Electronic Whoopie Cushion Deux
(Motorola E-field Sensor Contest Entry EF3423)

Abstract

Most of us who have read the advertisements in comic books or visited novelty stores know of the practical joke device known as the "whoopie cushion". This low-tech device is essentially a rubber bag with an opening on one end. This opening is like a valve in that it allows for easy flow of air into the bag but restricted flow out of the bag. The bag is placed either on top of a seat or in-between the cushion of a sofa or easy chair. When a person sits down in the chair, air is forced out of the bag through the opening, causing the bag to emit an embarrassing noise. This results in embarrassment for the victim, and more importantly, laughter among the non-victims.

While the whoopie cushion is considered a classic by the practical jokers of the world, it possesses several flaws, which are:

1. It is not inconspicuous. If left on the top of a chair, the would-be victim can generally recognize it as something that should not be there, and he/she immediately suspects foul play. Moreover, if it is placed underneath a sofa cushion, its inflated size makes it clearly visible, and the would-be victim immediately suspects foul play.
2. It possesses a repertoire of only one sound.
3. It is not self-retriggering. It must be removed from the chair and re-inflated before it is ready for the next victim.
4. It can only be triggered when someone sits in the chair. It does not possess the capability of triggering when the victim leaves the chair.

As with many things, we look to science and technology to solve our problems. While the parts required to produce an electronic version this classic gag device have existed for several years (I know – I made one), the "leapfrog" technology of the Motorola MC33794 E-field sensor IC provides an ideal, inconspicuous means of sensing the presence of the would-be victim. Thus, I present my newest creation – the *Electronic Whoopie Cushion Deux* (this means two, for those of you who do not speak French). It utilizes a MC33794 E-field sensor IC along with a specially designed seat cushion sensor and a Motorola MC68HC908QY4 microcontroller to sense when someone sits down or gets up from the chair. Once the presence of the victim is sensed, it plays a pre-recorded "sound". Although there is only one version of the device currently working, there will eventually be three versions, all differentiated by their level of functionality as follows:

- ***"Good"*** – this version features a single trigger mode (person sitting down in the chair) and has only one "sound" available. This version also has a fixed post-trigger-to-sound delay as well as a fixed re-arming delay. This is the version of the device currently working.

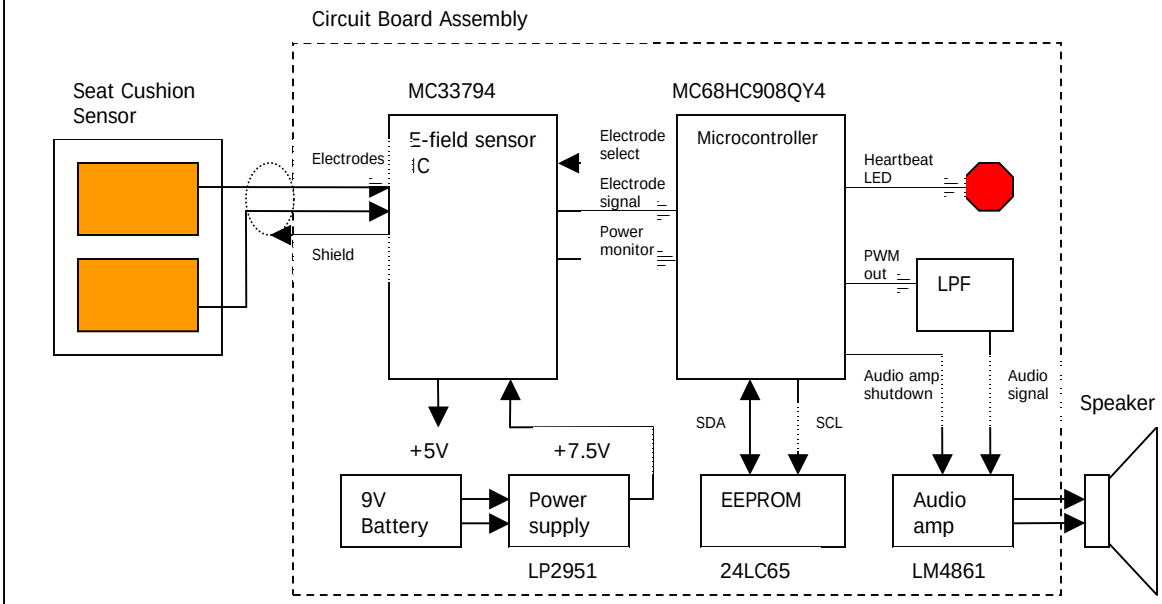
- ***"Better"*** – this version has dual trigger modes (person sitting down in the chair AND person getting up from the chair) and has only one sound available. This version also features a random post-trigger-to-sound delay as well as a random re-arming delay.
- ***"Best"*** – this version has dual trigger modes, random post-trigger-to-sound and re-arming delays, and multiple randomly chosen sounds.

