BEVERAGE VENDING MACHINE CONTROLLER

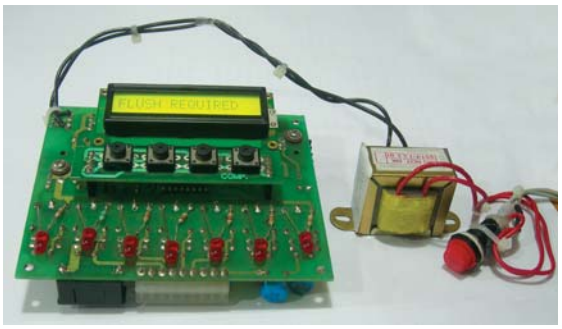
■ VINAY CHADDHA

Beverage vending machines are commonplace at railway stations, airports, fast-food restaurants and even in companies. Press a switch and the machine delivers a hot cup of your favourite drink.

This looks quite a simple operation but has a very complex logic behind it: It involves use of twelve precision timers and four counters apart from physical devices like display, solenoid and motor to deliver water and premixed tea/coffee/soup powder in exact quantity for better taste and in exact sequence.

This has become possible because of the use of microcontrollers, which allow compact size, higher reliability, lower cost and multiple functionalities.

This tea/coffee/soup vending machine controller uses Freescale's latest MC908JL16 microcontroller chip. The controller is programmable and user-friendly. You can set the quantity of the beverages through a button switch provided on the front panel of the controller as per your requirements. Thus, cups of any size can be filled at any time.



The prototype of beverage vending machine controller developed by the author

The hardware

Fig. 1 shows the block diagram of the vending machine controller. It comprises the following sections: power supply, microcontroller, relays, relay driver, alphanumeric display, keyboard and memory. The power supply circuit is shown in Fig. 2.

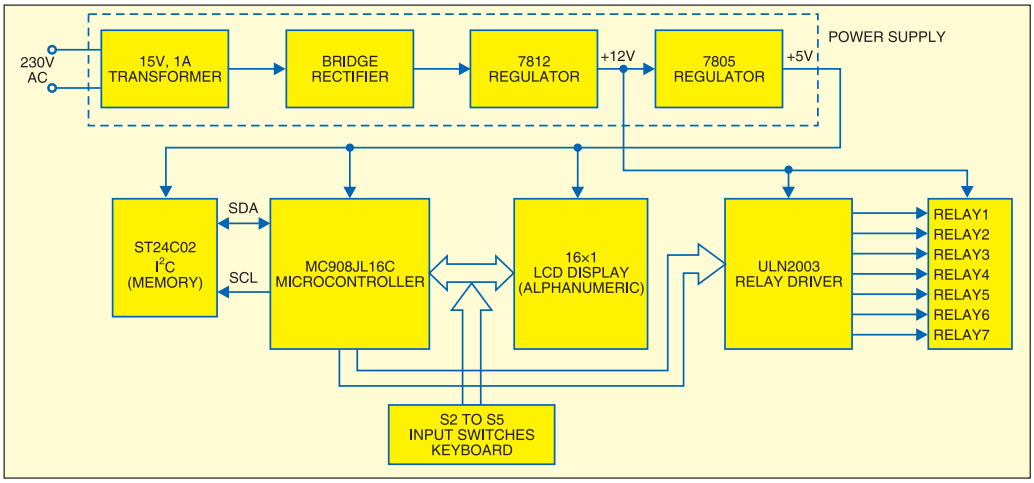


Fig. 1: Block diagram of the beverage vending machine controller

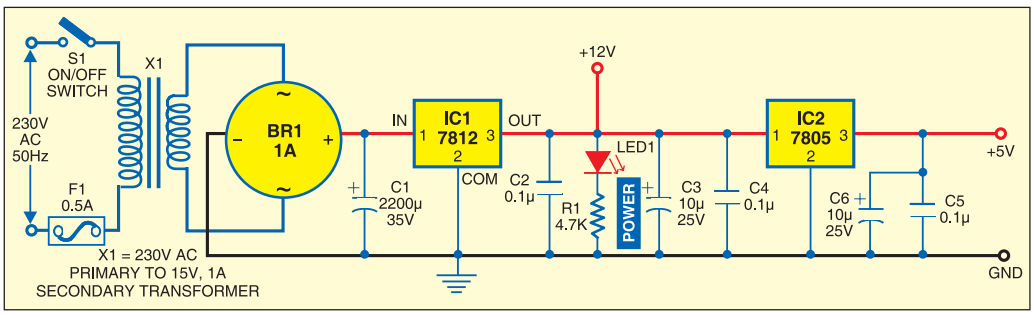


Fig. 2: Power supply circuit

Power supply. The relays need 12V DC and the microcontroller and memory need 5V DC for operation. Bridge rectifier, capacitive filter and regulator ICs 7812 and 7805 are the standard parts used in the power supply.

