S²RC Hardware Description

Toby Dayley
19 April 2005
ETEC 475
INTRODUCTION

This document is a functional hardware description of the S²RC (Super Swingin’ Radio Clock). The S²RC is a clock that receives and decodes the WWVB time signal broadcast out of Ft. Collins, CO. It then displays the time or date by swinging seven vertically aligned LEDs back and forth rapidly with precise timing to make the display appear to “float” in the air.

This project consists of 4 main modules: the power supply, the receiver, the user input, and the display. Each of these will be discussed in detail.

THE HARDWARE

Power Supply: The power supply is rather simple. It consists of a regulated wall wart that provides 24VDC to a series of linear regulators. The first regulator is a standard 3-pin 7812 that outputs 12VDC. This voltage is then fed into a standard 3-pin 7805 which outputs 5VDC. This supply provides for the 3 voltages (24V, 12V, and 5V) required by the S²RC. Because of a relatively high current draw, heat will be an issue. Consequently, each of the linear regulators will be mounted on a heat sink. 10µF bypass capacitors at the input and output of each regulator will compensate for any sudden current demands on the supply.

The Receiver: The real heart of the S²RC is the receiver. It consists of a simple ferrite rod antenna tuned to a resonant frequency of 60 kHz. The antenna’s output is fed into a Bi-FET amplifier that takes advantage of the high input impedance of the FET to prevent signal loss, while still producing a high gain in the bipolar transistor stage. This pre-amplifier provides a gain of about 40dB at 60 kHz.
An envelope detector is used to demodulate the incoming signal. A low voltage schottky diode is used, again to prevent signal degradation. Once the signal has passed through the envelope detector, it can be further amplified by a single supply operational amplifier. This op-amp adds an additional voltage gain of eleven. A high speed voltage comparator is implemented with the LM6511. This comparator translates the signal into a defined square wave. The final signal consists of a square wave with a binary one represented by a pulse width of 500ms and a binary zero represented by a pulse width of 200ms. By adding a feedback resistor to the comparator circuit, the reference voltage changes when the output changes. This feedback implements hysteresis in the response, preventing rapid switching near the reference voltage. This square wave is fed into the MC9S12DP256 microcontroller where software will read and decode the signal.

**The User Interface:** The user interface could not be simpler. It consists of two momentary push buttons that are tied to the microcontroller with 10kΩ pull-up resistors. One switch changes the time zone and the other switch toggles between date and time. The switches will be software debounced, allowing the freedom of choosing any simple momentary push button.

**The Display:** The display, although difficult to describe, is not all that complex. A rotary solenoid is used to rotate a swing arm 45 degrees. This rotation occurs many times each second. On the arm, seven 3mm blue LEDs are mounted and are blinking at just the right time to produce the effect of a floating display.

Because of the high voltage and current requirements of the rotary solenoid, it will be driven through a power MOSFET using a MAX5078 MOSFET driver. This should reduce $R_{ON}$ of the
MOSFET and allow more current to flow. One interesting thing to note is that the IRL540N power MOSFET has a free-wheeling diode built in to prevent surges as the solenoid coil is pulsed.

Each of the seven LEDs is driven through an open collector NPN transistor in order to provide a more constant current source and reduce the current draw through the microcontroller. An LED driver chip was not implemented because the extra cost was not necessary for this application. The LEDs will be swinging and blinking, so a slight variance in luminosity will have no negative effects on the final results.

In order to ensure accurate timing, an optical switch is used. As the swing arm returns from each pass, it will trigger an optical switch. The resulting signal tells the microcontroller that it is time to pulse the solenoid again and refresh the display. Ideally, this will all happen 20 or more times every second. Based on the principle of persistence of vision, even ten times per second should make the display legible, although flicker will be noticeable.

**CONCLUSION**

The S²RC is an interesting device requiring unique solutions to satisfy some of the design goals. A major factor in its successful completion will be the physical construction of the device. Each part must line up precisely and be well balanced. The electrical circuitry is sound and should function as described.