Neural Network Line Follower Controller(NNLFC001)

General Description

The NNLFC001 is an intelligent hardware solution to the problem of autonomous line following with mobile robotica. Its architecture contains a pre-calibrated, multi-layered neural network (NN) designed to take in analog data from a 16 input photo-sensor array interfaced through the ADC0817CCN (National Semiconductor). The NN will translate this data into two pulse width modulation (PWM) outputs with direction control for motors on a skid steered platform. The default configuration for the network requires these photo-sensors (photo-transistor/led pairings) mounted in a 2x8 array. Normally the NN is setup with 3 hidden nodes in a single hidden layer with 5 different direction outputs in a output layer. This may not be your ideal configuration for the chip as you may have different photo-sensors or mechanical platform than the NNLFC001's default. The chip's NN parameters can be modified by training and configuring a new network through placing the chip in training mode. This switches motion control of the robot to be manual activation based. You then control the robot by sending direction commands through the optional serial port. In this mode, photo-sensor information will be sent through the interfaced serial port at a constant rate. This is ideal for obtaining training data for another neural network configuration. The IC is designed such that any style of neural network learning can be used as long as trained weights can be extracted for programming onto the NNLFC001. The adaptability of this chip is quite diverse as its usability in the application as a line follower controller is very much dependent on the training of the neural network.

Application

To use the NNFLC001, you will require two interface ICs: ADC0817, and MAX232. The ADC chip is to read analog photo-sensor readings on the range of 0 to 5 volts, and requires merely the direct connection of appropriate signal lines on the ADC to the NNLFC001. The serial port is optional, as it is only required if you need to readjust the network parameters via retraining and configuration. It is suggested that the serial port interface is setup for when dealing with prototype systems to ensure correct robot operation as per the application. It can be omitted for production models. The MAX232 interface is trivial and requires only the direct connection of signals between the NNLFC001 and the standard RS232 serial port. Table 1 outlines the I/O pins on the NNLFC001 and the appropriate pin assignments between the interface ICs.

The suggested photo-sensor inputs are phototransistor/led pairings. A sample circuit for implementing such is depicted in Figure 1. The system clock should be set at 20MHz and the tolerances of the FPGA respected.

Weight Configuration

The runtime weights are hard coded into the FPGA, they can only be changed by re including the ROM by recompiled the VHDL. The included software can be used to generate the weights from training data and form a proper ROM file for use with MaxPlus II. The preconfigured weights are set to be able to follow a 1" reflective line on a high contrast background.

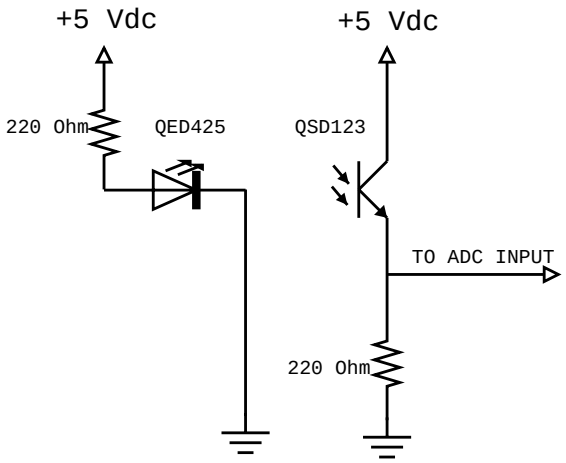

Figure 1: Phototransistor

Name	Chip Pin	UP1 Pin	Description
ResetBtn	29	FLEX-PB2	Pushbutton input for Reset
SerIn	190	24(c)	Serial data receive
SerOut	200	25(c)	Serial data transmit
Led1[7:0]	[14-11,9-6]	FLEX_DIGIT1	Upper Nibble LED
Led2[7:0]	[25-23,21-17,14-11]	FLEX_DIGIT2	Lower Nibble LED
ADC_SC	199	16(c)	ADC Start Conversion
ADC_OE	200	18(c)	ADC Output Enable
ADC_ALE	217	17(c)	ADC Address Latch Enable
ADC_Clock	203	19(c)	ADC Clock
ADC_EOC	201	15(c)	ADC End of Conversion
ADC_Mux[3:0]	[221,220,222,219]	47,46,48,45(c)	ADC Channel Select
ADC_Data[7:0]	[218,215,214,208 207,206,204,202]	35,37,38,39, 40,41,42,44(C)	ADC Data Input
PWMLeft	109	15(b)	Left Wheel PWM
PWMRight	110	16(b)	Right Wheel PWM
DirLeft	111	17(b)	Left Wheel Direction Bit
DirRight	113	18(b)	Right Wheel Direction Bit
clock	23	CLK	System Clock

Table 1: Pin Assignments