Build a nixie bargraph display

Most bargraph displays use LEDs, but why not try something different. How about a 120mm long nixie bargraph?

Nixie tubes were the most popular predecessors to the current crop of numerical displays like LEDs etc. They consist of a sealed glass envelope filled with neon or mercury/neon gas mixtures. Inside the tube was an anode and various numbers of cathodes. The anode was usually in the form of a fine mesh screen, so as to not interfere with the display. The cathodes were usually formed into the shape of numerals, and when high voltage, current limited DC (usually around 170 vlts) was applied between the anode and the selected cathode, the cathode would glow due to the neon gas inside the tube. Which cathode glowed was simple to control—just ground the appropriate cathode using a high-voltage transistor.

However, nixie tubes were not only available in numerical values, you could also get them in many special symbols, as well as linear bargraphs. Bargraph tubes are long, thin tubes with a cathode running the full length of the tube. As current varies, the length of the cathode that is lit varies in a pretty much linearly proportional manner.

The two most commonly available bargraph displays available nowadays are the IN-9, which requires a current of 10mA to fully light the cathode, and the IN-13, which requires only 4mA for a full display.

The IN-13 has the advantage that it also has a control cathode. This is a tiny second cathode that is separate from the main cathode. When lit, the control cathode causes the main cathode to always start glowing from the bottom end of the tube, thus making the bargraph fully controllable. Without the control cathode, the main cathode can start glowing anywhere, and usually starts in the middle of the tube, with the glow spreading towards each end of the tube as current increases. Obviously, in most cases, this is not what you want!

This kit forms a driver for the IN-13 (and IN-9 if you have them) by using a simple variable constant current circuit, an op-amp to drive it and an optional microcontroller to process the input signal if desired.

How it works

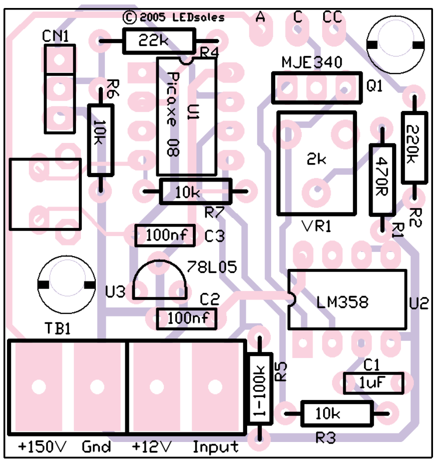
Firstly, let's look at the constant current driver. This consists of an MJE340, high voltage transistor, Q1, a 2k trimpot, VR1, and a 470R resistor, R1. The transistor is set up as an emitter follower, which means that whatever voltage is placed on its base, the emitter will follow, minus the base-emitter forward voltage drop. By having a set resistance between the emitter and ground, the current through the resistance is proportional to the voltage at the emitter (I=E/R). This means that the total current through the transistor is the same as that through the resistor, and as the vast majority of this current is coming from the collector of the transistor, then the current through the IN-13 is almost identical to that through the resistor to ground.

So, the result of this is that, as the voltage on the base of the transistor varies, so does the voltage on the emitter, and hence the current through the resistor, most of which comes through the bargraph tube. So, the tube display varies in proportion to the voltage on the base of the MJE340.

The kit was designed to work on a 0-5 volt input voltage range, but as most of the current controlling resistance actually consists of a 2k trimpot, you not only have precise trimming adjustment for transistor and resistor variations, but also to use other input voltage ranges, as well as for driving the higher current IN-9 tubes.

The one small problem with this constant current circuit is that the input voltage must reach the forward bias voltage of the base-emitter junction (about 0.65V) before any current will flow through the IN-13. To eliminate this problem, an op-amp was used to condition the input signal and provide the required offset so that a 0-5 volt signal will give full control of the IN-13.

The op-amp chosen was the LM358 (U2). While this is a dual op-amp, we are only using half of it in this circuit. It was chosen as it is very common almost everywhere, is very low cost,



and is designed to run from a single supply rail, and can handle input voltages right down to the ground rail.

The input control voltage is fed into the LM358 at pin 3, the non-inverting input for the first amplifier in the IC, via an RC filter consisting of a 10k resistor, R3, and a 1uF capacitor, C1 (incorrectly labelled at 100nF on the PCB). These components are needed to slow the slew rate of the signal to a speed that the IN-13 can respond to. If you change the current too quickly, the IN-13 can get confused and the lit section of the bargraph can jump away from the control cathode. This network is also used to convert the PWM (pulse-width modulated) output of the microcontroller (discussed next) into a steady voltage for input into the LM358.

