Description of M3.80

The Origin

This circuit was developed and built as a school project with three classmates within our apprenticeship (electronics technician, the proper German term is “Elektroniker für Geräte und Systeme”).

The goal set by the teacher was to develop a circuit that does something with the analog voltage the IR proximity sensor GP2Y0A21YK0F from Sharp puts out. The circuit should be able to use at least three different voltages and should only use discrete components or purely analog ICs like operational amplifiers or voltage regulators.

Our group decided to build a universal board that displays the distance in 10cm increments and has three open collector outputs that can be set by the user.
The name tells the basic functionality: 3 outputs, 80cm range.

The circuit

The operating voltage gets stabilized by a standard 7805 voltage regulator after passing a schottky diode for protection against reversed voltage. The input voltage must be higher than 5V because there is a voltage drop across the diode and the regulator. At least 9V should be applied but not more than 30V to be on the safe side.

The sensor is supplied with 5V and puts out the voltage depending on the distance to the target. This voltage gets stabilized with a capacitor and goes to every positive input of the operational amplifiers.
These amplifiers are in a configuration called comparators.
The adjustable voltage dividers at the negative input set the reference voltage. The output is near to ground (GND) when the voltage on the positive input is below the reference and switches to near +5V when this voltage gets above reference. This is where the corresponding LED or transistor is switched on.
The capacitors between the reference and output are stabilizing the comparator when the voltages are about equal. Otherwise the output gets indecisive and starts to oscillate (LED flickering, transistor switching fast between states).

There is one unused amplifier which got its inputs tied to GND. This is wrong because as described above the output gets indecisive when the input voltages are the same.
A better solution would be to make this an impedance converter and tie the positive input to positive or negative. In this simple circuit an oscillating amplifier does not have a big impact but in other applications this could lead to problems.

The LEDs are very bright ones and therefore need very little current to be as bright as a standard LED at 20mA.
The open collector outputs can not switch high currents. A couple of 10mA should be the limit and are more for digital applications like microcontrollers.

The circuit board

The board was actually the first one I ordered from a manufacturer, so far I only etched my boards for myself at home.
So did I with the prototype and after we fixed some little issues we ordered a bunch of PCBs.

For easier assembly of the through hole components especially the LEDs I designed a

soldering jig which is made of MDF and milled by hand on my little Proxxon mill at home. Back then we had no access to a CNC mill or a 3D printer but this jig worked just fine.

Adjusting
After assembly all the corresponding trimmers need to be adjusted so the voltages match the distances the sensor sees.
The sensor is clamped and is facing a white sheet of paper with at least 10cm long sides. Many cameras are sensitive to the IR light of the sensor so it can be checked that the spot is hitting the paper right.

Adjusting is easy, simply set the right distance and adjust the trimmer so the LED is just turning on. This can be checked by moving the target a bit back and forth. Repeat with the other distances.