The Perfect Coffee Cup

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INTRODUCTION:

The perfect cup of coffee. . . that's what Ponce de Leon was really searching for in the swamps of Florida all that time, NOT the fountain of youth. He got close a couple of times. While the flavor was exquisite each time, ultimate disappointment would always descend upon Ponce de Leon. The problem . . . temperature. Some neophytes think such things as the bean used, or the steeping time is what differentiates between a good cup of coffee and a bad cup. They are wrong. While these things provide the base for a good coffee, they don't make or break the ultimate cupajoe. Temperature is the key.

Low temperature is the ultimate killer of good coffee. Nobody likes to have the last half of their coffee being a tepid mess. Coffee needs to be HOT. Not, getting it in the drive-through, spilling it on your lap, burning yourself, suing a big company, and retiring in the lap of luxury hot, but rather, a pleasant warmth. The ideal coffee temperature is more akin to just too hot to gulp down. Much like a fine whiskey, coffee is a sippin' drink.

There is a problem keeping a cup of coffee warm. Some people have resorted to the monstrosity of the insulated mug; while others use small cups and constantly refill them with warm coffee fresh from the pot. Neither of these situations is acceptable to a real coffee drinker. The insulated mug removes the visceral pleasure of life giving warmth slipping from the coffee into the hands, while the small cup just isn't enough coffee to get the job done. The ideal cup can hold about 16 ounces of coffee and is made of glass.

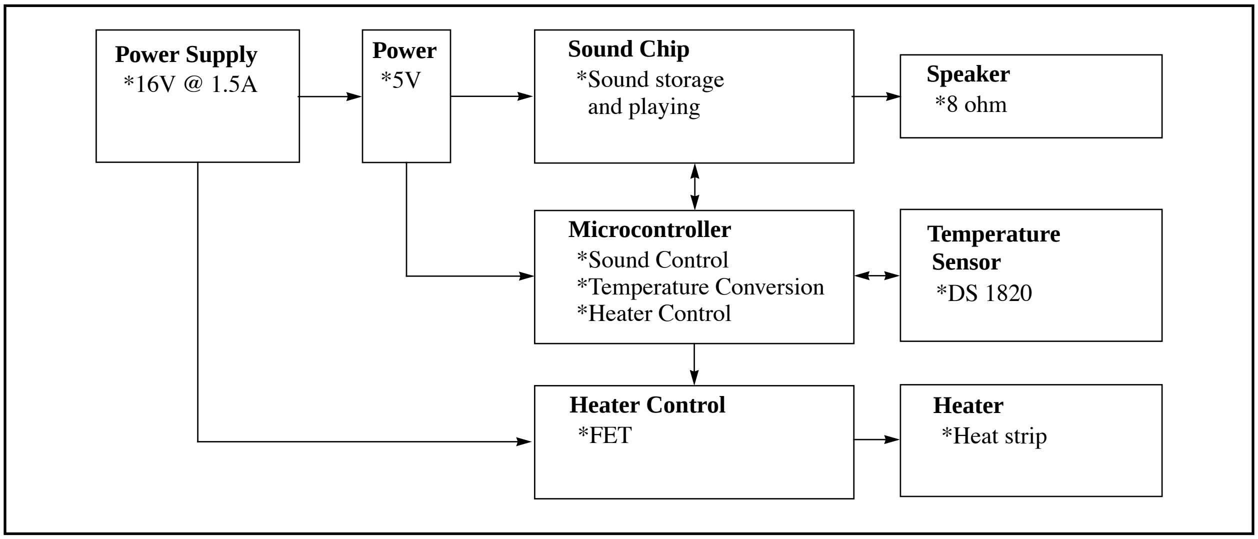
Mr. de Leon was bound to fail. Back in his swamp trolling days, the know-how to provide the ultimate cup of coffee just wasn't available. However, the marvel of modern technology has provided the tools to deliver to all of humanity coffee nirvana. Solutions Cubed, always on the leading edge of coffee research, has brought to bear its not-inconsiderable brain trust to birth the 4C-X2000. The 4C- is short for Cold Coffee Can't Cut it. X2000 signifies how rad, nifty, cool, out of control, and space age the 4C-X2000 is.