Block Diagram

The major parts that make up the *Electronic Whoopie Cushion Deux*, as shown in the block diagram, are:

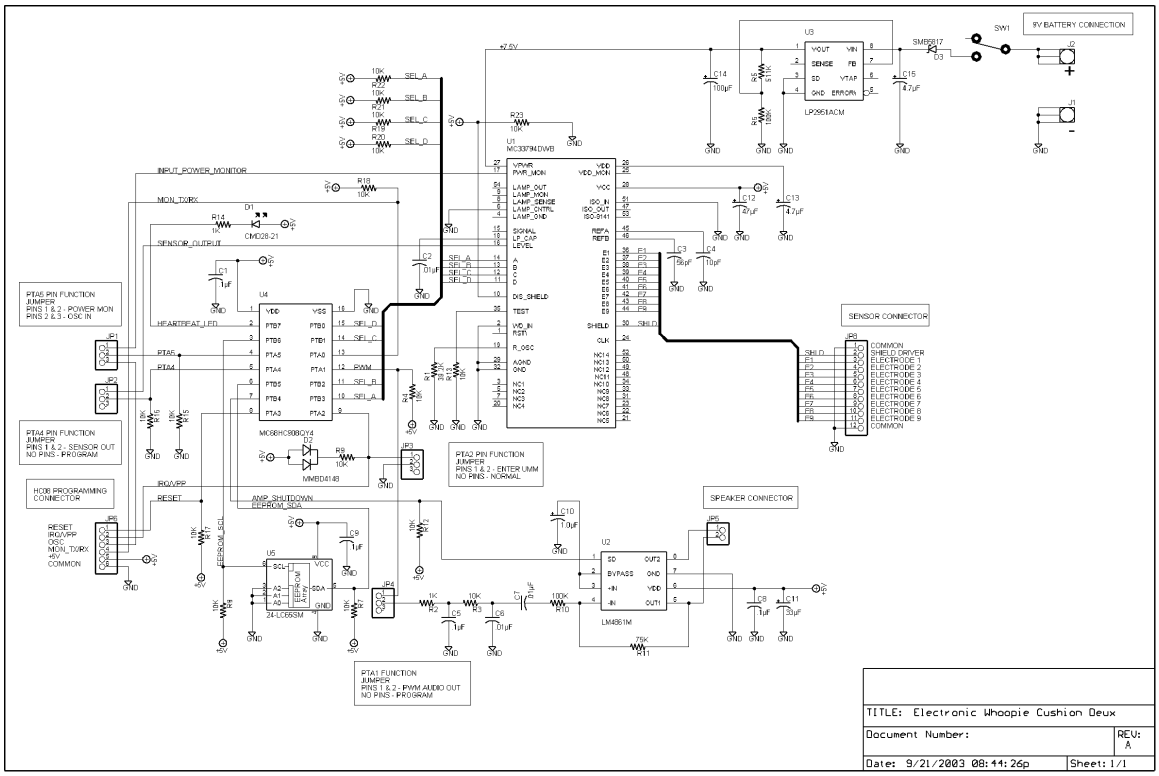
- A Motorola MC33794 E-field sensor IC
- A specially designed seat cushion sensor (made using one side of a mailing envelope and 3M 1245 embossed copper tape).
- A Motorola MC68HC908QY4 microcontroller (the "brains" of the device)
- A Microchip 24LC65 serial EEPROM to store sound data (used on ***"best"*** version to accommodate the multiple sound feature)
- A two pole low pass filter to recover the audio signal from the microcontroller PWM output
- A National Semiconductor LM4861 audio amplifier IC to drive the speaker.
- A CUI GA0576 55 mm, 0.25W speaker to provide the "sound".
- A Chicago Miniature Lamp CMD28-21VRC low current LED for indication of system operation ("heartbeat" indicator)
- A National Semiconductor LP2951 micropower voltage regulator, which provides the +7.5V power required to operate the MC33794.
- A 9V alkaline battery for providing power to the system

System Hardware Block Diagram



Schematic Diagram

The following is a schematic diagram of the *Electronic Whoopie Cushion Deux* circuit board assembly. Jumpers JP1, JP2, JP3, and JP4 are used to allow the microcontroller (U4) to be in-circuit programmed via the programming connector (JP6).



