EagleEyes Mouse Interface

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What is EagleEyes?

EagleEyes is a new technology that allows the user to move the cursor on the screen of a Windows or Macintosh computer by moving his or her eyes or head. Basically, the cursor follows the location that the user is looking at on the screen. In this way, the eyes replace the mouse. Selection is made by looking at a small area of the screen for a short period of time, which causes a mouse click. EagleEyes is based on measuring a user's EOG or electro-oculographic potential. The EOG is a small electrical potential which indicates the position of the eye relative to the head. Surface electrodes are placed on the user's head, above and below one eye, and on each side of the head to the left and right of the eyes. The five electrodes are connected to an electrophysiological amplifier which is connected to a computer. A program in the computer translates the signals received from the electrodes into the position of the cursor on the screen. When the user moves his or her eyes, the cursor moves.

(http://www.cs.bc.edu/~eagleeye/overview/overview.html)

Purpose of this Thesis:

There are four objectives that are addressed in this thesis. The first objective is to replace the expensive Analog to Digital converter PCI Card. This is used by EagleEyes to convert the analog signal from the amplifiers to digital signals that the software can use as inputs. The second aim is to make EagleEyes capable of connecting like a regular mouse where no special hardware or software would be needed. The interface should have a regular serial/ps2/usb connection and run off of a regular Microsoft mouse driver. The third objective is to isolate the person from the AC current supplied by the computer. Finally, the fourth goal is make the component battery powered and use low-power consumption components.

EagleEyes Mouse Interface:

The idea of using a state machine to send signals to an existing mouse achieved the goal of a using no special hardware or software for the EagleEyes interface with the computer. Through the use of an already existing mouse, there are drivers for the mouse and the connection is a serial or ps2 connection, which is standard on any computer. Also, an adapter can be used to convert the ps2/serial mouse into a USB mouse or the USB version of the mouse could be substituted. For this project, a Logic Tech wireless mouse was employed. By using a wireless mouse, the goal of isolating the person from the AC current coming from the computer was achieved. One problem that was discovered when using the wireless mouse was that the radio signal which the mouse sends out was distorting the ground lines of the circuit. This distortion was minimal at a value of .2mV.

The next step was to determine what signal had to be sent to the mouse in order to make it move in the directions up and down or left and right. The idea was to simulate signals given by the mouse's optical sensors from the turning of the wheels of the mouse in one direction. Using logic probes, the resulting patterns (see figure 1 &2) were seen coming from the sensors of the mouse for left and right motion. From this a state machine could be created (see figure 3). Q0 and Q1 represent the current state of the mouse and are the signals sent to the mouse to make the cursor move. X is the input from a TTL signal signaling a change of state of the machine while D0 and D1 represent the next state dependant on X, Q0, and Q1 (see figure 4 for equations).

Figure 5 is a representation the state machine. Also shown on the same page are the clock and X for the state machine. The clock comes from dividing a clock generator in half. Since it is the slowest available, a 32.768KHz clock generator was used, but this is still fast for the project. In order to get the desired speed; a D flip-flop was used to divide the clock speed by two. This new clock is used by the rest of the circuit as the clock signal. X is also run though a D flip-flop. By running the X(TTL) signal through the D flip-flop, a steady signal is be given which might not be present if received directly from the TTL signal (see Figure 9). The TTL signal fluctuates frequently in accordance with the comparing of the digital to analog converter output signal and the signal coming from the level shifter.

The Digital to Analog converter (see Figure 7) takes the input of 12 bits in binary code and then outputs the analog signal of the binary. The signal can be scaled by going through a level shifter in which the desired output is 0 to -2V. The 12 bit input comes from three cascading 4 bit up/down counters (see Figure 6). The equation for the U/D comes from the state machine, the X, and the not new clock (see Figures 3 & 4). The not new clock is used because the current state is desired rather than the next state. If the new clock were to be employed, one would not be able to differentiate between whether the previous or current state is being used.

The level shifter (see Figure 8) receives the input from the EagleEyes amplifier. First the signal goes through a non-inverting op amp. An impedance match can be created through a 75 ohms resistor since the coax connection has an impedance resistance of 75 ohms. The second op amp is then used for level shifting. The level shift equations for the resistors are Gain A= Rf/Ra and GainB= Rf/Rb. The resistance used for Ra as a standard low current part is 50 Kohms. GainA must be 1/8.8 since the input from the EagleEyes amplifier is +/-2.2V and the voltage needs to be scaled to +/-0.25V. Gain A comes from the equation (1/4)*(1/2.2) = 1/8.8. In order to find Rf, one uses 1/8.8=Rf/50K giving that Rf=5.682 Kohms. GainB must be 1/2, which is due to the input from the +2.0V Ref and the fact that voltage needs to be scaled to 1V. Therefore, GainB comes from the equation (1/2)*(1/1)= 1/2. In order to find Rb, one uses 1/2=5.682K/Rb, giving Rb=11.364 Kohms. This gives the output of the second op amp a range of –0.75 to –1.25V.

The reason behind the level shifter having a range of –0.75 to –1.25V,and the D/A Converter having a range of 0 to –2V is that the input from EagleEyes will never exceed the output of the Digital to Analog converter. The level shifter’s voltage range is centered around –1V because the middle of the Digital to Analog convert's output is also –1V. This solves the wrapping problem where the maximum or minimum of the output of the Digital to Analog converter is exceeded by the input of level shifter. In this way, if the person changes directions the mouse may go in the opposite of the new direction. By keeping the level shifter's range well inside the bounds of the Digital to Analog converter's output, the wrapping problem will never occur and the cursor will always go in the correct direction.

Cmos parts were used and all of the components except for the Digital to Analog converter, the 2 V reference, and the op amps run off of 5 Volts. The Digital to Analog converter and the 2 V reference functions on 9Volts, while the op amps function on +/- 9Volts. For purposes of testing, LEDs were connected to the each of the 12 bit inputs for the Digital to Analog converter. Two measurements were taken to find power consumption, first with all the LEDs in, and then with none. With the LEDs in, the +9V consumes 1.5mA, -9V consumes .8mA, and +5 consumes 13.0mA for a total of 15.3mA. Without the LEDs in, the +9V consumes 1.5mA, -9V consumes .8mA, and +5 consumes 4.0mA for a total of 6.3mA. A 9V Battery gives off 580mA hours, and without the LEDs that would give you 92 hours of use. The Low power consumption and battery powered goals have been achieved.

This unit replaces the expensive Analog to Digital converter PCI Card used by EagleEyes to convert the analog signal from the amplifiers to digital signals that the software can use as inputs.

Future Work:

To complete these project PC boards need to be built with two channels. One would be used to control up/down movements, and the other to control the left/right ones. This may solve the problem with the radio signal interfering with the ground signal. Also, instead of using all 12 bits of the counter as the display, one could use the MSBs from each counter or the MSBs and the next bit from each counter. This would serve to cut down on the power consumed by the circuit.

Bibliography

1. Wakerly, John. Digital Design: Principles & Pratices 2nd Edition. Englewood Cliffs: Prentice Hall, 1994.

2. Lancaster, Don. Active Filter Cookbook 2nd Edition. Boston: Synergetics Press, 1996.

3. "EagleEyes", http://www.cs.bc.edu/~eagleeye/overview/overview.html

Data Sheets

Toko Inc.	Part TK71120.
Fairchild Semiconductor	Part CD40193BC, CD4070BC.
National Semiconductor	Part CD4023BC, CD4013BC
Linear Technology	Part LTC7541A, LT1079