Driving IN-9 Neon Displays

Russian IN-9 neon bargraph indicator tubes are readily available on eBay and from a number of commercial sources. However, there seem to be no detailed characteristics or circuits for driving this tube published on web. The designs in this document are not particularly sophisticated, but should serve as a basis for experimenting with these interesting displays. Although these circuits were designed for the IN-9, they will also work for the similar IN-13 with changes as noted below.

The IN-9 is a current driven indicator. The length of the glowing bar is directly proportional to tube current over a most of the device's range (Figure A). Linearity is very good between 0 and 8mA with a fit constant of 10.3mm/mA. Sensitivity decreases rapidly for currents above 8mA. Once the cathode is saturated at 103mm, the glow brightness increases with increasing current. As shown by the V-I diagram (Figure B), the tube voltage drop remains nearly constant when the glow is expanding. This characteristic allows the IN-9 and a series resistor to be used as a voltage indicator. Once the cathode glow is fully expanded, the tube behaves as a resistance of approximately 400 ohms. The maximum recommended current for an IN-9 is 12mA. Those ratings were exceeded somewhat to produce these plots.

One of the simplest possible drivers for this tube is a single transistor current sink (Figure C). This circuit requires only two parts. If the transistor base current is neglected (good assumption, h_{fe} of a MJE340 is >200), the tube current is approximately $i = (V_{in} - V_{be}) / R$. V_{be} is typically a little over 0.6V for a silicon transistor. Thus, with R = 330 ohms, an input voltage of +0.6V to +5.0V will sweep the IN-9 through its entire normal operating range. (I do not have an IN-13, but with a design current range of 0 to 5mA, R = 820 or 1K ohm would be appropriate). For an easy test circuit, V_{in} can come from a 10k potentiometer connected between ground and +5V. Different high voltage transistors can substitute for Q1, but I wouldn't recommend the popular MPSA42. At full current, this circuit is too close to that part's maximum dissipation for my comfort. The MJE340 is inexpensive and widely available from Digikey, Jameco, Farnell and many others. Q1 will be warm to the touch in normal operation. If you intend to operate any of these circuits from a higher supply voltage than +150V (for example, the 170-190V typically available in a nixie clock), I would add a 2.2k or 3.3k resistor in series with the IN-9 to prevent excess power from being burnt off in the transistor.

A simple seconds indicator for an MCU based clock is given in Figure D. The TLV5625 is small (SMD) 8-bit D/A converter I happened to have on hand. The reference voltage is set so that the MCU can sweep the D/A from a count of 24 (0.6V) to a count of 144 (3.7V) incrementing at a rate of 2 counts per second. This produces a nice jump in the glow bar each second.

Figure E shows an equivalent circuit that uses discrete counter ICs, a parallel D/A converter and an op amp. The NAND circuit causes the counters to reset at a count of 60 instead of 256. In a nixie clock, this circuit can directly replace the counters used to scale the 1Hz timebase input to the 1/60Hz minute signal. The diode in the op amp feedback path introduces a 0.6V offset in the output to offset the V_{be} drop. The op amp and diode types are not critical. The supply voltage requirements of this circuit are somewhat inconvenient; a possible modification would be to change the +12V supply to +5V and use a rail-to-rail op amp, and to generate the negative supply using one of the many LM555-based inverter circuits available on the web.

The main short-coming of the simple current sink is the V_{be} drop subtracted from the input voltage. V_{be} is not constant; it varies with both collector current and junction temperature. Luckily, the collector current effect is negligible at the operating point used and even if the whole assembly was moved from the Sahara to the Arctic, V_{be} temperature dependence would only shift the bar length by a few millimeters (changes in tube gas pressure would likely have a much greater effect under those circumstances). In many cases, however, it is useful to have an indicator that starts at 0V. The circuit in Figure F uses an op amp to remove the V_{be} offset and compensate for any temperature dependent effects. Current through the indicator tube is simply $i = V_{in} / R$, with no offset adjustment needed.

Questions are welcome.

IN-9 Current -> Length Transfer Function

Length (mm)

Current (mA)

Fit (0-8mA): 10.3 mm/mA
Correlation: 0.999
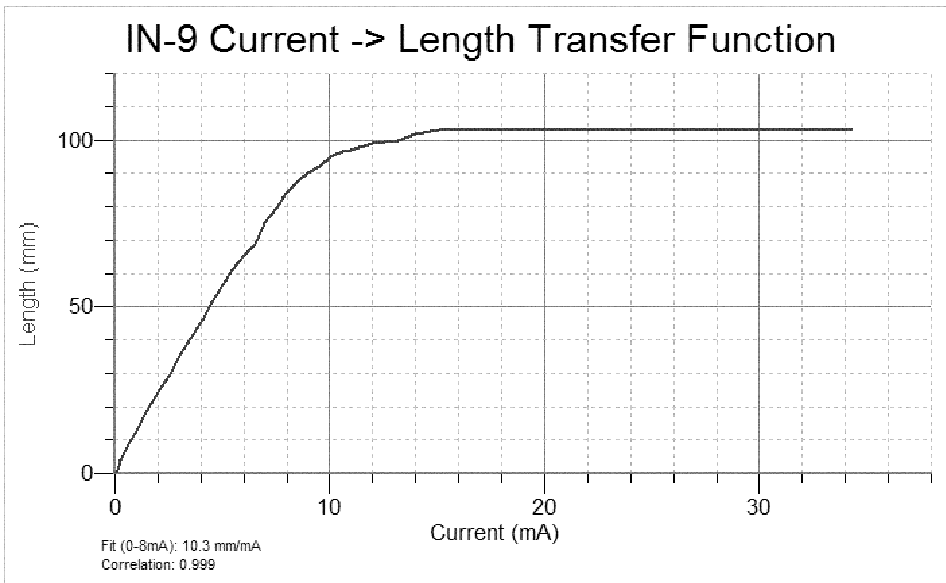
Figure A. Bar length as a function of tube current.

