

Design of a Quick-View Weather Station

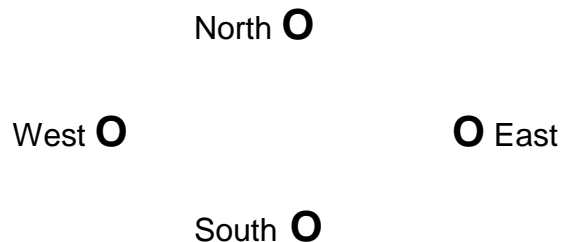
Introduction:

You work for the ACME Weather Co. and one of your valued customers has asked you to design a new quick-view weather station (QWS). The new QWS will provide current information on weather conditions using only 10 LEDs. This will allow the customer to get a “quick view” of the weather conditions before determining what weather conditions need to be further analyzed.

The QWS receives digital signals from the outdoor weather sensors and processes (or decodes) those digital signals. Depending on the states of the sensors (0's & 1's), the QWS displays the current conditions on the weather indicator display. There are 4 types of sensors that will provide signals to the QWS: the temperature sensor, the barometric pressure sensor, the wind speed sensor, and the wind direction sensor. The signals from the sensors are digital with +5V = 1 and 0V = 0. The wind direction sensor provides 3 bits of information, the temperature and barometric pressure sensors each provide 2 bits of information, and the wind speed sensor provides 1 bit of information.

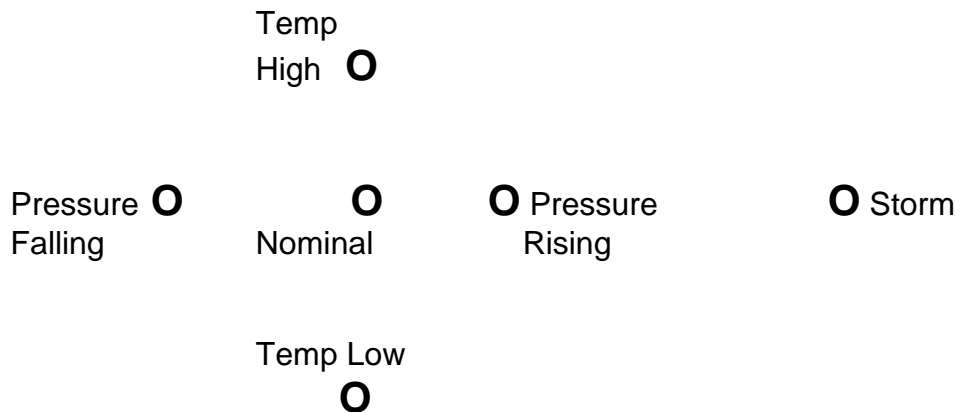
The QWS will decode the digital signals from the wind direction sensor and provide status using the 4 LED configuration shown below.

Wind Direction LEDs



The QWS will decode the digital signals from the temperature, barometric pressure, and wind speed sensors and provide status using the 6 LED configuration shown below.

Weather Condition LEDs



Appendix A, posted to Blackboard in the folder for this lab, shows a sample set of how the QWS LEDs may be lit.

Below are tables showing the digital signal outputs of the sensors and the corresponding meaning of each bit or pair of bits.

Wind Direction	W ₂	W ₁	W ₀
North	0	0	0
North-East	0	0	+5V
East	0	+5V	0
South-East	0	+5V	+5V
South	+5V	0	0
South-West	+5V	0	+5V
West	+5V	+5V	0
North-West	+5V	+5V	+5V

Temperature	X ₁	X ₀
Temp > 75° F (High)	0	0
40° F < Temp < 75° F (Nominal)	0	+5V
Temp < 40° F (Low)	+5V	0
Invalid Temp Reading	+5V	+5V

Barometric Pressure	Y ₁	Y ₀
Pressure Falling	+5V	+5V
Pressure Stable	+5V	0
Pressure Rising	0	+5V
Invalid Pressure Reading	0	0

Wind Speed Sensor	Z
Wind Speed > 30 mph	+5V
Wind Speed < 30 mph	0

The QWS will be designed to read the digital outputs of the sensors and display status using 10 LEDs. The table below shows which LEDs should be lit for each condition. **A “don’t care” or “X” in the table below indicates that more than one set of conditions may occur at the same time and be displayed at the same time.** Three examples of this are included below for clarification. This illustrates the relationship between the weather conditions (provided by the sensors) and the corresponding QWS display (state of the individual LEDs).

Wind Direction	QWS Display LEDs			
	North	East	South	West
Wind direction N	ON	OFF	OFF	OFF
Wind direction NE	ON	ON	OFF	OFF
Wind direction E	OFF	ON	OFF	OFF
Wind direction SE	OFF	ON	ON	OFF
Wind direction S	OFF	OFF	ON	OFF
Wind direction SW	OFF	OFF	ON	ON
Wind direction W	OFF	OFF	OFF	ON
Wind direction NW	ON	OFF	OFF	ON

