A LOW COST NEGATIVE VOLTAGE SUPPLY TO BIAS EXTENDED TEMPERATURE LCDS

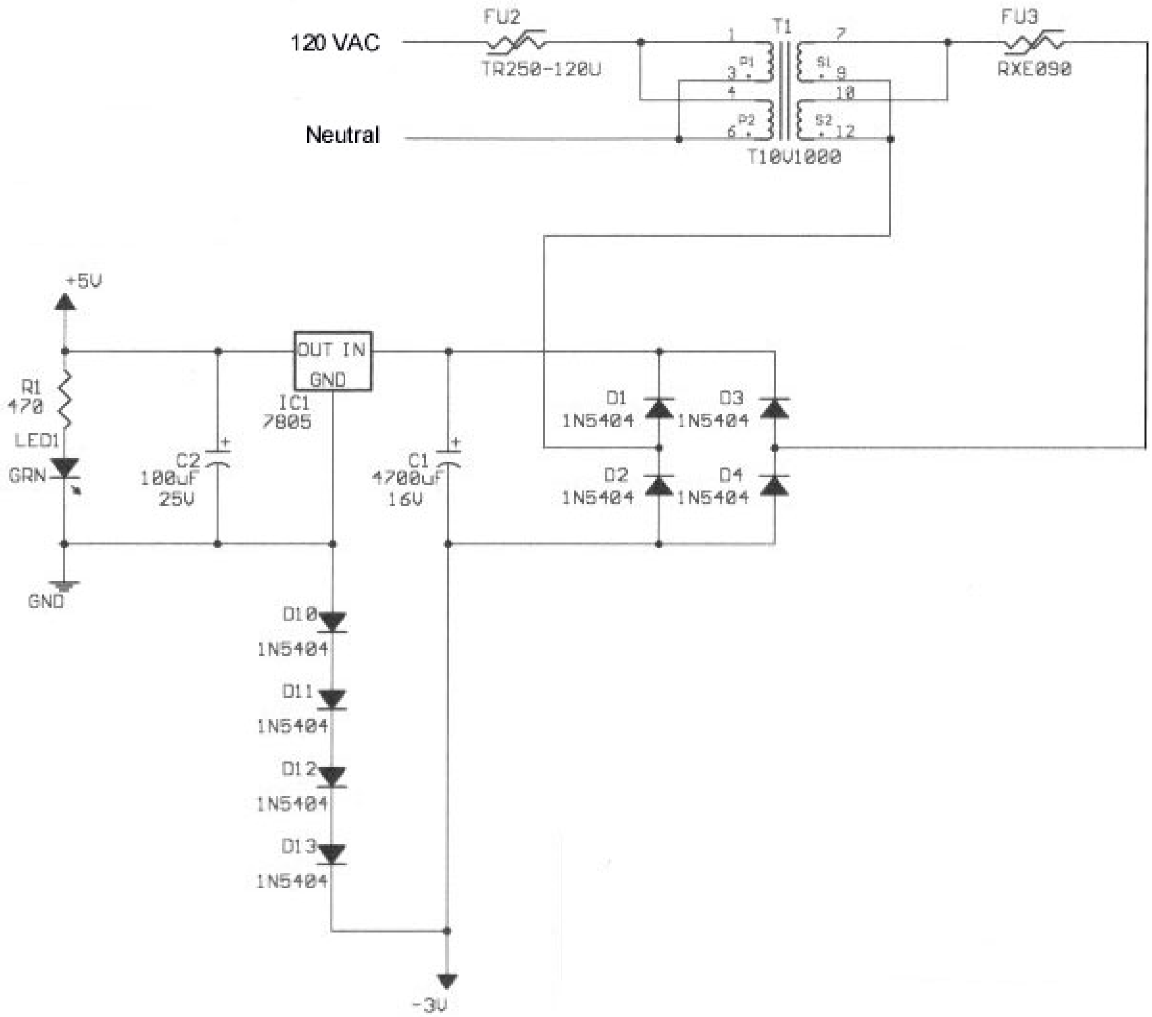
Most character LCDs require a bias voltage of a few volts to produce the proper contrast. This can be easily derived from a +5V supply by using a potentiometer. The potentiometer provides an adjustment to compensate for the display contrast variations that occur over a wide temperature range.

If the LCD is to be used over a narrow temperature range, two resistors can be selected to provide the proper bias voltage. Connect the resistors in series, with one end of the series combination connected to ground, the other end connected to +5V, with the common point between the resistors providing the bias voltage to the LCD. The series resistance combination should be around 10K. This is known as a voltage divider.