Microcontroller. We need individually

The control unit uses low-cost, readily available components. The temperature control section has not been included in the design as the parts required are expensive and not easily available. However, a low-cost thermostat used in water heaters can be used in the unit.

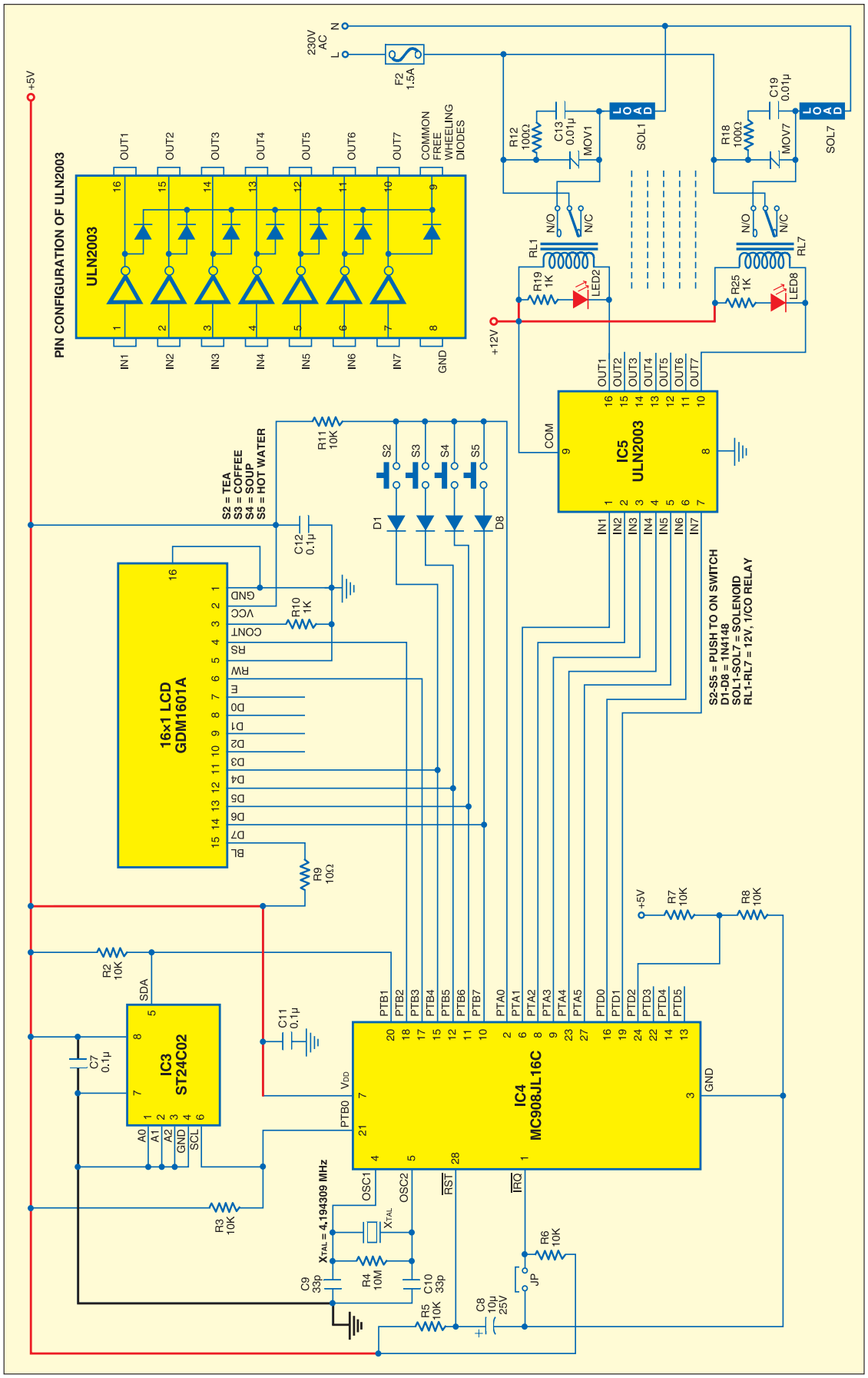
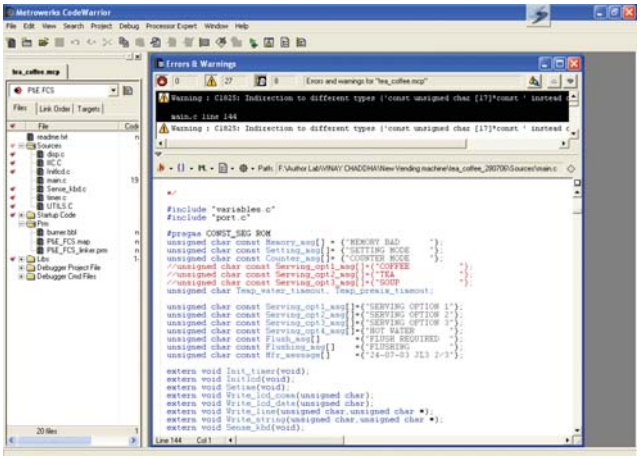


