REMOTE CONTROL LED WITH TIME/TEMPERATURE/DATE DISPLAYING LCD SCREEN AND TOUCH SENSOR

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Contents

1. Introduction

While most of the LEDs that we commonly used are being controlled by a single wired switch, sometimes when we are right about to fall asleep in our cozy bed, especially in the winter, we find it so tormenting to get up, reach the switches, and turn off the LEDs. A friendly designed wireless bedside system that controls all the LEDs around the house would avoid such cases.

1.1 Objective

Since some people might prefer other bedside functionalities as well, we propose to create a multi-functional user-friendly remote control LED system that has some designed features including:

1. LCD screen that displays the current time, room temperature and room humidity to the user.
2. Functioning alarm clock which rings at user's predefined time.
3. Capacitive touch switches that turn the LEDs on and off.
4. LEDs brightness level controlling through power MOSFETs.

1.2 Background

Although some companies(Siemens[1], etc.) have been developing bedside displays(usually in the form of a digital clock plus radio), our design is significantly different from most of the existing designs, in a way that our system are targeted to switch the LEDs around the house and adjust their brightness. We are confident that if we can produce such bedside system with affordable parts, it will be a marketable product as one of the most powerful bedside systems.

1.3 High-level Requirements List

1. Need to use work on a MOSFET circuit effectively for brightness control and turning-on command transmission so that our LED strip would be turned on to the accurate chosen brightness level.

2. The LCD screens should display time, humidity, and temperature in full functioning. And the capacitive switch should work as a parallel sensor with these three sensors mentioned above.

3. We are using 3.3V, 5V and 12V sources together for power supply for different chips involved in our circuit development. Specifically, two LCD screens uses 3.3V voltage supply. LED and MOSFET control circuit uses 12V and 5V voltage supplies. Our three sensors use 5V voltage supply. Those voltage supply differences should not be mixed up and be separated clearly.

2. Design

2.1 Block Diagram

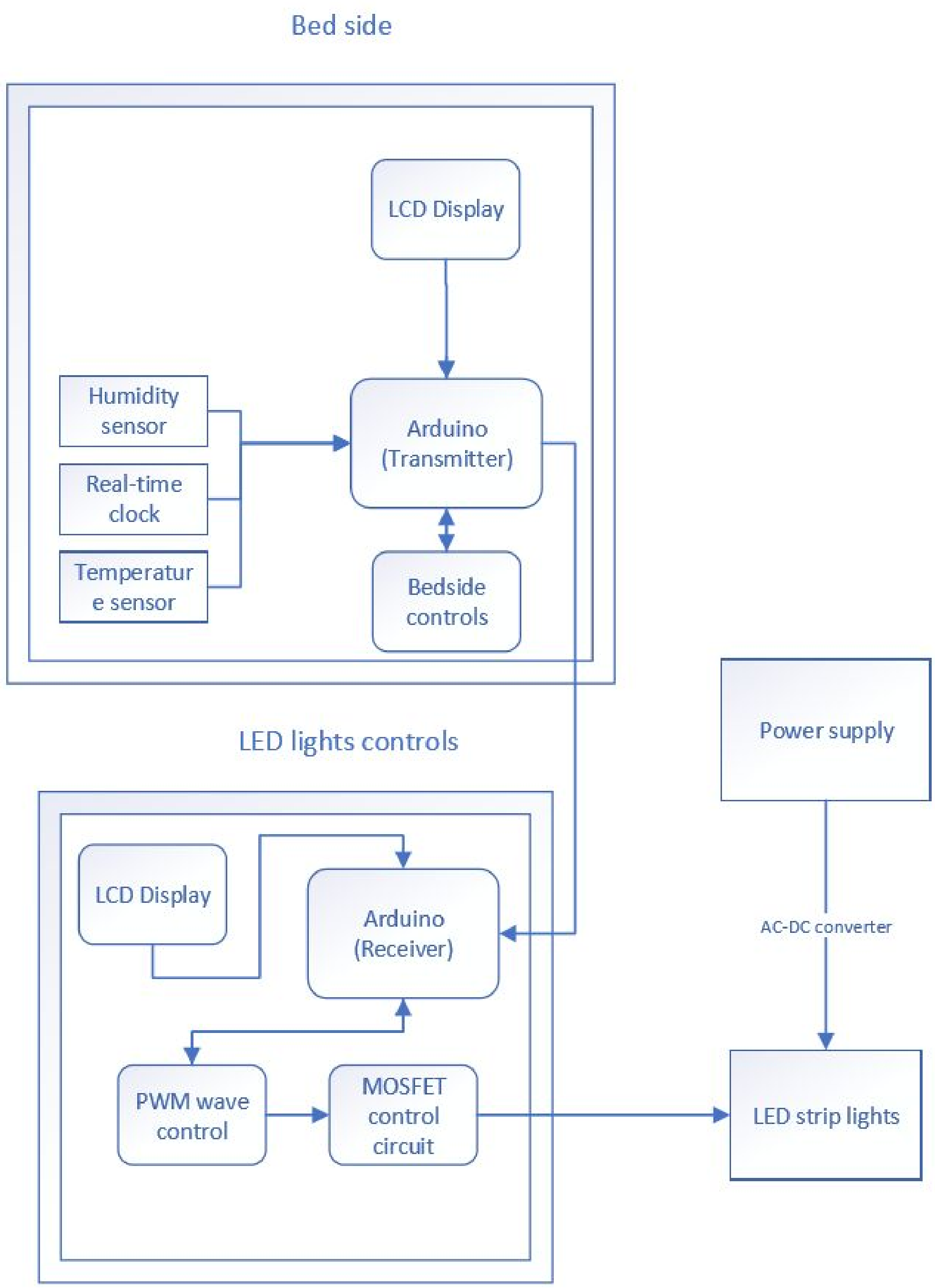


Figure 1 Block Diagram

2.2 Physical Design

We split our designs into two parts, the bedside and the wallside.