IN-9 Characteristics

Voltage (V)
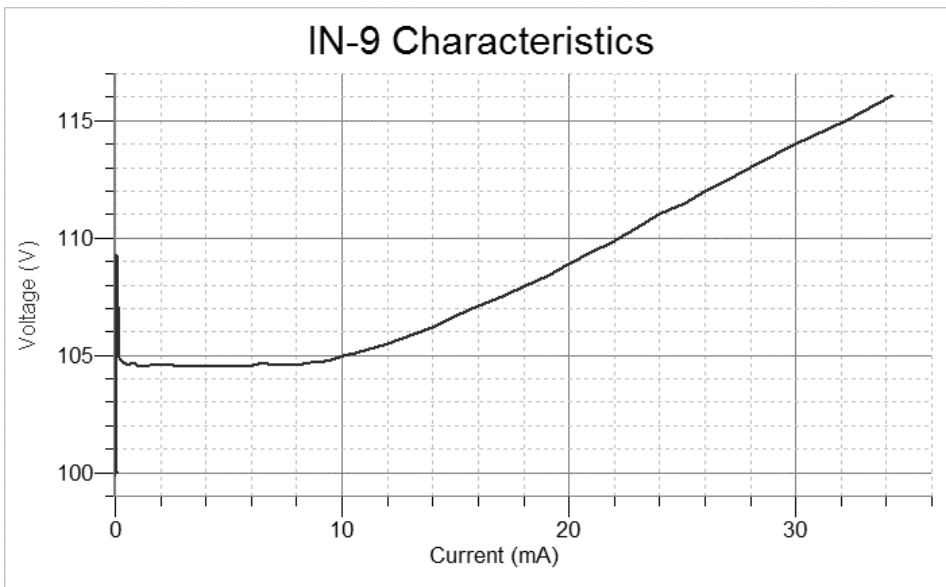
Current (mA)

Figure B. V-I characteristics.

Current Sink IN-9 Driver

$Ic = (Vin - Vbe) / R1$

IN-9

Q1 MJE340

R1 270

+150v

IN

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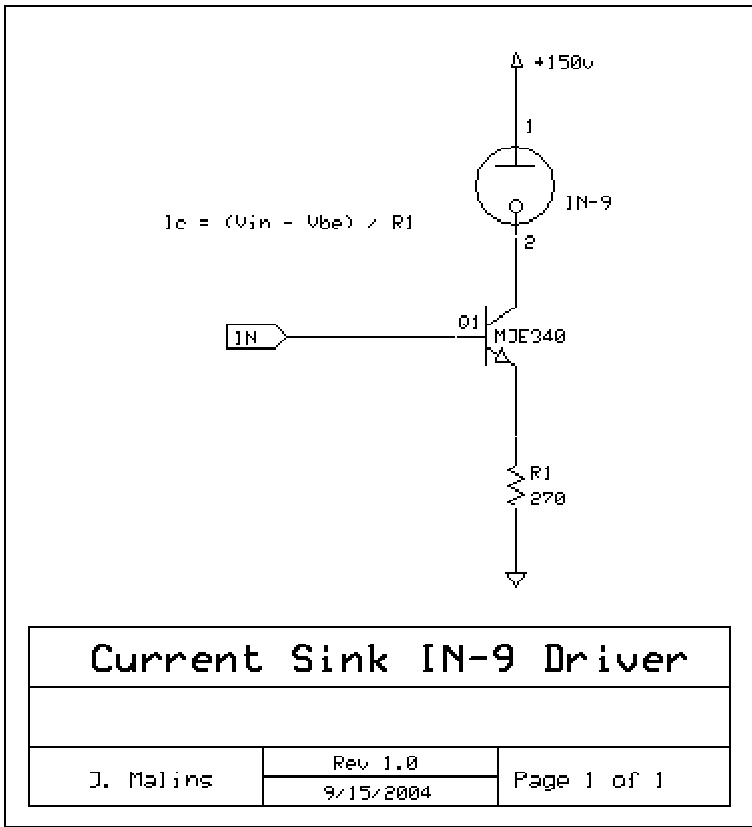
Figure C. Single transistor current sink.