You will notice that the input voltage doesn't go directly to the RC network as described above. In fact, it goes to pin 6 of the microcontroller, U1, which can be either a Picaxe08 or 08M (or another suitable micro if you feel like it). The micro can be used to condition the input signal in whichever way you wish. The micro sends its output in the form of a PWM signal from pin 5 to the LM358 via the RC network.

However, with a microcontroller in place, you don't even need to have an input signal. You can simulate one if you wish by any simple program you can think of. A few test programs showed this system to be very versatile.

If you decide you don't need the microcontroller, then you must jumper pin 5 to pin 6 on the microcontroller IC socket. Don't be tempted to just solder these pads together on the bottom of the board, as if you then later plug in a micro and forget to unsolder those pads, the circuit won't work and/or the micro may be damaged. A component pigtail offcut bent into a U shape makes the perfect jumper between IC socket positions.

You might also have noticed resistor R5. This is marked 1-100k and will vary depending on whether you actually use it, and what you use it with. If you are feeding the circuit a controlled voltage, you won't need R5. However, it is there to provide the bottom half of a resistor network should you decide to use the circuit with simple sensors, such as LDRs or thermistors. Testing the circuit with an LDR connected between 12V and ground and with R5 as a 100k resistor and no microcontroller used, the IN-13 varied from fully off to fully on when the LDR was moved from a dark room to a sunlit room. It is quite impressive to see your circuit respond in this way in fact!

The rest of the circuit consists of an 78L05 5 volt regulator and associated components to provide the regulated 5 volt supply for the micro, and the programming components R4 (22k) and R6 (10k), and the 3-pin header (CN1). There is also a pushbutton switch for control over the micro if you wish, and its associated pull-down resistor, R7. The last component, R2, a 220k resistor, is used to provide the small current needed for the control cathode. And that's about it!

Building it

Start with the resistors, capacitors and VR1, and then install the IC sockets, CN1 and the terminal block. Now you can install the 78L05 and the MJE340, making sure you get the latter the correct way around. The metal side goes towards the trimpot VR1, and the writing towards the edge of the board and the IN-13 tube position.

Now install the IN-13 tube. This is mounted with the viewing side facing away from the board. You can mount it close to the board, or leave some lead length for adjusting the position, it is up to you. I found that if you mount it close to the board, you can use some hot melt or similar glue to bond it to the MJE340, thus giving it much more support—indeed, it becomes self supporting and won't need additional mounting brackets, unless the circuit is to be used in mobile or other high vibration applications, which isn't recommended!

The smoke test

Start by connecting just the 12 volt DC and ground supply connections. You should not have either 8-pin IC in the board at this time. Now, check the supply voltage at pins 1 and 8 of the microcontroller's IC socket. You should have something very close to 5 volts here, positive at pin 1. Also check that you have 12 volts across pins 8 and 4 of the LM358's socket, positive at pin 8.

Now you should power down and connect the 150 volt DC supply to the appropriate position on the terminal block (ground is shared with the 12 volt supply—the safest way to provide the 150 volt supply is using a small DC-DC converter, such as the LEDsales nixie power supply kit, which runs from 12 volt DC). Now, power up the 12 volt and 150 volt supplies. Nothing should happen, except that the control cathode in the IN-13 should be glowing.

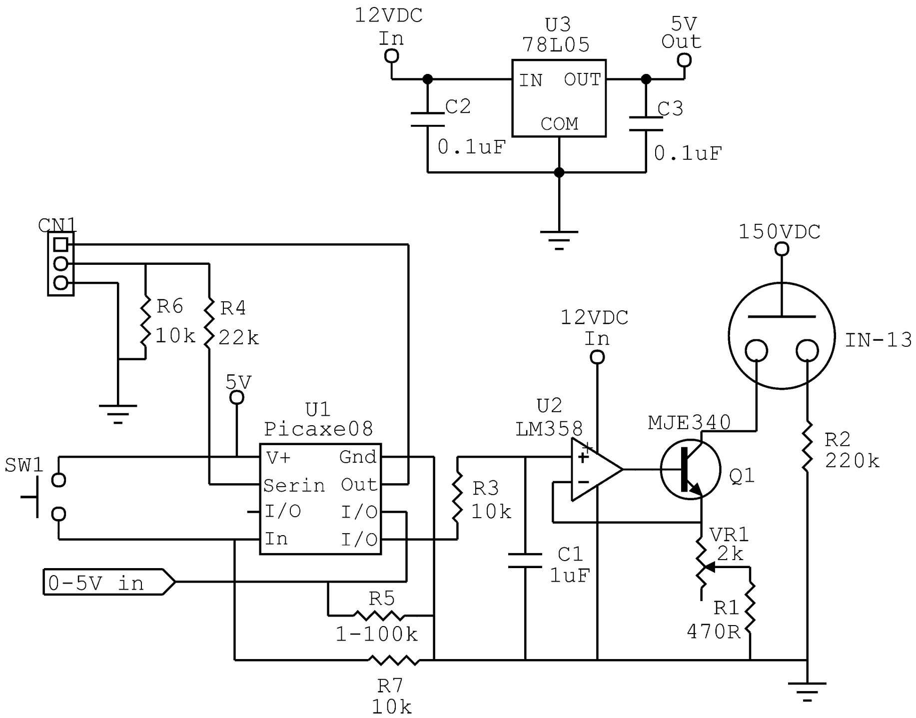
If all is well, power down and install the ICs into their correct sockets, making sure they are the right way around. If you are not using the micro, then remember to jumper pins 5 and 6 of its socket together.