APPLICATION OPERATION:

The 4C-X2000 uses the PIC12C508 8 pin microcontroller to control a thermometer, a sound controller, and a heating element. As a hallmark of good engineering practice, the 4C-X2000 leverages the sound producing and temperature measuring technology of the revolutionary 4T-X2000. Sound is supplied by the low cost and easily acquired Information Storage Devices ISD2590, and the temperature is read using the Dallas DS1820.

Figure 1 gives the block diagram of the system. Figure 2 gives a flow chart of the main program flow. The system works fairly simply. Basically, every 30 seconds the temperature of the coffee cup is measured. If the temperature is too low, the heater is turned on and the sound chip informs the coffee drinker that the coffee is not yet at an ideal sippin' temperature. If the temperature is above the high temperature zone, the heater is turned off and the coffee drinker is informed that the coffee is ready to drink. After this, the program loops back to the beginning and starts the process all over again.

FIGURE 1: BLOCK DIAGRAM OF 4C-X2000



Hardware Methodology:

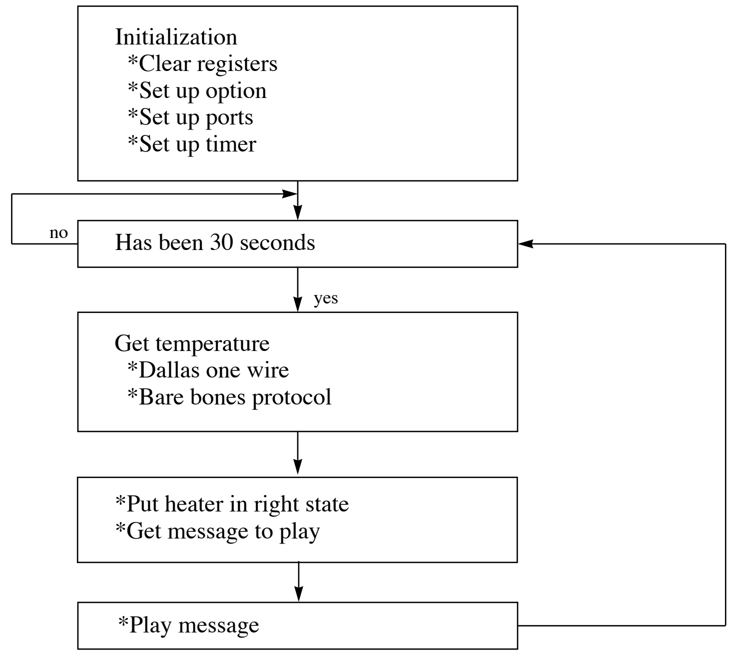
The heart of the system is the PIC12C508. It is run off of its handy and versatile built-in internal 4MHz RC oscillator. This frees up two bi-directional I/O pins. The internal /MCLR was used to give an extra input pin.

The 4C-X2000 uses all of the I/O pins on the PIC12C508 to raise the bar of modern coffee warming a couple of notches. The temperature measurement is accomplished with the Dallas DS1820. The DS1820 uses a 1-wire communication protocol/parasitic power bus. This means that digital communication can be accomplished using only two wires (including ground). So for the same connector issues of a thermistor, a noise-resistant digital communication interface can be implemented. The pull up resistor (R4) allows for the pseudo-open collector communication channel to be implemented.

The heater is provided by Minco and comes with a handy self adhesive strip, which allows it to attach conveniently and safely to a heatsink. It is a resistive load of about 15 ohms. This means there is approximately 17 watts of life-giving heat available for the coffee to sustain itself with. The n-channel FET (Q1) is logic level, allowing for easy interfacing to the microcontroller.

The rest of the I/Os were used to interface to the ISD2590 sound chip. This chip is able to directly drive a speaker, thereby alleviating the need for drive circuitry. R1, R2, and R3 are used to put the chip in the special message cueing mode. All of the other address lines are not used and tied to ground to avoid entering spurious modes. The /OVF pin is left floating because it is an output.

