Homework 5: Circuit Design and Theory of Operation

Due: Friday, February 24, at NOON

Team Code Name: Digital Real-time Intelligent Networked Kegerator Group No. 4

Team Member Completing This Homework: Ian Snyder

NOTE: This is the second in a series of four "design component" homework assignments, each of which is to be completed by one team member. The completed homework will count for 10% of the team member's individual grade. The report itself should be a minimum of five printed pages, **not** including the cover sheet, references, or any attachments (DRC, BOM). **Electronically submit the ".DSN" schematic file along with the ".doc" version of this report zipped into one file.**

Evaluation:

Component/Criterion	**Score**	**Multiplier**	**Points**
Introduction & Theory of Operation	0 1 2 3 4 5 6 7 8 9 10	X 4	
Documentation for Circuit Design	0 1 2 3 4 5 6 7 8 9 10	X 4	
List of References	0 1 2 3 4 5 6 7 8 9 10	X 1	
Technical Writing Style	0 1 2 3 4 5 6 7 8 9 10	X 1	
		TOTAL	

Comments:

1.0 Introduction

The Digital Real-time Intelligent Networked Kegerator is a smart beverage dispensing device. With the microcontroller based DRINK system, the owner is able to control, monitor, and record draft beverages on a per user basis through a web interface. Users are able to view various consumption statistics and other information through a serial graphical LCD interface and pushbutton optical encoder circuit. The system authenticates users by using an RFID tag located on the bottom of cup and a PIN entered via the system's pushbutton optical encoder. This report details the unique hardware characteristics and requirements of each of the components in the DRINK system, along with the circuit theory of operation. Additionally, the rationale for circuit design choices is explained beside alternative design options.

2.0 Theory of Operation

2.0.1 AC/DC Power Supply and DC/DC Converters

Power for all components is supplied through an XP Power AC/DC converter. This device taps into the freezer's AC power line near the compressor using an electric box with a standard wall plug. The supply's 12V output is then supplied to the PCB using a barrel connector. Once on the PCB, this 12V is used to power the solenoids and bill acceptor.

The 12V rail is also routed to one LTC1265-3.3 and one LTC1265-5 high efficiency step down DC/DC converter. These converters provide the 3.3V and 5V required for the digital components on our PCB. The microcontroller and LCD are the primary 3.3V components while the RFID reader is the primary 5V component.

Both chips are located near the PCB's power connector and are physically separated from the digital components on the board. Both the 3.3V and 5V ground rails tie to the common ground at one point. Low ESR capacitors are used to "prevent large voltage transients" [1].

2.0.2 Biometric and Future Expansion

Future expansion capabilities are provided through a PAL16V8 programmable logic device. This chip will be placed into a DIP socket for easy removal for programming. All pins are accessible through a two male headers. Using the headers located at the microcontroller, this PLD can easily be wired to any pin.

Biometric identification is also included as a future expansion. Unfortunately, interfacing and operating information for the leading biometric fingerprint reader modules is not publicly accessible information. The twelve pin header has been included to be overkill for any future RS-232 serial communications biometric device.

2.0.3 LCD

The ezLCD-001 display module is an RS-232 serial device interfaced using a MAX3232 RS-232 transceiver chip. Communication occurs at a data rate of 115.2k baud. Single byte serial commands are issued to perform operations such as setting the color, positioning the cursor's XY position, drawing bitmaps, etc. This device can be flashed using the development board to load font and bitmap information into the firmware. These fonts and bitmaps can be instantly recalled using single byte commands.

All connections are made through two headers, with a majority of the pins not having connections. These additional pins are used for USB and I^2C interfaces and are not required when using the serial interface. This device can accept 3.3V or 5V, but total power is minimized when using 3.3V [2].

2.0.4 Microcontroller

The microcontroller is responsible for solenoid control, compressor control, temperature monitoring, user input processing, serial communications, and web hosting. Access to every microcontroller port pin is supplied through four single row headers. A reset pushbutton is provided on the /RESET_IN port to assist in circuit debugging. Port PE0 is uses the keg flow input lines with an XOR gate to trigger an interrupt every time a flowmeter pulses. A single 0.1 uF bypass capacitor is connected to the VCC port of the module.

Five of the six serial ports on the microcontroller are used. The connected devices include flash memory on the Rabbit module, graphical LCD, Texas Instruments RFID reader, ICT bill acceptor, and Bioscrypt biometric fingerprint reader. The LCD, bill accepter, and fingerprint module all make use of MAX3232 RS-232 level translators for microcontroller interfacing. The microcontroller uses a 3.3V to 5V level translator to transmit data to the RFID module, but receives data with its 5V tolerant inputs [3].