Weather Condition	QWS Display LEDs				
	High	Nominal	Low	Falling	Rising
Temp Low	OFF	X	ON	X	X
Temp Nominal	OFF	ON	OFF	X	X
Temp High	ON	X	OFF	X	X
Pressure Falling	X	X	X	ON	OFF
Pressure Stable	X	ON	X	OFF	OFF
Pressure Rising	X	X	X	OFF	ON
Temp Average & Pressure Stable	OFF	ON	OFF	OFF	OFF
Temp Low & Pressure Rising	OFF	OFF	ON	OFF	ON
Temp Nominal & Pressure Falling	OFF	ON	OFF	ON	OFF
Temp High & Pressure Stable	ON	ON	OFF	OFF	OFF

Weather Condition		QWS Display LED
Wind Speed	Pressure	Storm
< 30 mph	Falling	OFF
< 30 mph	Stable	OFF
< 30 mph	Rising	OFF
< 30 mph	Invalid	OFF
> 30 mph	Falling	ON
> 30 mph	Stable	OFF
> 30 mph	Rising	OFF
> 30 mph	Invalid	OFF

For the special cases of an invalid temperature reading and/or invalid pressure reading, the following rules apply for the LEDs. A “don’t care” or “X” in the table below indicates that more than one set of conditions may occur at the same time and be displayed at the same time. An invalid temperature reading could be detected, for example, but the pressure reading remains valid and must be displayed properly.

Two examples of this are shown in the table below as clarification.

Invalid Digital Output	QWS Display LEDs				
	High	Nominal	Low	Falling	Rising
Invalid Temp Reading	ON	X	ON	X	X
Invalid Pressure Reading	X	X	X	ON	ON
Invalid Temp and Invalid Pressure Reading	ON	OFF	ON	ON	ON
Invalid Temp, Pressure Stable	ON	ON	ON	OFF	OFF
Temp High, Invalid Pressure	ON	OFF	OFF	ON	ON

Prelab:

Your completed prelab is due at the **beginning of lecture on the day of your lab period**. Use the following Boolean variables for your design:

QWS Sensors	
Temperature	X₁, X₀
Barometric Pressure	Y₁, Y₀
Wind direction	W₂, W₁, W₀
Wind Speed	Z

QWS Display LEDs	
North	N
South	S
East	E
West	W
Temp High	H
Temp Low	L
Pressure Rising	R
Pressure Falling	F
Nominal	NO
Storm	ST

Step 1 - Using the Boolean variables as defined in the tables above, develop the truth tables necessary to describe the relationship between the inputs to the QWS and the outputs to the LEDs. Use the appropriate truth table templates posted to Blackboard in the folder for this lab. **In your truth table, enter a “0” to indicate LED = ON and a “1” to indicate LED = OFF.**

HINTS:

- Blank truth tables with many rows and columns are provided. You may or may not need all the rows or columns!
- There are 10 LEDs, so make sure that you understand which LEDs are lit for each possible condition or possible conditions.
- Since there are multiple inputs and multiple outputs, consider whether it is simplest to combine all of the inputs and all of the outputs into a single truth table or if more than one truth table would simplify the design process. Carefully examine the dependencies between all of the inputs as well as whether an output is dependent on all the inputs.

Step 2 - Use Karnaugh maps to determine the minimized SOP boolean expressions for each of the 10 QWS LEDs. Use the appropriate 3 variable or 4 variable K-Map templates provided and record your answers on the SOP template provided; both are posted to Blackboard in the folder for this lab.

Step 3 - Determine the all-NAND equivalent of the minimized Boolean expressions for the QWS outputs. Use the all-NAND template as posted to Blackboard in the folder for this lab.

Your prelab results should consist of the following:

- Lab cover sheet
- Truth tables
- Karnaugh maps
- Resulting minimized SOP Boolean expressions
- All-NAND equivalent equations for the 10 QWS LEDs

Procedure:

Step 1 – Using the all-NAND equivalent equations as derived in your prelab, simulate your QWS design in Multisim.

If it is helpful to you, you may create a schematic on paper before inputting the design into Multisim, but it is not necessary for your lab write-up.

Hints for Multisim:

- The NAND and NOT gates needed for your circuit can be found under “**Place-Component-Misc Digital-TIL**”.
- The LEDs needed can be found under “**Place-Component-Diodes-LED**”. Choose single LEDs
- Use multiple pages in your schematic to help with debugging.
- Use net colors to tracking connectivity through your schematic.

Demonstrate your results to your instructor. Save a copy of your Multisim schematic to print out for your lab report.

Step 2 - Add IC identifiers and pin numbers to your gate-level schematic in preparation for building your circuit in hardware.

Step 3 - Build and test only the weather condition portion of your QWS design (the 6 LEDs representing temperature, pressure, and storm indicators).

If it is helpful to you, you may create a wiring diagram for your circuit, but it is not necessary for your lab write-up.

Demonstrate your results to your instructor.

Results:

Your lab report for this lab consists of the following and is due at the start of next week's lab period:

- Completed ELET215/CPET215 cover sheet with name and date lab performed. A copy of the cover sheet can be found on Blackboard under Lab Content/Lab Reference Material.
- **Completed prelab, including any corrections made to the prelab during the lab period.**
- A complete printed schematic in Multisim. Each schematic page must include:
 - Schematic title
 - Name and date of lab procedure
 - Neatly labeled appropriate Boolean expressions
 - Inputs and outputs labeled so they can be easily recognized
 - IC identifiers and pin numbers used in your hardware implementation