MCU-based IN-9 Driver

+5v   +5v   +150v

IN-9

Q1 MJE340

DATA
CLK
SYNC

DIN   VDD   OUT
SCLK
/CS   U1 TLV5625
SYNC   REFIN
GND

R1 10k
R2 20k
R3 310

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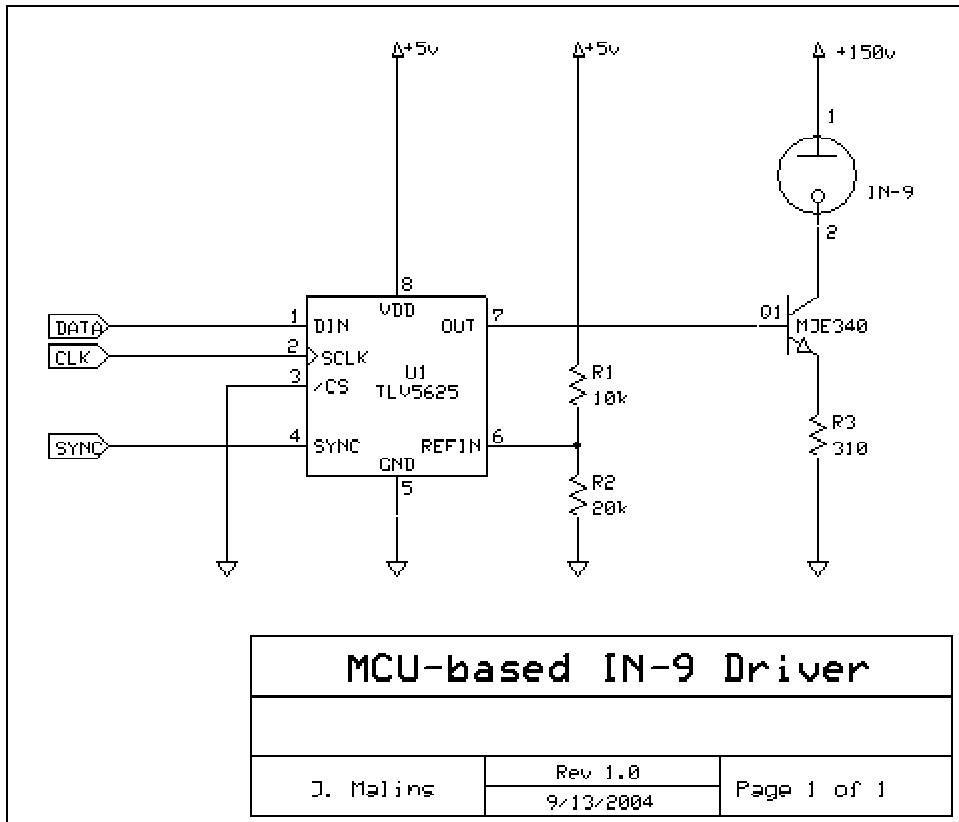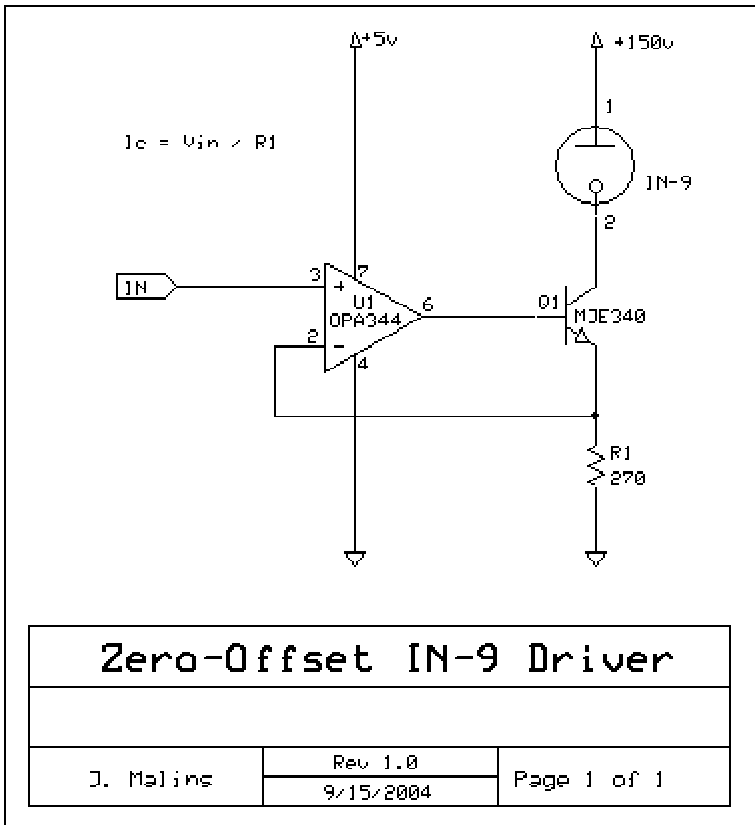
Figure D. MCU driven D/A driver circuit.

Figure E. TTL discrete IC driver.

Figure F. Op amp based driver with zero offset voltage.