2.0.5 Optical Encoder

User menu navigation and select capabilities are provided by a Grayhill optical encoder with pushbutton. This device has detents to prevent the dial from coming to rest between positions. Two input lines that are 90 degrees out of phase go to the microcontroller determine which direction the dial has been turned. The microcontroller uses quadrature input ports PF0 and PF1 to interpret the standard 2-bit code. Two 2.2k ohm external pull-up resistors are required for operation [4].

2.0.6 Piezo Audio Transducer

The CMT-1603 piezo audio transducer will be used to provide audio feedback to the user whenever an RFID on a cup is read. This device will also be used to provide an alarm feature if beverage or compressor temperature limits have been exceeded. The CMT-1603 is ideal for this application because it is powered directly from a 3.3V microcontroller port pin and its maximum current consumption is 3.2mA, far below the 6.8mA limit the microcontroller can source [5].

2.0.7 RFID

The Texas Instruments RFID module uses asynchronous serial to communicate with the microcontroller. Additional interfacing options exist for continuous polling, but we have opted to use our own software to determine the optimal poll frequency for this device. RFID tags will be read using a hex string of “0102083238” This read command consists of a 50 ms power burst to charge the RFID tag, followed by a 20ms read window. The module will then return a 64-bit ID string, a no read string, or an error string.

The antenna is a homemade 40mm diameter disc antenna. This 27 turn, enameled wire coil has a low Q value in order to operate in the proximity of metal. This antenna plugs directly into the RFID module with no additional hardware [6].

2.0.8 Solenoids and Flowmeters

Each keg has solenoid and flowmeter connection supplied through a six pin Molex connector. When a Molex connector is plugged into the board, the microcontroller will be notified through a KEGX_STS_L pin and a LED will light up.

Flow pulses are 5V optically isolated inputs that go to both a microcontroller port pin and an external interrupt pin through a two level XOR circuit. This XOR circuit is used to determine which flowmeter is causing the interrupt. Potentially two flow pulses could occur at the exact same time and incorrectly register flow readings. This is deemed an acceptable accuracy loss as the flowmeters pulse with a millisecond range period while the XOR gate switches with a nanosecond range period.

The solenoids are normally closed devices. They are controlled using NPN Darlington optocouplers. When activated, 12V is supplied to the solenoid, which causes it to open. An arc suppression diode is used to protect the circuit.

2.0.9 SRAM Backup Battery

The RCM3315 microcontroller module supports SRAM backup through an external battery. A Panasonic 3V 165mA lithium coin battery is connected to the microcontroller's VBAT_EXT port to provide power to retain our SRAM information. This battery will not discharge while the system is powered on. Based the SRAM's continuous current drain while the system is powered off, this battery is expected to last three years. [3]

2.0.10 Temperature Sensors and Compressor Control

Three temperature sensors are used to actively monitor environmental temperatures. Sensors are located in the freezer, near the compressor, and on the outside of the packaging. The freezer temperature sensor will report the air temperature on the inside of the freezer, which will approximately be the same temperature as the liquid inside the kegs under normal operation. The sensor near the compressor will be used to prevent compressor from overheating. If the temperature exceeds 65 degrees C, the piezo buzzer will sound an alarm indicating the problem. The temperature probe outside the packaging will report the ambient temperature on the LCD screen.

The sensors themselves are DS18S20 High-Precision 1-Wire Digital Thermometers. These sensors require only one port pin for interfacing to our microcontroller and a connection to ground. They receive “parasite power” from the microcontroller’s port pin. Temperature readings will be polled at ten second intervals by first transmitting the desired slave temperature probe’s address over the single wire bus and then listening for the probe’s temperature data. A 4.7k ohm “weak” pull-up resistor is used to keep the temperature probe’s internal capacitors charged. [5]

Compressor operation is provided by an AC contactor located off PCB near the compressor itself. This device will open or close the AC power line to the compressor in order to regulate temperature. Microcontroller timer channels will be used to limit the frequency at which the compressor can be turned on and off due to temperature variations. This is to prevent wear and tear on the compressor.

3.0 Summary

The DRINK smart draft beverage dispensing system’s circuit has been designed to minimize complexity, lower maintenance, and allow easy debugging through headers. Serial communication between devices is provided through level translator chips and off board inputs are optically isolated to prevent damage to other board components. Future expandability options have been left open to facilitate the use of additional peripherals.