All the three sensors and capacitive switch are located on the bedside. Those sensors give us feedback on room humidity, room temperature and local time, along with the capacitive touch switch which gives us information on whether the LEDs are on or off. If the user turn the capacitive touch switch on, then the arduino on the bedside will send a turn-on message to the arduino on the wallside, which, after receiving the signal, gives commands to PWM wave control and further controls the MOSFET block for LEDs brightness. Finally, the MOSFET block decides with the brightness level in which LEDs will be turned on.

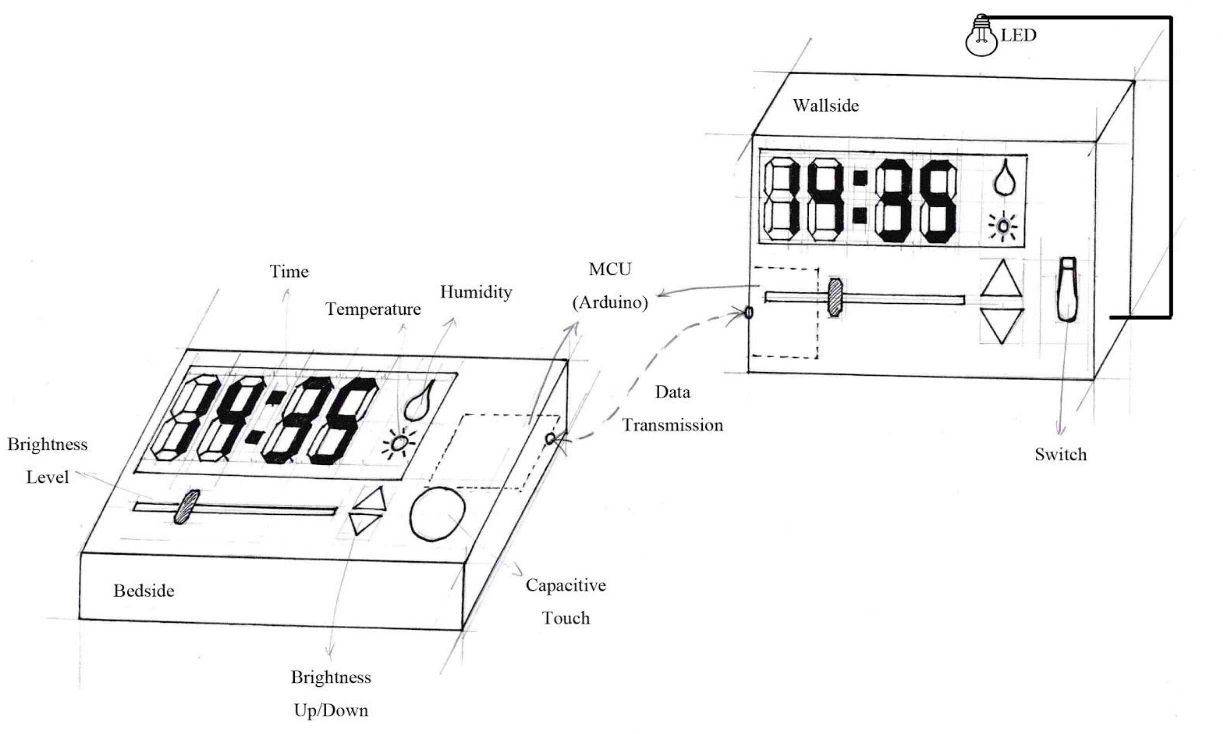


Figure 2 Physical Design Sketch

2.3 Subsystems

2.3.1 Power Subsystem

2.3.1.1 AC to DC Converter

A standard AC to DC converter to transfer AC circuit provided at houses to DC circuit needed for LED circuit.

Requirement	Verification
Outputs DC source with 3A current and 12V voltage.	A. Measure output voltage and current using multimeter

2.3.1.2 Current Regulator

A current regulator that ensures the circuit current does not go too high and cause some potential danger.

Requirement	Verification
Limits current to be lower than 10A.	A. Measure current using multimeter

2.3.2 Sensor Subsystem

2.3.2.1 HDC2010 Humidity Sensor

A Humidity sensor that gives out in-room humidity information to be put in two LCD screens.

Requirement	Verification
1. Outputs accuracy ? 2. Required power ?	1A. How to test accuracy? 2A. Test using existing power supply?

2.3.2.2 LM35 Temperature Sensor

A Temperature sensor that shows real time temperature to be put in two LCD screens.

Requirement	Verification
1. Outputs accuracy ? 2. Required power ?	1A. How to test accuracy? 2A. Test using existing power supply?

2.3.2.3 DS3231 Real-time Clock

A Real-time clock that gives very accurate time information to be indicated in two LCD screens.

Requirement	Verification
1. Outputs accuracy ? 2. Required power ?	1A. How to test accuracy? 2A. Test using existing power supply?

2.3.2.4 TTP223B Capacitive Touch

A capacitive touch which decides whether or not to turn on the LED. This is the most important sensor in all these four sensors.

Requirement	Verification
1. Outputs accuracy 2. Required power 3. working effectively (define efficiency?)	1A. How to test accuracy? 2A. Test using existing power supply? 3A. Every time users approach the switch our LED strips would be automatically turned on

2.3.3 Central Control Subsystem

2.3.3.1 Main Control Units

We use two arduinos, or ATMega328P micro-processor chips for data and command position and orientation. Since ATMega328P chips are central units for Arduino, we should be able to write code to decide their behaviors just as we did in other classes involving the use of arduino.