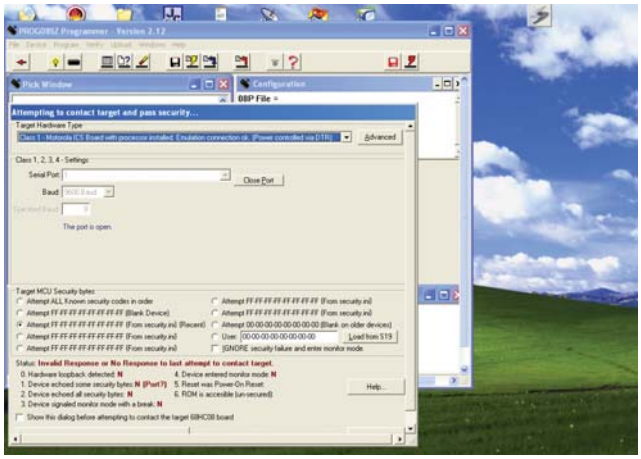
Fig. 3: Circuit of the beverage vending machine controller

settable timings for the seven relays and multiple time delays between the operation of these relays, i.e., the water inlet relay should operate only when water has to be dispensed. All these functions, though possible using discrete components, are best handled by Freescale's MC908JL16 microcontroller.

Relays. Selection of each beverage requires two solenoid valves, one for premix powder and another for water outlet. The solenoid valves are operated through relays. That is, for three beverages, we need six solenoids and six relays to operate them. The water heater tank is not connected to the source of water as this may increase the power consumption. The water inlet is opened for some time after one cup is filled to allow small quantity of water to be



Screenshot 1: The CodeWarrior 5.2 integrated development environment



Screenshot 2: The PROG08SZ programming environment

filled again in the tank. This requires one more solenoid. So a total of seven solenoids are required.

To activate these high-current solenoids, sugar-cube type relays are used. These are cheap and used in low-cost UPS for PCs. The relays need around 100mA, 12V supply to operate.

Relay driver ULN2003. The microcontroller cannot drive 12V, 100mA relays directly and needs a buffer. This can be easily achieved using BC547 transistors and a few resistors. However IC ULN2003 has been used to drive the relays.

Alphanumeric display. The operator needs a visual interface for setting the various parameters and the status of the input switches pressed. LED displays will not be visible in brightly-lit places, so LCDs are the best choice. Character size is not a constraint as the machine is to be operated from a close distance. A standard-size, 16-character, single-line alphanumeric LCD has been used here. It is readily available and commonly used in industrial applications and PCO monitors.

Keyboard. We need at least four keys: two for beverages (one each for tea and coffee), one for half or full cup, and one for hot water. Tactile key switches have been used here. These are low-cost and readily available.

Memory. The control unit doesn't have a battery backup system and will lose the set data when power fails. So a provision has to be made to ensure that the unit recalls the set parameters when power resumes. This is achieved by using a small-size 24C02 memory, which is commonly used in electronic goods like TV sets.