Code Sample

The software for the *Electronic Whoopie Cushion Deux* was written in C using the Metrowerks CodeWarrior HC08(S) Special Edition development environment. The following code example is the **AnalogIn.C** file, which contains the functions used for accessing data from the analog inputs, such as the MC33794 E-field sensor IC output:

```
/*****************************************************************************
*
 *
 * Module  Name :        analogin.c
 *
 * Initial Design Date : 9/3/2003
 *
 * Product Name :        Electronic Whoopie Cushion Deux
 *
 * General Description:  This file contains the functions used for accessing
 *                       data from the analog inputs
 *
 *
 ***revision-history***
 ***revision-history***

*****************************************************************************/

/* specify header files needed */
#include <hidef.h>
#include <MC68HC908QY4.h>
#include <stdtypes.h>

#include "analogin.h"

/*****************************************************************************
*
 *
 * Function   : GetA2DReading
 *
 *
 * Description: Function used to obtain reading the on-chip 8 bit ADC
 *
 *
 *
 * Inputs :        ADSCRValueForConversion - used to specify which analog input
to read
 *
 *
 *
 * Returns:        A2D reading from selected input channel
 *

*****************************************************************************/
#define NUMBER_OF_A2D_READINGS_TO_AVERAGE    4

Byte GetA2DReading(Byte ADSCRValueForConversion)
{
   Byte ReturnValue;
   Word TempAccumulator = 0;
   Byte ReadingCount;

   for(ReadingCount = 0;ReadingCount <
   NUMBER_OF_A2D_READINGS_TO_AVERAGE;ReadingCount++)
```

```
   {
      /* write to ADC status/control register (selects desired input
      channel to convert) */
      ADSCR = ADSCRValueForConversion;

      /* wait for conversion complete flag to be set */
      while(!(ADSCR & ADSCR_COCO_BIT));

      /* extract result */
      TempAccumulator += ADR;
   }

   ReturnValue = (Byte)(TempAccumulator / NUMBER_OF_A2D_READINGS_TO_AVERAGE);

   return ReturnValue;
}


/*****************************************************************************
*
 *
 * Function   : CheckForLowBatteryCondition
 *
 *
 * Description: Function used to obtain reading from input power monitor
 *                to determine if battery is becoming weak and needs replacing
 *
 *
 *
 * Inputs :        NONE
 *
 *
 *
 * Returns:        1 if low battery condition exists, 0 otherwise
 *

*****************************************************************************/

#define MINIMUM_POWER_MONITOR_LEVEL   30 // .0859 * 7.0V / 5.0V * 256 = 30.78

Byte CheckForLowBatteryCondition(void)
{
   Byte ReturnValue = 0;
   Byte TempReading;

   /* obtain reading from PTA5 (MC33794 power monitor output) */
   TempReading = GetA2DReading(MEASURE_MC33794_POWER_MON_OUTPUT);

   /* if reading is below our minimum input voltage level, we have a low battery
   condition */
   if(TempReading < MINIMUM_POWER_MONITOR_LEVEL)
      ReturnValue = 1;

   return ReturnValue;
}


/*****************************************************************************
*
 *
 * Function   : GetCushionSensorReading
 *
 *
```

```
 * Description: Function used to obtain reading from seat cushion sensor
connected
 *                to electrodes E1 and E2 of MC33794 E-field sensor IC
 *
 *
 *
 * Inputs :        NONE
 *
 *
 *
 * Returns:        Reading from seat cushion sensor
 *

*****************************************************************************/

#define E_FIELD_SENSOR_SELECT_PORTB_MASK   0x0f
#define E_FIELD_SENSOR_SELECT_E1           0x08

Byte GetCushionSensorReading(void)
{
   Byte ReturnValue = 0;
   Byte Temp;

   /* for now, we will select electrode E1 and take A/D reading from PTA4 input
*/
   Temp = PTB;
   Temp &= ~E_FIELD_SENSOR_SELECT_PORTB_MASK;
   Temp |= E_FIELD_SENSOR_SELECT_E1;
   PTB = Temp;

   /* obtain reading from PTA4 (MC33794 LEVEL output) */
   ReturnValue = GetA2DReading(MEASURE_MC33794_LEVEL_OUTPUT);

   return ReturnValue;
}
```

Project Photograph

The following is a photograph of the *Electronic Whoopie Cushion Deux*, showing all the components of the device: the seat cushion sensor, the circuit board, and the speaker.