Requirement	Verification
1. Bluetooth transmission speed up to 25Mbps 2. Required power from 0.5mW to 100 mW.	1A. Transmit data between chips and record the time taken 2A. Test using existing power supply?

2.3.3.2 Brightness Control

For brightness control we use L7805CV electronic parts distributor along with two IRF540p power MOSFET and a BD139 NPN bipolar- junction transistor, two 100 kΩ resistors, four 10 kΩ resistors, one 500 ohm resistor, two 0.1 uF capacitor and 5V, 12V voltage supply.

Requirement	Verification
1. Required power ? 2. Different Level of brightness is provided and controllable 3. Brightness level storage is working well so that the next time we turn the LED strips on they would be in the same brightness level as they used to be when we turned them off before.	1A. Test using existing power supply? 2A. Test that we have several different brightness levels. 3A. Turn on the LEDs, change the brightness level then turn them off. They should be at the same brightness level when we turn them on again.

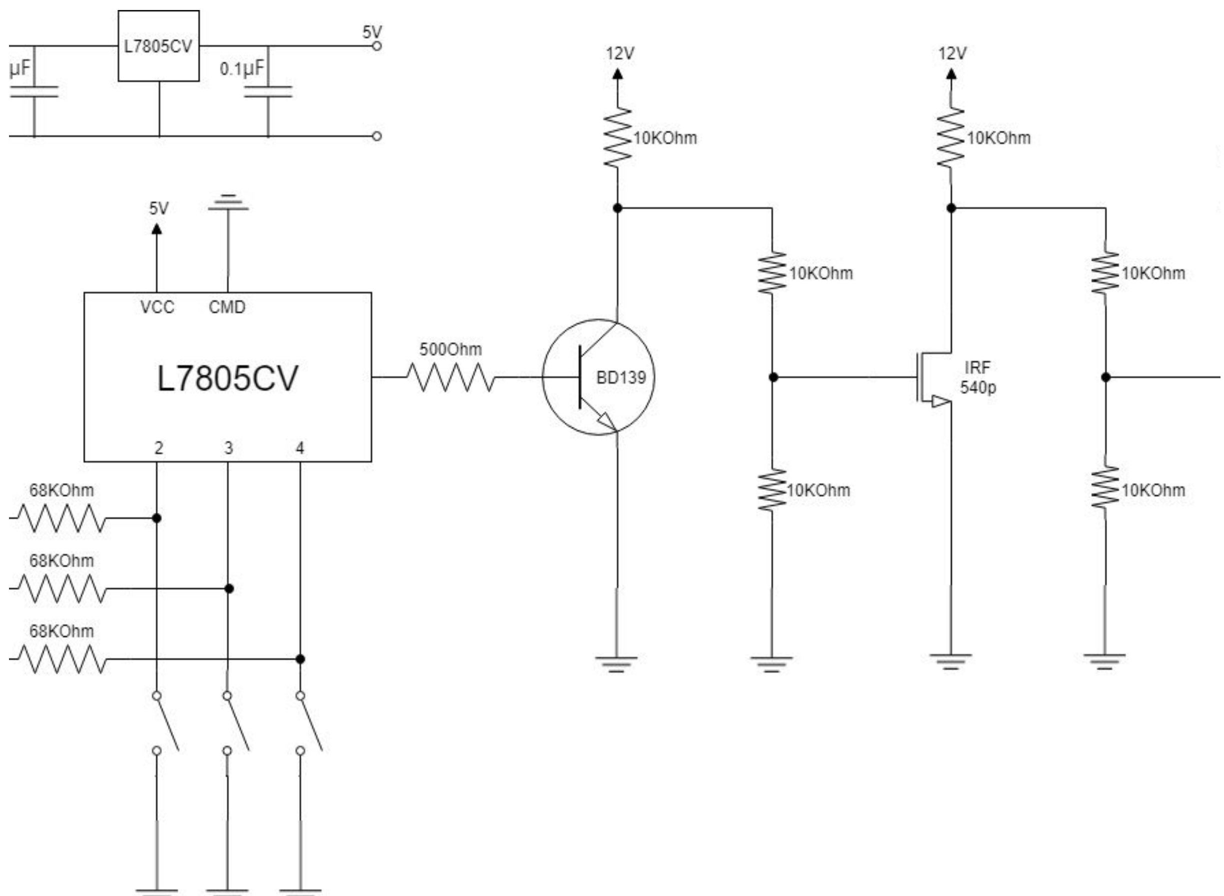


Figure 3 Brightness Control Circuits

2.4 Functional Overview

2.4.1 Remote control

this function is essential in our design. Currently we plan to use bluetooth for wireless connection between bedside and LED side. Possible replacement includes antenna to transmit signal, but because of the various antenna design considerations it's not our best choice. Such replacement would definitely add difficulty to our design.

2.4.2 LCD display

Accurate time, temperature and humidity captured by the corresponding sensors should show up on the LCD displays in a favorable way.

2.4.3 Capacitive touch

The capacitive touch should allow the users to turn on and turn off remote-controlled LED strips without directly touching the switch.

2.4.4 Brightness control

As we know, in the daytime we do not want strong light while at night we want our LEDs to be brighter. Such design of twelve adjustable brightness levels makes our design user-friendly.

2.4.5 Brightness storage

Everytime we turn on our LED strips, they would remain in the same brightness level as they used to be in the last time when we turned it off. With this functionality, users do not need to press the brightness adjustment knob several times to adjust the LED to their favorable brightness level.