FIGURE 2: FLOW CHART OF 4C-X2000 OPERATION



Software Methodology:

The software can be broken up into three main sections: Setup, Temperature, and Sound. They will be discussed in that order.

Setup

The setup is fairly simple for this program and chip. First of all, the user registers are cleared so they are of a known state going into the program. A simple indirect addressing routine is used for this. Then the OPTION register is set up. After this, the GPIO pins are set up for direction and initial values. The most important thing here is that the PD pin is high, thereby powering the ISD chip down. This ensures it will not spuriously play during the power up sequence.

Temperature

All of the actual temperature measurement is done in the DS1820, therefore the PIC12C508 merely has to read in the data and then it is ready to roll. As mentioned before, the DS1820 uses a 1 wire interface, which relies on pulse widths in a data window to signify ones and zeros. It also needs to be an open collector type system. The GPIO TRIS command allows for a fairly easy implementation of this.

The DS1820 reads temperature in celsius to the nearest half degree. This temperature is used to find if the coffee is too cold or warm. The system uses hysteresis to ensure that the system isn't switching on and off and *irritate* the user. The hot and cold set points were found using strict empirical methods.

Sound

There are 8 "good" messages and 8 "bad" messages. These are found using a pseudo-random generator using the free running TMR0 as a base. If a good temperature is found, a good message is played, while, appropriately enough, if a bad temperature is found a bad message is played.

The ISD2590 allows for a very sophisticated addressing system in 150mS increments. This was not used. Because of the I/O constraints, one of the built in "operational modes" was used: Message Cueing. This allows for rapid fast forwarding to relative positions of messages. For example, to play the first bad sound, all that is necessary is knowing that the first bad message is in position 9. Appendix A shows the positions of the messages in the chip. After getting to the message that needs to be played a simple chip enable strobe is performed, the message plays and the PIC12C508 is in “hands off” mode. In this case, the PIC12C508 waits until the message is over to ensure that the second message does not start playing over the first.

RAM Used:	7 bytes, 3 bytes are TEMP registers
Program Bytes (as presented):	177 bytes
OSC:	Internal RC
WDT:	Off
CP:	Off
MCLR	Internal
Check Sum:	86A5

Where to Go from Here:

There are numerous places to go with the 4C-X2000. A pressure sensor/limit, switch/light, sensor or some other thing could be used to sense if a cup was in the holder, thereby avoiding spurious heater activation and sound playing.

The sound could be dramatically improved. Using the top of the line ISD development system would allow computer editing of the messages. Also the chips that have less space for sound use a faster sampling rate, which increases the sound quality. Finally, ISD provides a serially controlled sound chip.

The implementation of the DS1820 communication is bare-bones. Multiple DS1820s can be put on one bus, which requires greater communication overhead than was implemented. However, multiple temperature sensors wouldn’t really gain the 4C-X2000 anything. The DS1820 has temperature alarms, scratch-pad RAM, and CRC protected communication. None of this was implemented.

The mechanics of the system leave a bit to be desired. The heat transfer between the cup, the temperature sensor and the heater can be improved. At the moment, it takes approximately 2 minutes for an ideal temperature coffee cup to put the 4C-X2000 into its “good” range. This is also true if a cold cup is put into a pre-warmed temperature sensor system.

APPENDIX A

Message Number	Message
1	1st good coffee temperature message
2	2nd good coffee temperature message
3	3rd good coffee temperature message
4	4th good coffee temperature message
5	5th good coffee temperature message
6	6th good coffee temperature message
7	7th good coffee temperature message
8	8th good coffee temperature message
9	1st bad coffee temperature message
10	2nd bad coffee temperature message
11	3rd bad coffee temperature message
12	4th bad coffee temperature message
13	5th bad coffee temperature message
14	6th bad coffee temperature message
15	7th bad coffee temperature message
16	8th bad coffee temperature message