University of Florida
Department of Electrical Engineering
EEL 5934: Intelligent Machines Design Laboratory

Sharp IR Sensor Hack for Analog Distance Measurement

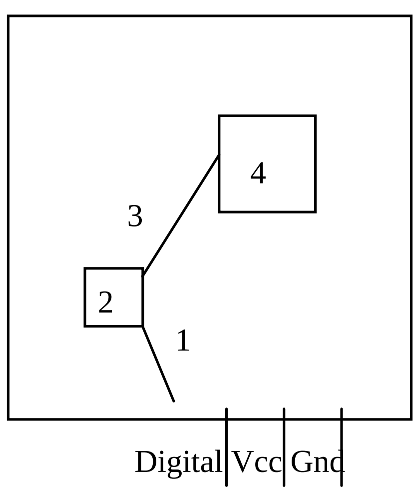
UPDATED 5/4/96 by Keith L. Doty

The Sharp hack was originated by Ariel Bentolila and demonstrated to me by lab member Scott Jantz in February of 1995. I subsequently engaged in several experiments to improve the transient response of the device. All mentions of the Sharp device are in reference to the SHARP GPIU58X or the GPIU58Y. These two parts possess identical electrical characteristics. The three leads of the GP1U58X project from the back of the can in line with the viewing lens. Those of the GP1U58Y project perpendicular to the viewing lens, allowing for easy printed circuit board mounting. Information presented is taken from lectures from *EEL 5934, Intelligent Machine Design Laboratory* or the authors' research.

The Analog Hack

The unmodified Sharp has only a single digital output pin. This signal is taken from a Schmitt trigger in series with a 40KHz bandpass filter and signal amplifier. An integration element (capacitor) is applied before the Schmitt trigger.

Gain access to the Sharp miniature, internal, printed circuit board by carefully bending the lower lid back. Careful! Bending the lid too many times will cause the metal to fatigue and break, thus, eliminating the lower part of the faraday cage protecting the device from electromagnetic interference. Examine the exposed side of the Sharp printed circuit board (Refer to Fig.1). Two test points will be found to the left of the



1) Trace to test point (very thin)

2) 0.1µf surface-mount capacitor

3) Trace to integrated section (the analog IR signal).

4) Integrated section (black dome)
   * Solder analog tap on the "P" side of the capacitor.

Figure 1 View of opened GP1U58X or GP1U58Y Sharp case from underside

digital output pin. The amplified filter output, an analog signal (trace 3), is integrated by a surface mount capacitor (2). The lead (trace 3) from the capacitor into the integrated section (black mound, 4) is readily visible. A wire soldered directly to trace 3 will give the analog response. For practicality, it is much easier to solder to the capacitor terminal than the trace itself. With a multimeter, it can be verified that the other capacitor terminal is grounded and that the capacitor has a value of 0.1µf.

It is critical that the metal case of the sensor be grounded for proper operation. Simply apply a large blob of solder to the outer ground pin (Fig.1 GND) and heat the metal case with the same soldering iron until the solder flows and a join forms.

When the IR detector is modified in the above manner, both analog and digital responses can be taken from the same sensor. In other words, the sensor that previously was only used for digital IO can now also measure short distances (about 100mm to 300mm with about 5 bits precision, i.e., to about 6.25mm accuracy).

Signal Characteristics:

Zero reading : 1.5V, Full saturation: 2.5V, Rise/Fall time : 100ms

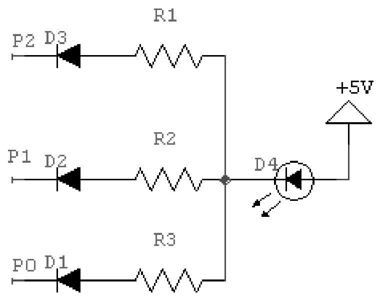
The analog tap (trace 3) is extremely sensitive to loading. Any analog input into which the signal is applies should be of <20pf capacitance. Practically, this means that an MC68HC11 analog input is OK, but a 4000 series analog MUX is not. Also, because of the rise/fall time, a sampling rate of only 10Hz is supported.

The rise/fall time can be reduced to 1-2ms by replacing the surface-mount integrating capacitor. A value of 5000-10000pf will give rise/fall times of 1-2ms respectively. Using the 5000pf option, the author achieved rise, saturation, and fall within 1ms allowing for a 1KHz sampling rate. Signal stability and range is preserved at these values. Lower values causes significant ripple. Using the improved time-constant hack will destroy the digital response of the sensor. It is no longer possible to use the same Sharp for analog and digital measurements.

Detection Range

Range of the hacked Sharp depends on the level of IR used by the emission system and the degree of collimation. A favorite method of collimation used at MIL is to cut the tube of a black Paper-Mate pen and hot-glue the Infrared LED into the tube. Using the standard size LED, the fit is perfect. A length of 1 to 1.5 inches of tube from the back of the LED is used. This tube can then be glued to the side of the Sharp device to form a formidable ranging device.

Range is greatly enhanced by allowing digital control of the IR level. The method currently used at MIL, developed by Scott Jantz and Tae Choi, uses a 74HC374 output latch to sink current through a binary resistor network. The network is illustrated on the next page. In our applications, the latch serves as an output latch under the control of a microcontroller. The P2-P0 pins depict outputs of the 74HC374 latch. Any digital port can be used, but the provision of sinking substantial current must be taken into consideration . Selecting binary ratios for the resistor values, $R_3 = 2\ R_2 = 4\ R_1$, allows the user to drive the LED by current through any of eight resistance values by appropriate grounding of the pins P2-P1-P0. For Vcc=5V, the appropriate range for R_1 is



300ohms ≤ R_1 ≤400ohms. The 74HC374 can sink over 20mA per pin. By using software control of the LED level, a range of 0.5 to 44 inches (a little over a meter) can be realized. The algorithm for achieving a meter range requires the software to start at the highest level P2=P1=P0=GND and decrease the level if the response is saturated at 2.5V. To achieve optimum accuracy, one should select the resistor range that drives the analog signal as close to 2.0V as possible . Alternatively, plot the response of each level vs. distance and define the most linear sections. Then create a composite of eight linear sections with enough offsets to prevent overlapping. This almost yields 8-bits resolution across the 0.5 to 44 inch range when one uses an 8-bit A/D with reference voltages greater than (2.5-1.5V) 1V. This approach is particularly useful for the MC68HC11 which requires a minimal difference of 2.5V between reference voltages.

For up to date research on the variety of projects pursued at MIL, check out our WEB site *http://www.mil.ufl.edu* .The site provides the email addresses of all persons in the lab and their current research as well as a link to NovaSoft’s autonomous mobile robot products.