Circuit description

Fig. 3 shows the circuit of the vending machine controller.

Power supply. The power supply circuit comprises a 15V, 1A step-down transformer, filters, 12V DC regulator 7812 (IC1) for relays and 5V DC regulator 7805 (IC2) for microcontrollers (see Fig. 2). Fuse F1 protects against surge current in the event of short circuit.

Microcontroller. The MC908JL16 microcontroller (also called the MC68HC908JL16) from Freescale Semiconductor, Inc. (formerly Motorola) has 28 pins with 23 general-purpose I/O lines, 16 kB of flash memory to store program and 512 bytes of RAM. It utilises an HC08 CPU core and provides a cost-effective reprogrammable flash memory. It also has two 16-bit timers and other standard functionalities, making it an all-in-one control IC.

The device is a part of the growing JL Family that includes multiple clock options, keyboard interrupts, low-voltage inhibit and a watchdog timer. In particular, the MC908JL16 has a built-in serial communications interface module, master inter-integrated circuit (I^2C) interface and 10-bit analogue-to-digital converter (not used in this program).

The MC908JL16 is a low-cost, high-performance, 8-bit microcontroller unit. It uses the enhanced M68HC08 central processing unit (CPU08) and is available with a variety of modules, memory sizes, package types, etc. Its datasheet is available on Freescale's website 'www.freescale.com.'

Relays. The 12V, 1/CO relays are capable of switching up to 7A, 220V AC loads. Across each relay contact, metal-oxide varistor (MOV) and resistor-capacitor (RC) snubber circuit have been added to reduce noise generated by sparking at relay contacts at the time of switching. Fuse F2 used for protection against surge current can be replaced with another higher-current fuse as per the requirement of the solenoid used.

Relay driver. The relay driver ULN2003 with seven outputs is capable of sinking 500mA on each output. Inputs are TTL CMOS-compatible and outputs are fed to relay coils directly. With this driver, no free-wheeling diode is required across the relay coils. Datasheets are included in this month's EFY-CD.

Display. The display GDM1601A used here is a 16x1 alphanumeric LCD based on Hitachi HD44780 LCD controller. It is interfaced to the microcontroller using four data lines (D7 through D4) and two control signals (RS and E). Complete details of HD44780 are available on the Internet.