2.5 Supporting Material

2.5.1 LM35 Temperature sensor datasheet

Temperature tolerance range: 2°C to 150 °C

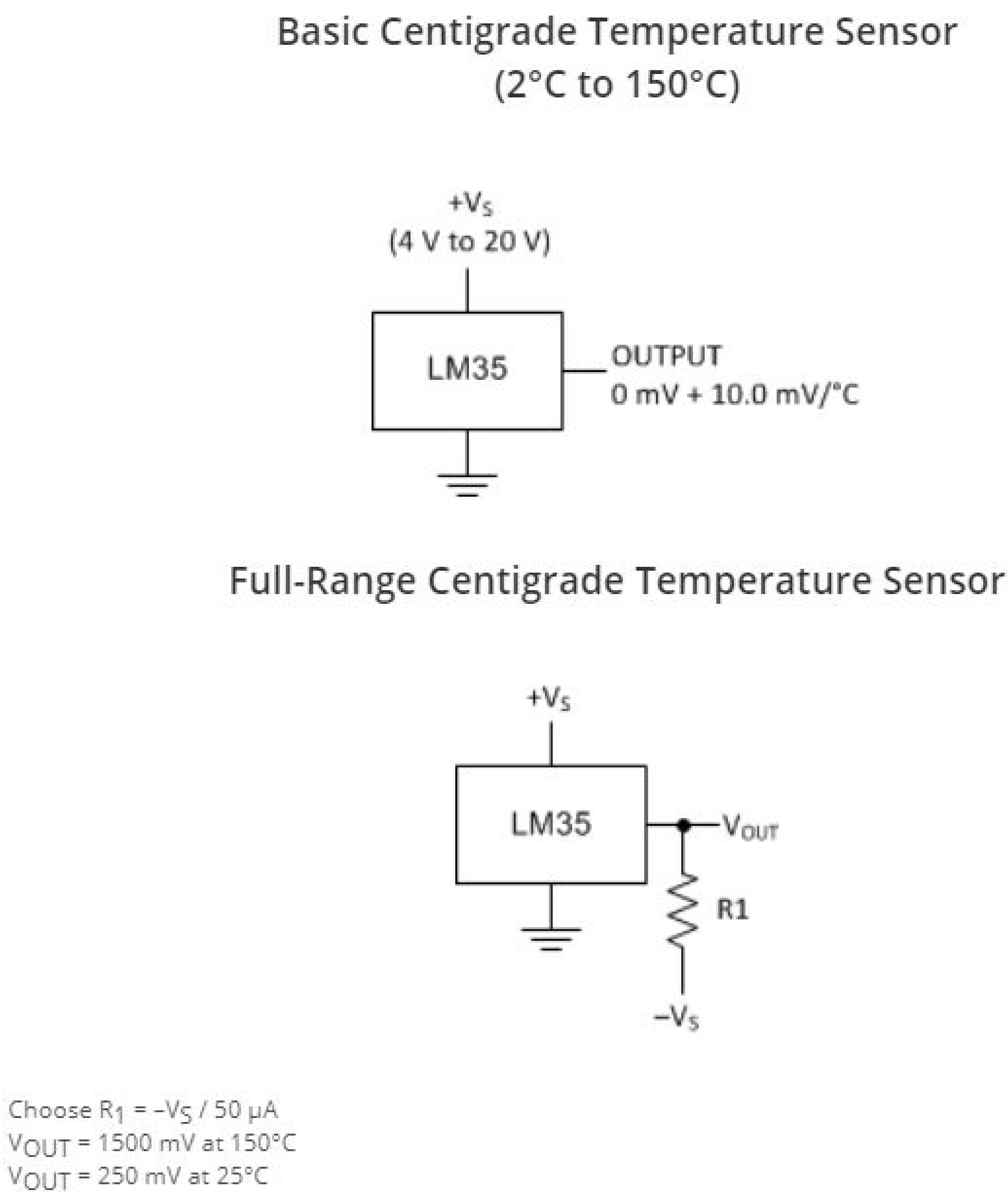


Figure 4 LM35 Circuits

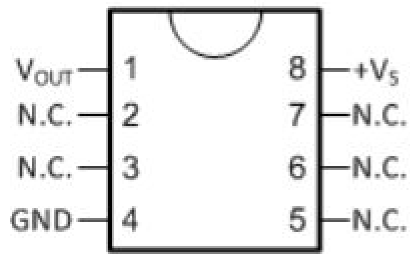


Figure 5 LM35 Pins (N.C. = not connected)

