Logic probe

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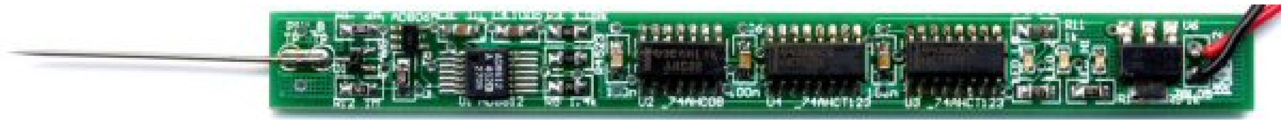

Introduction

A ligic probe is a very simple, yet very useful tool for digital electronics project. The basic principle is very simple: you attach it to a signal in your circuit and it shows you the signal level on the wire. The simplest version of it would be an LED driver and an LED. If it lights up, there is a high signal on the wire, if it does not, there isn't.

There are some serious problems with this simple approach that limits its usefulness. One of the main limitations is that if the high-level on the wire exists only for a short period of time, the LED might not light up or if it does, it's brightness is so low that it cannot be seen. The other major problem is that it cannot distinguish between low levels and no driver on the wire (also called a high-impedance, or 'Z' state).

This project solves these problems. It can detect pulses of 5ns or larger and displays three states of the signal: low, high and high-impedance.

Features

- Three independent LEDs for three detectable states
- Over one 1MOhm input impedance
- 100MHz operation
- Pulse stretching for detection of non-repetitive events

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Design description

Analog interface

To detect three distinct states on the wire, a window-comparator must be employed. This comparator is set up to detect the the ranges of valid CMOS low and high levels as high and low, and the in-between region as high-impedance state. This comparator is fed through a high-bandwidth operational amplifier to provide the required high input impedance. It is required so that the probe doesn't interfere with the drivers on the wire and not to alter the voltage levels set by pull-up or pull-down resistors. The input of the operational amplifier is biased to the middle of its operating range and since the amplifier is not a real-to-rail device, an input divider is used to move the input levels into the operating range. The input impedance of the circuit is set by this divider to be above 1MOhm. This however also means that the operational amplifiers input will be drive through an extremely high impedance, so the bias current of the inputs of the amplifier could produce a significant voltage drop. Also, in order to work up to 100MHz a high bandwidth amplifier had to be chosen. The amplifier that met these requirement was the AD8065 from analog devices. The high-speed dual comparator that is used in the window-comparator configuration is the AD8612.

Digital logic

The output of the window comparator is fed through some logic gates that decode the three distinct states of the wire. These signals are then wired to re-startable monoflops built from 74AHCT123 ICs. These devices are used to stretch the length of short pulses to the level detectable by the human eye. The output of these monoflops however will return to 0 after their time elapses even if the input is still high. Wired OR configuration of diodes is used to drive the LEDs from both the input and the output of the monoflops to get both pulse and static readings.

Powering options

The internal circuit runs from a 5V power supply but an on-board regulator is provided, so the circuit can be powered from a wide range of power supplies. Power consumption can be in the 50mA range while detecting high-speed signals.

Physical layout and operation

The device is laid out in a pen-like fashion, in fact it can be put inside a large pen. The needle at the front is the probe, and can be inserted into small vias or holes on the tested PCB. Power supply to the probe is provided on the other end. Note that the ground of the probe and the tested device must be connected some way to do measurements.

Design files

Schematic and PCB in PDF format (HSNCL)