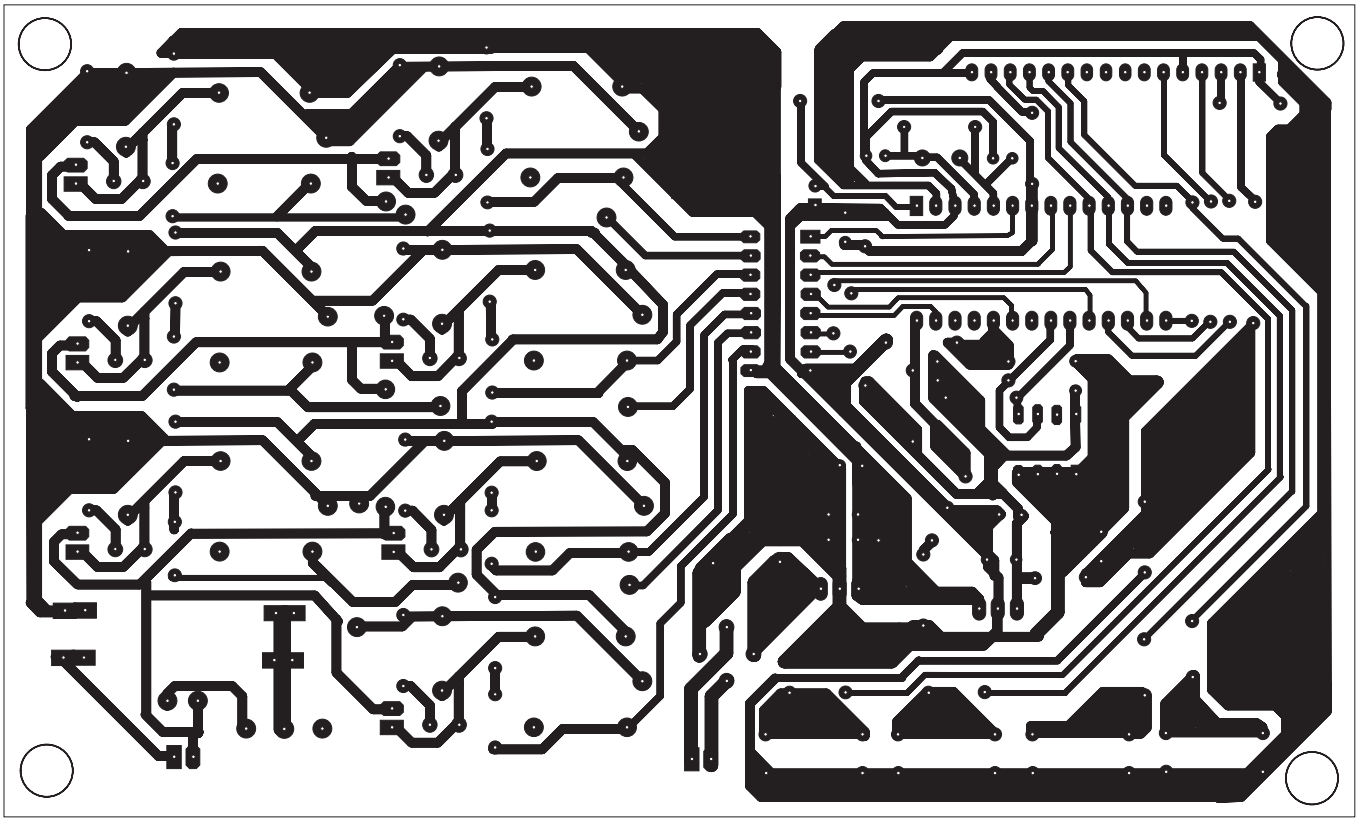


Fig. 4: An actual-size, single-side PCB layout for the beverage vending machine controller