2.5.2 DS3231 Real-time Clock Datasheet

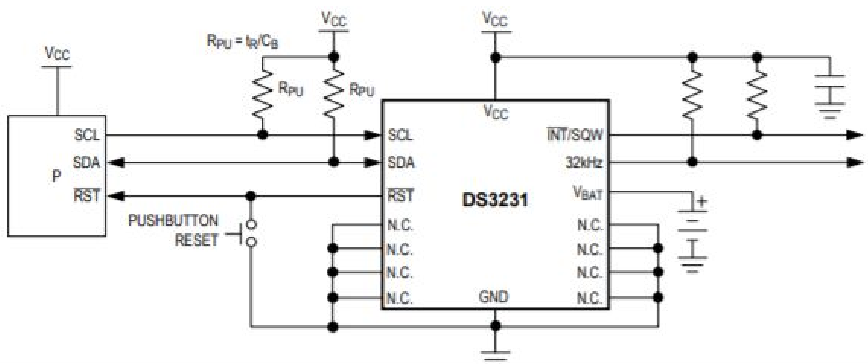


Figure 6 DS3231 Circuits

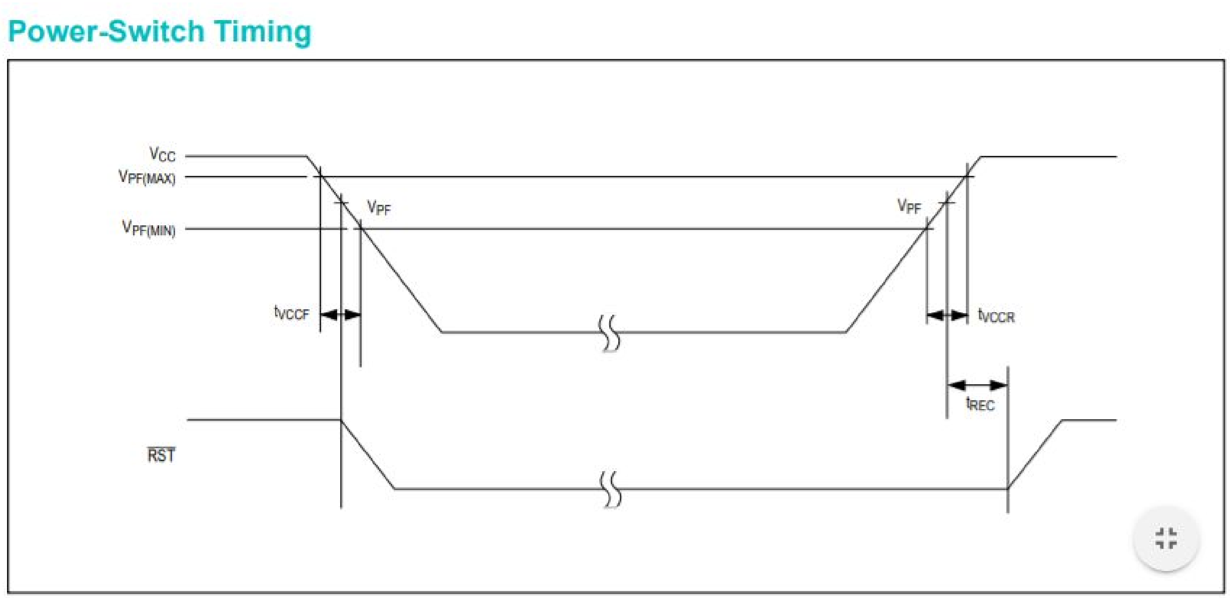
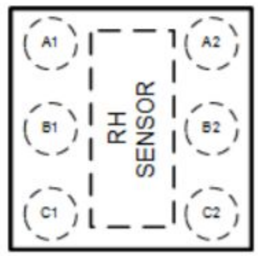


Figure 7 DS3231 Power-Switch Timing

2.5.3 HDC2010 Low-Power Humidity and Temperature Digital Sensors

WLCSP (DSBGA)
6 Pin YPA
Top View



Pin Functions

PIN		I/O TYPE (1)	DESCRIPTION
NAME	NO.		
VDD	A1	P	Positive Supply Voltage
ADDR	B1	I	Address select pin – hardwired to VDD or GND. GND: slave address: 1000000 VDD: slave address: 1000001
GND	C1	G	Ground
SDA	A2	I/O	Serial data line for I^2C, open-drain; requires a pullup resistor to VDD
SCL	B2	I	Serial clock line for I^2C, open-drain; requires a pullup resistor to VDD
DRDY / INT	C2	O	Data ready/Interrupt. Push-pull output

(1) P=Power, G=Ground, I=Input, O=Output

Figure 8 HDC2010 Pins

2.6 Tolerance Analysis

2.6.1 LM35 Temperature Sensor Tolerance

		MIN	MAX	UNIT
Supply voltage		–0.2	35	V
Output voltage		–1	6	V
Output current			10	mA
Maximum Junction Temperature, $T_J$max			150	°C
Storage Temperature, T_{stg}	TO-CAN, TO-92 Package	–60	150	°C
	TO-220, SOIC Package	–65	150	

Figure 9 LM35 Maximum and Minimum ratings

		MIN	MAX	UNIT
Specified operating temperature: T_{MIN} to T_{MAX}	LM35, LM35A	–55	150	°C
	LM35C, LM35CA	–40	110	
	LM35D	0	100	
Supply Voltage ($+V_S$)		4	30	V

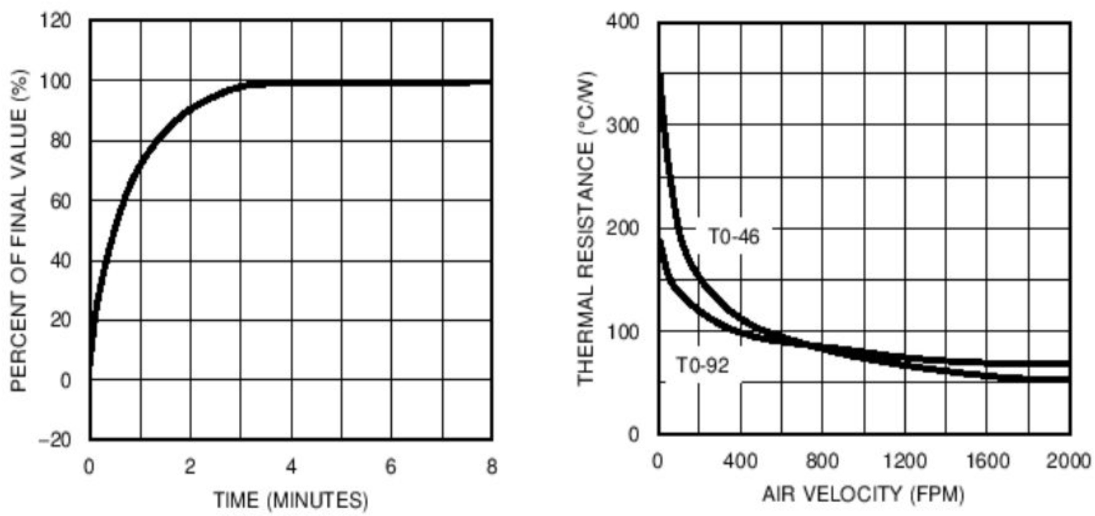


Figure 10 LM35 Recommended operating conditions

2.6.2 DS3231 Real-time Clock Tolerance

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}		2.3	3.3	5.5	V
	V_{BAT}		2.3	3.0	5.5	V
Logic 1 Input SDA, SCL	V_{IH}		0.7 x V_{CC}		V_{CC} + 0.3	V
Logic 0 Input SDA, SCL	V_{IL}		-0.3		0.3 x V_{CC}	V