Now, power up again and all should be well. If you have the micro installed, then it's test program will be producing a varying display on the IN-13 that swings from fully off to fully on. If this is what you see, then let the circuit run for a few minutes to warm up the IN-13, and then adjust the trimpot VR1 so that when the display reaches the peak of the cycle, the bargraph is fully lit. Don't adjust it so that it is fully lit before the peak, as you will be overdriving the tube to some degree. Be careful when working with the circuit, as there is a potentially lethal DC voltage on the PCB.

If you didn't opt for the microcontroller, then you will need to feed a variable voltage of 0-5 volts into the input position on the terminal block. Set the input voltage to 5 volts, and adjust VR1 for full bargraph illumination.

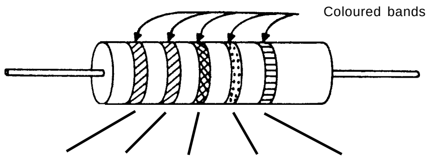
Displaying audio signals

The kit can be used to display audio signals, however, as the kit works in a linear mode, and audio signals are logarithmic, the result will be a fairly continuous low level display at the bottom of the tube, punctuated by short full-scale bursts. Really what you need is to convert the signal to something more usable. The common LM3915 bargraph IC would be suitable. This takes an audio signal and drives 10 outputs, which are usually connected to LEDs. However, a simple resistive ladder digital to analogue converter (DAC) can convert the output of this IC into a 10-step voltage that can be fed into the LM358.



Identifying the parts of your speed controller kit

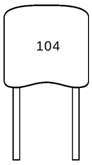
The following guide should help you to identify the parts and assemble it successfully.



Resistors

The coloured bands represent numbers and multipliers as shown in the table. Some resistors have four bands (two digits, a multiplier band and a tolerance band) while some resistors have five bands. Five-band resistors are read in the same manner as four-band resistors, except that the first three bands are digits, the fourth a multiplier and the fifth the tolerance band.

Colour	Hundreds	Tens	Units	Multiplier	Tolerance
Black	0	0	0	1	20%
Brown	1	1	1	10	1%
Red	2	2	2	100	2%
Orange	3	3	3	1000	
Yellow	4	4	4	10,000	
Green	5	5	5	100,000	
Blue	6	6	6	1,000,000	
Violet	7	7	7		
Grey	8	8	8		
White	9	9	9		
Gold				0.1	5%
Silver				0.01	10%

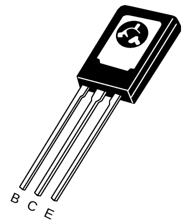


Capacitors

The 100nF (0.1uF) capacitors will be marked 100n or 104. The 1uF capacitor will be marker 1uF or 105. These are not polarised and can be installed either way around.

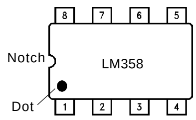
The MJE340

The MJE340 will be marked MJE340 or similar. Note that it must be installed the correct way around, with the metal side of the device facing towards the trimpot, VR1.



The LM358 and Picaxe08

These are the 8 pin devices. Note that they must be installed the correct way around. Pin 1 is marked with a small dot, and the pin 1 end of the chip will have a semicircular notch or mark. The IC sockets also have this notch, so make sure they are also installed the correct way around, as this notch is used to indicate device polarity.



Parts list

Part #	Value/description
U1	Picaxe 08M
U2	LM358
U3	78L05
Q1	MJE340
C1	1uF mono ceramic
C2, C3	0.1uF mono ceramic
R1	470R
R2	220k
R3, R6, R7	10k
R4	22k
R5	1-100k (see text)
VR1	2k trimpot
CN1	3 way connector
TB1	4 way terminal block
SW1	PCB switch

Warning!

This voltages used by this circuit, while not as dangerous as mains power, provides enough energy to potential kill a person should they be connected between the high voltage supply and ground in the right way, so be careful when working on this circuit!

Always, turn off the power and wait for the high voltage output of your power supply to drop to a safe level before making any changes to the circuit.

When completed, the circuit must be mounted inside an insulated case to prevent anyone accidentally coming into contact with the high voltage supply!