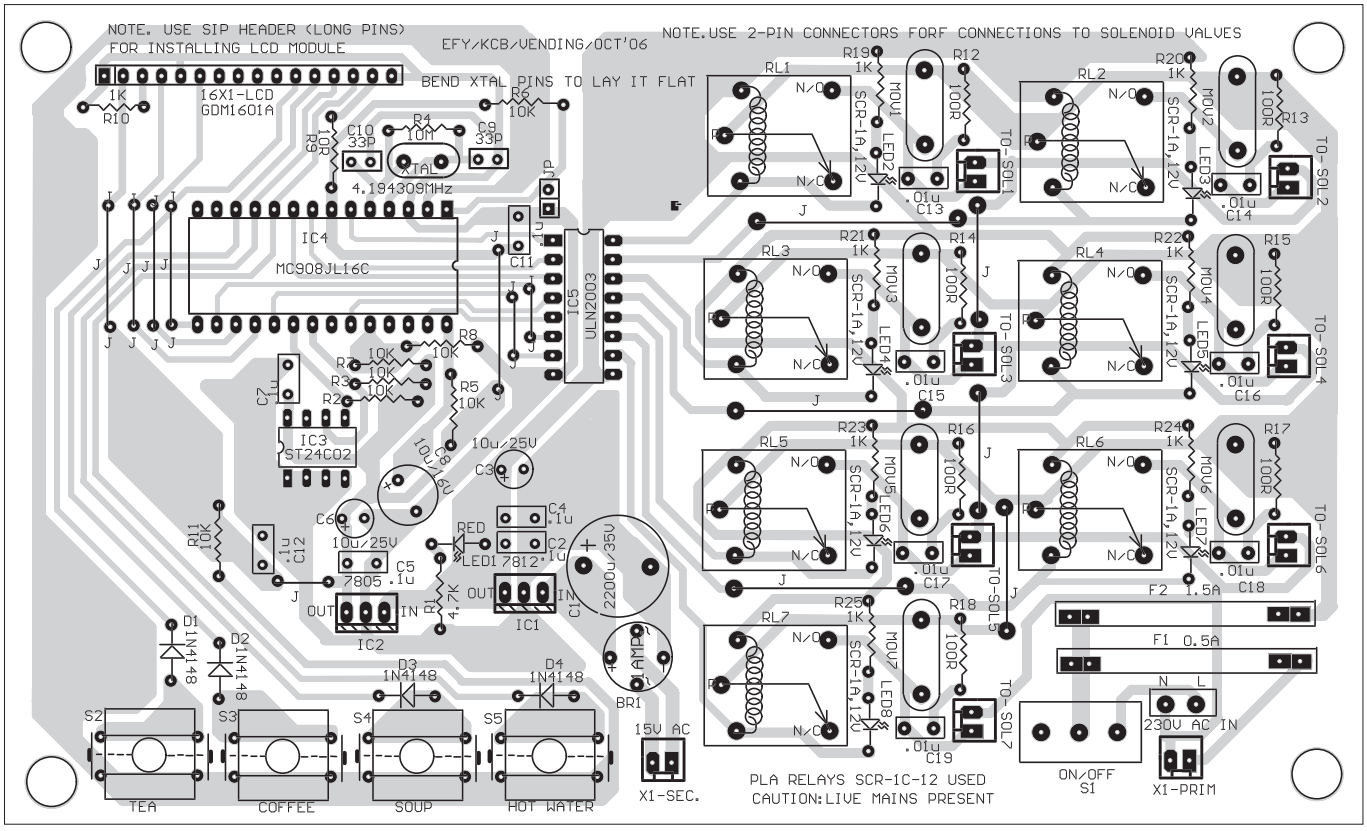


Fig. 5: Component layout for the PCB

PARTS LIST

Semiconductor:

IC1	-	7812, 12V regulator
IC2	-	7805, 5V regulator
IC3	-	24C02 I²C memory
IC4	-	MC908JL16C microcontroller
IC5	-	ULN2003 relay driver
D1-D8	-	1N4148 switching diode
LED1-LED8	-	5mm light-emitting diode
BR1	-	1A bridge rectifier

Resistors (all ¼-watt, ±5% carbon):

R1	-	4.7-kilo-ohm
R2, R3, R5, R6, R7, R8, R11	-	10-kilo-ohm
R4	-	10-mega ohm
R9	-	10-ohm
R10	-	1-kilo-ohm
R12-R18	-	100-ohm

Capacitors:

C1	-	2200µF, 35V electrolytic
C2, C4, C5, C7, C11, C12	-	0.1µF ceramic
C3, C6, C8	-	10µF, 25V electrolytic
C9, C10	-	33pF ceramic
C13-C19	-	0.01µF ceramic

Miscellaneous:

X1	-	230V AC primary to 15V, 1A secondary transformer
S1	-	On/off toggle switch
S2-S5	-	Push-to-'on' switch (4-pin)
RL1-RL7	-	12V, 1/CO relay
X_{TAL}	-	4.1943MHz crystal oscillator
F1	-	0.5A fuse
F2	-	1.5A fuse
SOL1-SOL7	-	Solenoid valve
LCD	-	16×1 liquid-crystal display

Keyboard. It has four push-to-on switches (S2 through S5) connected to the microcontroller using five lines, of which four are shared with LCD data lines as shown in Fig. 3.

Memory. EEPROM 24CO2 permanently stores information like different timings, options for switches and count of cups filled. It is connected to the microcontroller using two lines, namely, serial data (SDA) and serial clock (SCL). Technical details of I²C bus and the memory have been covered earlier in EFY. (Refer to articles 'Access Control' in EFY Sept. 2002, 'Set-Top Converter' in EFY June '97, 'Caller ID' in EFY April '99 and 'Remote-Controlled Audio Processor Using Microcontroller' in EFY Sept. '99). Datasheet and I²C protocols are included in this month's EFY-CD.

An actual-size, single-side PCB layout for the beverage vending machine controller is shown in Fig. 4 and its component layout in Fig. 5.

The software

The software has been developed in 'C' language using Metrowerks' Code Warrior 'C' compiler. A 16kB free version of the compiler is available on the website 'www.metrowerks.com'

The program in 'C' is written on the MC68HC908JL8, which is equivalent to the MC68HC908JL16, except that the MC68HC908JL8 has only 8kB flash memory and 256 bytes of RAM. A specially developed programmer board along with PROG08SZ software (www.pemicro.com) has been used for programming the microcontroller chip.

Seven program modules have been used for this project: 'disp.c,' 'iic.c,' 'main.c,' 'initlcd.c,' 'sense_kbd.c,' 'timer.c' and 'utils.c.'