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Active Supply Current	I_{CCA}	(Notes 4, 5)	V_{CC} = 3.63V			200	µA
			V_{CC} = 5.5V			300	
Standby Supply Current	I_{CCS}	I2C bus inactive, 32kHz output on, SQW output off (Note 5)	V_{CC} = 3.63V			110	µA
			V_{CC} = 5.5V			170	
Temperature Conversion Current	$I_{CCSCONV}$	I2C bus inactive, 32kHz output on, SQW output off	V_{CC} = 3.63V			575	µA
			V_{CC} = 5.5V			650	
Power-Fail Voltage	V_{PF}			2.45	2.575	2.70	V
Logic 0 Output, 32kHz, $\overline{INT}$/SQW, SDA	V_{OL}	I_{OL} = 3mA				0.4	V
Logic 0 Output, $\overline{RST}$	V_{OL}	I_{OL} = 1mA				0.4	V
Output Leakage Current 32kHz, $\overline{INT}$/SQW, SDA	I_{LO}	Output high impedance		-1	0	+1	µA
Input Leakage SCL	I_{LI}			-1		+1	µA
$\overline{RST}$ Pin I/O Leakage	I_{OL}	$\overline{RST}$ high impedance (Note 6)		-200		+10	µA
V_{BAT} Leakage Current (V_{CC} Active)	I_{BATLKG}				25	100	nA

(**V_{CC} = 0V, V_{BAT} = 2.3V to 5.5V**, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Active Battery Current	I_{BATA}	$\overline{EOSC}$ = 0, BBSQW = 0, SCL = 400kHz (Note 5)	V_{BAT} = 3.63V			70	µA
			V_{BAT} = 5.5V			150	
Timekeeping Battery Current	I_{BATT}	$\overline{EOSC}$ = 0, BBSQW = 0, EN32kHz = 1, SCL = SDA = 0V or SCL = SDA = V_{BAT} (Note 5)	V_{BAT} = 3.63V		0.84	3.0	µA
			V_{BAT} = 5.5V		1.0	3.5	
Temperature Conversion Current	I_{BATTC}	$\overline{EOSC}$ = 0, BBSQW = 0, SCL = SDA = 0V or SCL = SDA = V_{BAT}	V_{BAT} = 3.63V			575	µA
			V_{BAT} = 5.5V			650	
Data-Retention Current	I_{BATTDR}	$\overline{EOSC}$ = 1, SCL = SDA = 0V, +25°C				100	nA

Figure 11 (VCC = 2.3V to 5.5V, VCC = Active Supply (see Table 1), TA = TMIN to TMAX, unless otherwise noted.) (Typical values are at VCC = 3.3V, VBAT = 3.0V, and TA = +25°C, unless otherwise noted.)

Power-Switch Characteristics

(T_A = T_{MIN} to T_{MAX})

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{CC} Fall Time; $V_{PF(MAX)}$ to $V_{PF(MIN)}$	t_{VCCF}		300			µs
V_{CC} Rise Time; $V_{PF(MIN)}$ to $V_{PF(MAX)}$	t_{VCCR}		0			µs
Recovery at Power-Up	t_{REC}	(Note 13)		250	300	ms

