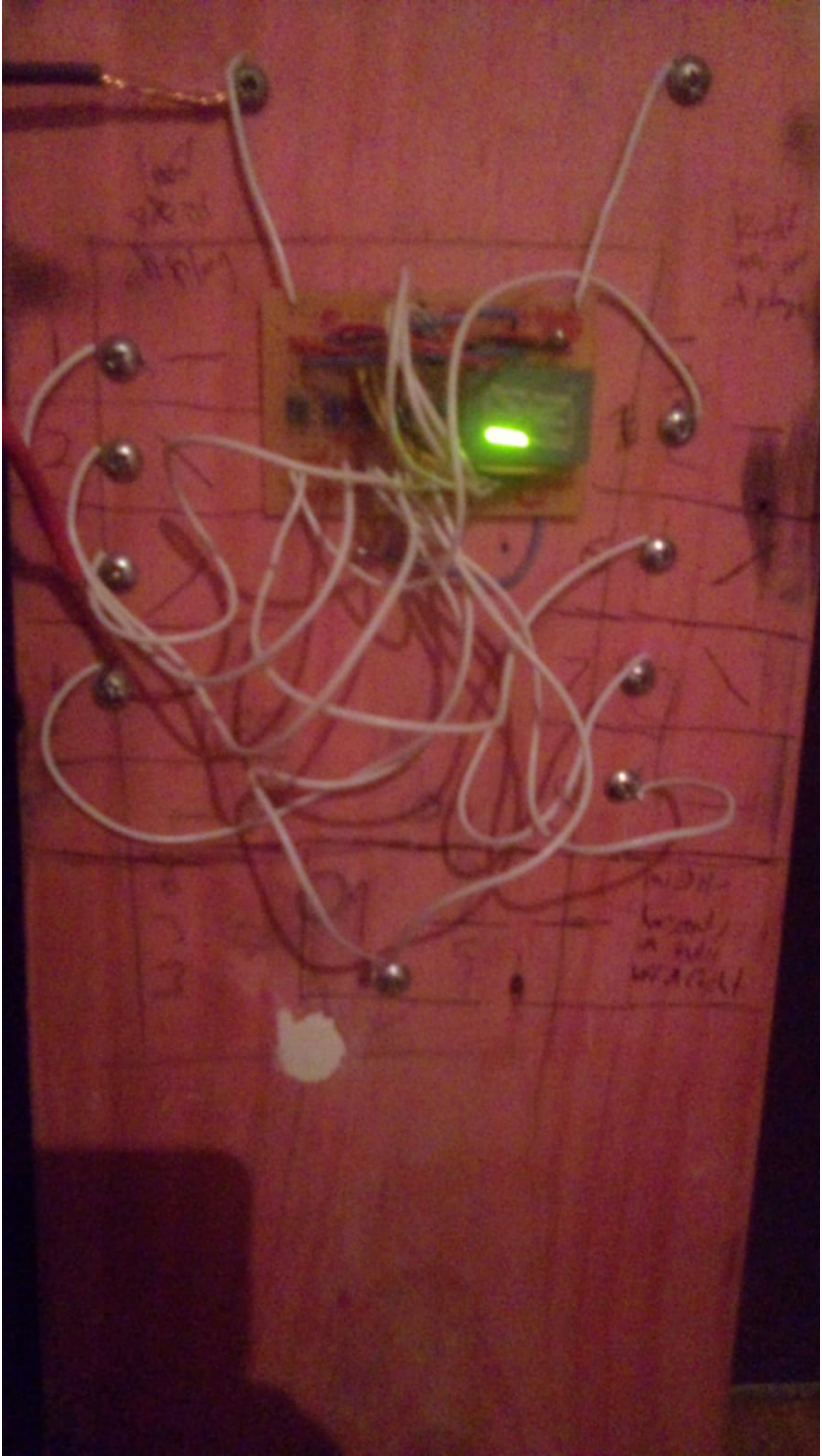
Testing screw 2 (negatve on ground, positive on screw 2):



Testing screw 3 (negative on ground, positive on screw 3):



Testing screw 4 (negative on ground, positive on screw 4):



I also have the corresponding photographs for screws 5 to 9 inclusive, but I don’t have the patience to include them here. The photograph for screw 9 is the only one in which more than one segment of the display lights up at a time. I am happy to publish them if anyone is really interested in them.

Remaining steps to take:

I would be happy to have feedback from others (knowledgable in the relevant fields) before proceeding with the remaining steps for testing the cable. The remaining steps are, if I am not mistaken:

1) Build a DB9 connector of the appropriate gender into the “smart end” pictured above, with its nine pins connected to the appropriate screws. I would be happy to have some advice on how to securely mount the DB9 connector, preferably with the appopriate nuts so that the screws of the cable connector can screw into it (to make the connection robust). So far, I have the DB9 connector but no wire and no backshell; I have used up all of the white wire (shown in the photographs above) that I bought from Jaycar, but I think that it is probably not the best type of wire for soldering into the DB9 connector. It is multi-stranded: I think that wire with a single hard strand would be better. I would be happy to have advice on this, because I want everything to work reliably.

2) Build the dumb end; similar comments apply here. I have the DB9 connector for the dumb end, and a block of wood for it, but none of the other parts for it except maybe the screws.

3) Use the completed apparatus to determine the wiring of the cable from Jaycar.

4) Publish the wiring of the cable from Jaycar!

5) Get advice from others on whether or not the wiring is correct for our application.

6) If it is, proceed with the data extraction from the old computer!

7) If not, possible consider getting a cable from another source, or wiring up one of our own after consultation with appropriate experts, test it with our apparatus, and if wiring is correct then proceed with the data extraction from the old computer!

References:

1: *Recovery of 1990s emails from Dr Michael Lennon:* https://vixra.org/abs/2201.0097.

2: https://www.jaycar.co.nz/