List of References

[1] XP Power. (2006) AED Series Power Supplies Available:
http://www.xppower.com/orderPriceList.taf?seriesid=100065#
Feburary 22th, 2006. [Date accessed]

[2] EarthLCD. (2005). ezLCD-001 Data Sheet. Available:
http://www.earthcomputer.com/public_html/downloads/ezLCD-001_DataSheet.pdf
Feburary 10th, 2006. [Data accessed]

[3] Rabbit Semiconductor. (2005). RCM User Manual. Available:
http://www.rabbitsemiconductor.com/products/rcm3305/
Feburary 10th, 2006. [Date accessed]

[4] Grayhill. (2006) 62S Optical Encoder. Available:
http://lgrws01.grayhill.com/web/new/HumanOpticalEncoders/
Feburary 22th, 2006. [Date accessed]

[5] CUI Inc. (2006) Piezo Audio Transducer. Available:
http://www.cui.com/pdffiles/CMT-1603.pdf
Feburary 22th, 2006. [Date accessed]

[6] Texas Instruments. (2005) S2000 Low Frequency RFID Reader Datasheet. Available:
http://www.ti.com/rfid/docs/manuals/pdfSpecs/RI-STU-MRD1.pdf
Feburary 10th, 2006. [Date accessed]

[7] Maxim-IC. (2006) 1-Wire Parasite-Power Digital Thermometer. Available:
http://pdfserv.maxim-ic.com/en/ds/DS18S20.pdf
Feburary 22th, 2006. [Data accessed]

IMPORTANT: Use standard IEEE format for references, and CITE ALL REFERENCES listed in the body of your report. Provide "live" links to all data sheets utilized.

Appendix A: Design Rule Check Report

Checking Pins and Pin Connections

Checking Schematic: SCHEMATIC1

Checking Electrical Rules

Checking for Unconnected Nets

Checking for Invalid References

Checking for Duplicate References

Check Bus width mismatch

Appendix B: Bill of Materials Report

DRINK Schematic Team 4 Revised: Friday, February 24, 2006
Revision: 1.0

Bill Of Materials February 24,2006 9:50:02 Page1

Item	Quantity	Reference	Part
1	2	C7,C9	220uF
2	2	C8,C12	1000pF
3	2	C10,C14	3900pF
4	2	C11,C13	120pF
5	2	C17,C21	68uF
6	14	C18,C19,C20,C22,C39,C40, C41,C42,C43,C44,C45,C46, C47,C48	0.1uF
7	2	D2,D3	1N4099
8	7	D8,D10,D12,D13,D16,D17, D18	LED
9	4	D9,D11,D14,D15	DIODE
10	1	HS1	BACKUP BATTERY
11	1	HS2	PIEZO Audio Transducer
12	1	J12	RPG Header
13	4	J13,J14,J15,J16	CONN PCB 6
14	1	J26	3.3V DC Converter
15	1	J27	LCDCN2
16	1	J28	LCDCN1
17	1	J29	BIO
18	1	J30	5V DC Converter
19	3	J35,J36,J38	MOCD223-M Optocoupler
20	4	J37,J39,J40,J41	MOC3010-M Optocoupler
21	2	J42,J43	MAX3232C
22	1	J45	Compressor Header
23	1	J47	Temp Probe 2
24	1	J48	Temp Probe 3
25	1	J49	Antenna
26	2	J50,J54	Temp Probe 1
27	1	J51	RFID
28	1	J52	CONN DSUB 9-P
29	1	J53	Quad Dual Input XOR
30	1	J62	PLD OUTPUT HEADER
31	1	J63	PLD INPUT HEADER
32	1	J65	DIPSOC-7x2
33	1	J68	HEADER 16

34	2	J70,J71	HEADER 15
35	1	J72	HEADER 17
36	1	J73	12V DC Input Jack
37	2	J3 on RCM3315, J4 on RCM3315	HEADER 17X2
38	2	L2,L3	33uH
39	2	RS2,RS3	0.1 Ohm
40	6	R3,R4,R16,R17,R20,R22	1k
41	2	R9,R14	2.2k
42	11	R13,R15,R18,R19,R21,R23, R24,R25,R26,R27,R29	220 Ohm
43	2	R28,R30	27k
44	1	R31	4.7k Ohm
45	1	SW2	RESET
46	1	U1	PAL16V8