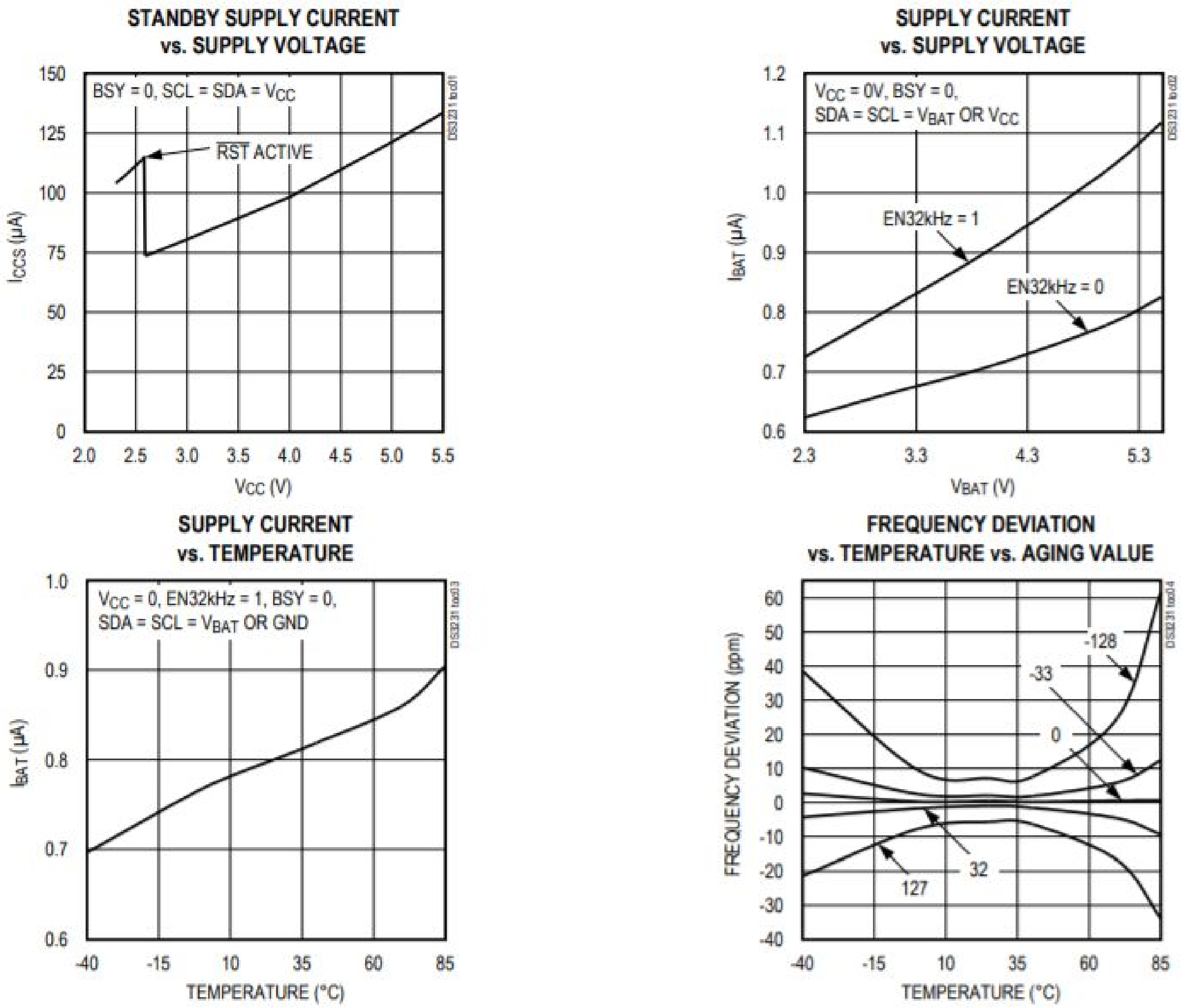


Figure 12 Power-Switch Characteristics (VCC = +3.3V, TA = +25°C, unless otherwise noted.)

2.6.3 HDC2010 Low-Power Humidity and Temperature Digital Sensors Tolerance

6.1 Absolute Maximum Ratings(1)

		MIN	MAX	UNIT
VDD	Input Voltage	-0.3	3.9	V
GND	Input Voltage	-0.3	3.9	V
ADDR	Input Voltage	-0.3	3.9	V
SCL	Input Voltage	-0.3	3.9	V
SDA	Input Voltage	-0.3	3.9	V
T_{stg}	Storage temperature	-65	150	°C

6.4 Thermal Information

THERMAL METRIC[1]		HDC2010 DSBGA (YPA) 6 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	114.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	0.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	35.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	0.6	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	35.4	°C/W

Electrical Characteristics (continued)

at T_A = 30°C, V_{DD} = 1.8 V, 20% ≤ RH ≤ 80% (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{DD}	Supply current	RH measurement[1]		650	890	µA
		Temperature measurement[1]		550	730	
		Sleep Mode		0.05	0.1	
		Average at 1 measurement/second, RH or temperature only[1] [2]		0.3		
		Average at 1 measurement/second, RH (11 bit) + temperature (11 bit)[1] [2]		0.55		
		Average at 1 measurement every 2 seconds, RH (11 bit) + temperature (11 bit)[1] [2]		0.3		
		Average at 1 measurement every 10 seconds, RH (11 bit) + temperature (11 bit)[1] [2]		0.105		
		Startup (average on startup time)		80		
I_{DDHEAT}	Heater[3]	V_{DD} = 3.3 V		90		mA
RELATIVE HUMIDITY SENSOR						
RH_{ACC}	Accuracy[4] [5] [6]			±2	±3	%RH
RH_{REP}	Repeatability[7]	14 bit resolution		±0.1		%RH
RH_{HYS}	Hysteresis[8]			±1		%RH
RH_{RT}	Response Time[9]	$t_{63\%}$ step[10]		8		s
RH_{CT}	Conversion-time[7]	9 bit accuracy		275		µs
		11 bit accuracy		400		
		14 bit accuracy		660		
RH_{OR}	Operating range	Non-condensing[11]	0		100	%RH
RH_{LTD}	Long-term Drift[12]			±0.25		%RH/yr
TEMPERATURE SENSOR						
$TEMP_{OR}$	Operating range		-40		125	°C
$TEMP_{ACC}$	Accuracy[7]	5°C < T_A < 60°C		±0.2	±0.4	°C
$TEMP_{REP}$	Repeatability[7]	14 bit resolution		±0.1		°C
$TEMP_{CT}$	Conversion-time[7]	9 bit accuracy		225		µs
		11 bit accuracy		350		
		14 bit accuracy		610		

(1) I2C read/write communication and pull up resistors current through SCL, SDA not included.
(2) Average current consumption while conversion is in progress.
(3) Heater operating range – 40°C to 85°C.
(4) Excludes hysteresis and long-term drift.

6.6 I2C Interface Electrical Characteristics

At T_A = 30°C, V_{DD} = 3.3 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IH}	Input High Voltage		0.7 x V_{DD}			V
V_{IL}	Input Low Voltage				0.3 x V_{DD}	V
V_{OL}	Output Low Voltage	Sink current 3 mA			0.4	V
HYS	Hysteresis		0.1 x V_{DD}			V
CIN	Input Capacitance on all digital pins			0.5		pF

6.7 I²C Interface Timing Requirements

At TA = 30°C, VDD = 1.8 V (unless otherwise noted)

		MIN	NOM	MAX	UNIT
f_{SCL}	Clock Frequency	10		400	kHz
t_{LOW}	Clock Low Time	1.3			µs
t_{HIGH}	Clock High Time	0.6			µs
t_{SP}	Pulse width of spikes that be suppressed by input filter(1)			50	ns
t_{START}	Shutdown entry delay		10	15	ms

(1) This parameter is specified by design and/or characterization and it is not tested in production.