The software is developed in two stages: First, basic common input/output (I/O) routines are developed to display information on the LCD, read or write data from a specific memory location, scan the keyboard input (check which key has been pressed) and switch on the relays. Next, logic/program specific for this function is developed. This is more or less a translation job where you convert the end-product requirement in 'C' language so that it performs as expected.

CodeWarrior. The CodeWarrior 5.2 integrated development environment (IDE) includes compilers, linkers, source-code browser, debugger, editor and rapid application development tool set (see Screenshot 1). You can use it to edit, navigate, examine, compile and link code throughout your software development process. You can also configure options for code generation, project navigation and other operations.

If you have this IDE tool, just copy the relevant files from the EFY-CD into your PC. Open the project file 'tea_coffee.mcp.' When the source code is compiled, a '.s19' file is generated in 'bin' folder of the directory where the original source code is located. This file is equivalent to the hex code in other programming tools.

Programmer. The PROG08SZ version 2.12 is a programmer for EEPROM/EPROM modules internal to a Motorola HC08 processor. It communicates to the processor's monitor mode (MON08) via one of P&E Microcomputer Systems' hardware interfaces that is designed to work with the monitor mode. Alternatively, the MON08 circuitry can be built directly into the end user's hardware. The PROG08SZ programming environment is shown in Screenshot 2.

The connection dialogue appears initially. We have used 'class-3 direct serial-to-target W/Mon08 serial port circuitry' option for the programmer board used for programming. Next, select the serial port, tick the box corresponding to the 'ignore security failure and enter monitor mode' and then click 'contact target with this setting…' The 'power cycle dialogue' box appears. Now switch off the programmer board.

Switch on the programmer board again and press 'ok.' Select the device and open '.s19' file under 'File' menu to program into the chip.

Operations of the unit

Each switch performs dual functions as follows:

Switch	Normal mode	Setting mode
S2	Tea	Reset
S3	Coffee	Increment
S4	Soup or half/full	Decrement
S5	Hot water	Setting/next/OK

Setting mode. Normally, this mode is used only once to set various parameters as per the specific requirement, say, the size of the cup. This can be done by following a simple procedure. Switch off the controller unit. Press switch S5 (marked as 'hot water') for the settings mode and switch on the unit. Follow the instructions on the LCD. Press switch S5 again for the desired option. Press-

Message Displayed on Pressing Switches S2 through S5

Switch pressed	Message displayed
S2 for dispensing tea	Serving tea
S3 for dispensing coffee	Serving coffee
S4 for dispensing soup	Soup or half/full depending on the setting
S5 for dispensing hot water	Hot water

ing switches S3 and S4 will increment or decrement the value (in seconds), respectively.

The program has an option for a half or full cup of the beverage. S4 can be used for either 'soup' or 'half/full' option in the setting mode. When 'OPT3' is selected, S4 will function as a switch for dispensing the soup. When 'half/full' option is selected, S4 will function as a switch for filling up the cup to half or full. For dispensing tea and coffee, two time settings are required, i.e., premix-dispensing time and water-dispensing time. These can be adjusted as per specific requirements, say, quantity and strength (flavour) of the beverage.

Dispensing of tea has an extra function of brewing (optional). In this mode, water is dispensed for a second, then stopped to allow mixing of the powder with water, and dispensed again after some time. This timing can be set through the 'brew time' option.

Common setting for tea/coffee/soup. The time for activation of the water solenoid valves can be set to allow hot water to be dispensed through the common outlet.

After dispensing, some water remaining in the pipes cools off. In the next dispensing, this water is dispensed along with hot water from the water heater. So a provision is made to automatically flush the cold water out from the pipes at regular intervals. The time interval to flush out the cold water can be set by the user. For example, if you set 'Flush To' as '010 m,' i.e., 10 minutes as the time duration for which nobody uses the machine, message "flush required" will be displayed. The user will have to press switch S5 to flush the water out.

Apart from this, there are time settings for delay, refill, etc. The delay time is the time interval between the consecutive dispensing of water and premix powder. Refill time is the time for refilling water into the water heater. Relay RL7 energises through pin 10 of IC5 to refill water in the heater.

After you are done with settings, switch off the power supply for about 30 seconds to allow complete discharge of the filtering capacitor used in the power supply section. Switch on the unit again and it is now ready for use. The display will show "have a nice day."

EFY note. 1. The source codes have been included in this month's EFY-CD.

2. This article is based on commercial vending machines developed by GVC Systems. ●