If you'd prefer a contrast adjustment, but don't want a knob for the user to turn, you can substitute a DigiPot (TM) or similar device for one of the resistors in the voltage divider. A DigiPot is a potentiometer that can be controlled with a digital signal. The microcontroller can then adjust the DigiPot, either under pushbutton user control, or automatically if the microcontroller has access to environmental temperature data.

There are several LCDs available through surplus or traditional commercial channels which allow an extended temperature range. This sounds ideal, as there seems to be nothing for the designer to do, but as usual there's a catch. The extended temperature range LCDs require a negative bias voltage to operate. Without it, there is no contrast and the display is completely blank. For the 4 line by 20 character LED backlit liquid crystal display I recently used, the display was very legible with a bias voltage ranging from -1.5V to -4V. Unfortunately, negative voltage supplies can add some complexity to the design. The surplus dealer that supplied the LCD I was using included some datasheets for nice Maxim parts that use flying capacitors to generate a regulated negative voltage. That seemed like overkill to me for this low current supply with such loose voltage requirements.

The 7805 linear regulator I was already using is common to most microcontroller power supply circuits. It's a three terminal device, IN, OUT and GND. Essentially, an input voltage of +7V or more is supplied to IN, and the regulator maintains OUT at +5V. Almost invariably, both IN and OUT are referenced to the same ground potential at GND. With it's ability to keep OUT at +5V with respect to GND, it's possible to trick the 7805 into simultaneously providing a regulated +5V and a regulated negative voltage. This is done by placing a diode string in the path between GND used as the ground reference for the output and the input ground reference as shown in the following schematic.



The diode string is forward biased, providing a voltage drop of about .6V per silicon diode. The voltage measured at -3V is actually more like -2.6V. Three diodes in the string would have produced about 1.8 V.

Notes & Caveats:

Even though the LCD bias requires a very small current, I had to use rather large 1N5404 diodes in my design because all of the current sourced and consumed by the LM7805 passes through the diode string, not just the current required from the negative supply, and I had some power hungry devices on my +5V supply. For most applications, the smaller and less expensive 1N4001 diodes will work. They're rated for 1A.

The negative supply can be adjusted by adding or removing diodes, with each diode representing .6V. If you prefer, a single zener diode of the appropriate voltage rating can be used. Zener diodes work in the reverse biased mode, so be sure to install any zener diode backwards from the polarity shown in the schematic.

The transformer must have an unregulated output voltage that is at least equal to the negative voltage you want, plus the +5V output of the 7805, plus the minimum 2V dissipated by the 7805 to regulate the voltage. Any voltage above that total will be dissipated by the 7805. As an example, for the circuit above, I used a transformer that supplies 10V when both secondaries are in parallel as shown. 10V > 5V+2V+2.6V.

The 7805 has an upper limit on power dissipation. In most applications it'll dissipate from 2V to 7V or so without problems. For the higher voltages, a heat sink may be required. Carefully feel the case with your finger while the regulator is supplying the full current it will be expected to source. If it's too hot to touch, add a heat sink.

The capacitors shown are for a high current industrial design. For light duty commercial applications, less expensive capacitors could be used. For most applications, C1 could be 100-220 uF, and C2 could be 1-10 uF. Both should be rated for 16V or more.

The negative voltage produced by this circuit is fairly well regulated by the diodes, but the forward bias voltage produced by the PN junction of a silicon diode does vary a bit with the current flowing through the diode. For most circuits, this slight variation is not a problem. A single zener would probably perform a bit better in this regard as it would be operating in the avalanche mode with very little voltage dependence on current.

Finally, note that FU2 and FU3 are positive temperature coefficient (PTC) fuses. These cost about the same as any decent fuse that mounts on a printed circuit board, yet offer the advantage of automatically resetting after an over current condition. They work by a nonlinear heating effect. As the current through the device increases beyond the rated holding current and approaches the trip current, the fuse goes into a thermal runaway condition. The resistance increases to the point that only a small current is flowing through the fuse and into the circuit, and the fuse remains in this tripped condition until power is removed for several seconds allowing the fuse to cool. Essentially, you get an automatically resetting fuse for about the same cost as a fuse that would need to be unsoldered and replaced. This is especially handy when testing prototype circuits. I tested FU3 a couple of times during my development. It's also a great feature to prevent products from being returned for servicing due to a blown fuse. The PTC fuses are manufactured by Raychem under the name Polyfuse. Bourns also manufactures a similar line of PTC fuses. Both are available from Digi-Key, 1-800-DIGI-KEY, or www.digikey.com.

Good luck.

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