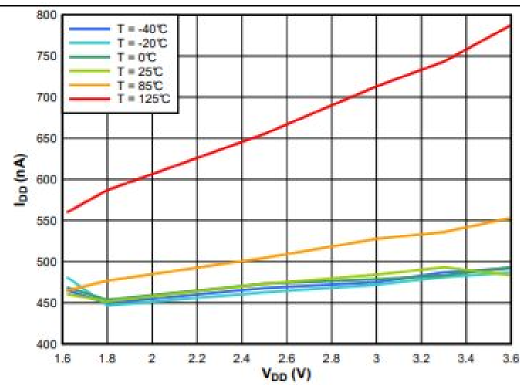


Figure 4. Supply Current vs. Supply Voltage, Average at 1 Measurement/Second, RH (11 Bit) + Temperature (11 Bit)

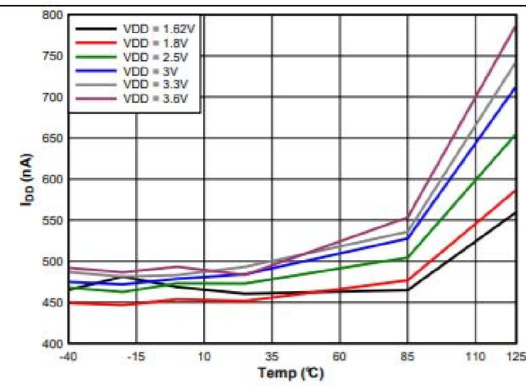


Figure 5. Supply Current vs. Temperature, Average at 1 Measurement/Second, RH (11 Bit) + Temperature (11 Bit)

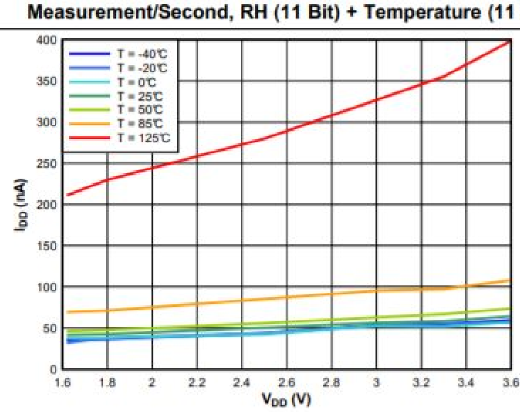


Figure 6. Supply Current vs. Supply Voltage, Sleep Mode

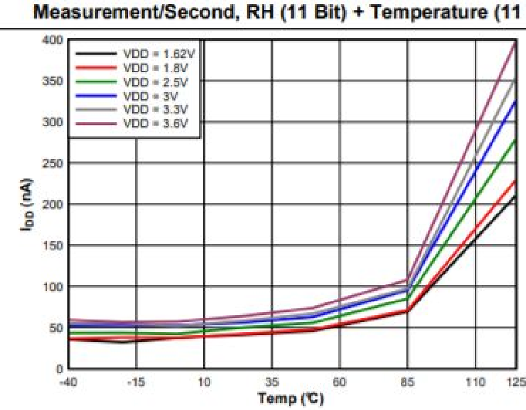


Figure 7. Supply Current vs. Temperature, Sleep Mode

3 Cost and Schedule

3.1 Cost Analysis

Our analog sensors are cheap. All these sensors and MOSFETs and resistors, capacitors can be covered within 80 dollars. We might buy multiple sensors for different versions of PCBs so they might cost more. But we can definitely cover the cost within about $120. Power supply is already offered in the kit box, with 5V and 12 V voltage sources. These are exactly our wanted voltage supply levels. We have already bought some LED strips in use, and they are cheap. And also we have some capactive touch switch sensors. Such sensors each costs less than $5 if we need to get a new one.

3.2 Schedule

4 Discussion of Ethics and Safety

All the parts are important to make a successful project with all our expected functions of it working well. However, one of the most important part to achieve this goal is the inter-reaction between two ATMega328P chips. They are the central control unit for all the other controls and they connect the information given from four sensors to the displayed information on LCD screens. They also help to generate PWM wave control signal for LED brightness control. There might be some other issues such as the voltage might go too high that LEDs cannot bear, leading to some potential burning-ups. So we need a voltage regulator for the power supply part because LEDs are fragile electronic devices.

When soldering, always remember to solder + and - sides of LED strip to + and - ends of power supply correctly, else ATMEga328P chip on the receiver side might be burned. Even if the + and - sides are connected correctly, we still need voltage regulators in case of sudden rise of voltage provided to LED strips leading to LED burning-ups.

5 Citations

[1] Mid Century 1970's Orange Radio Alarm clock Siemens Alpha - Digital Alarm Clock
https://www.etsy.com/listing/695360056/mid-century-1970s-orange-radio-alarm
[2] LM35 ±0.5°C Temperature Sensor with Analog Output and 30V Capability
http://www.ti.com/product/LM35
[3] DS3231 Extremely Accurate I²C-Integrated RTC/TCXO/Crystal
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[4] TTP223 Capacitive Touch Switch Circuit
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[5] ATmega328P - 8-bit AVR Microcontrollers
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[6] L7805CV STMicroelectronics
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https://www.ieee.org/about/corporate/governance/p7-8.html
[8] HDC2010 Low-Power Humidity and Temperature Digital Sensors