By Michael Simpson

Important

Requires ZeusPro
V1.70 or later

Catch the Wind
as seen in
February 2007 of Nuts & Volts Magazine

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I have always been fascinated by the weather. I own several of those remote gauges; you know, the ones that sit on your desk and display the outside temperature and humidity. Some display rainfall, while others display barometric pressure. I even have a couple that display a neat little forecast of the upcoming weather. And then it occurred to me; Why not build my own weather station?

This is the first in a series of articles where I will take you into the world of building your own weather station and home automation system. I live in a rural environment where violent thunder storms seem to seek me out as if they are on a search and destroy mission. I have lost every single TV antenna I have placed on my roof. I have had to replace 5 ISDN routers. When a bad storm rolls through, I run around the house like a madman unplugging things and shouting "the rain", "the rain".

Anyway… Wouldn't it be cool to automatically detect the lightning and turn off or isolate various devices? This is exactly what we are going to do in future articles, as we build a home automation system using X10.

Let's take some time and look at a wind speed sensor, otherwise known as an anemometer. I will show you three types. It may look like we are starting in the middle, as many would have started with a temperature or humidity gauge first. I wanted to jump feet first into anemometers since they are one of the most expensive and most complicated devices in the home weather station. The anemometer is also the coolest and most responsive environmental sensor. It can display real-time information several times a second.

Kronos Robotics and Electronics
www.KronosRobotics.com

I built four completely different weather stations while researching this series, and with each I found that starting with the anemometer seemed to make the assembly of the rest of the station proceed the smoothest.

While the basic construction of most anemometers is similar, there are three approaches you may take in adding one to your weather station.

- Building a home made anemometer
- Purchasing and building an anemometer kit
- Purchasing a fully assembled anemometer

All three approaches are very reasonable in cost. After I discuss the mechanical aspects of each device, I will provide some basic hookup and testing instructions.

Home Made Anemometer

One of the most difficult aspects of making an anemometer is the construction of the Cup and Hub assembly. If they are not perfectly balanced the anemometer may not operate properly or even worse, fly apart at high speeds. A company called ForceField has solved this problem for us. They offer a molded plastic Cup and Hub assembly for around $20.

Figure 2

As shown in Figure 2 the assembly has a very small pre drilled hole in the center, so all we need to do is enlarge it to the size we need and it will always be dead center.

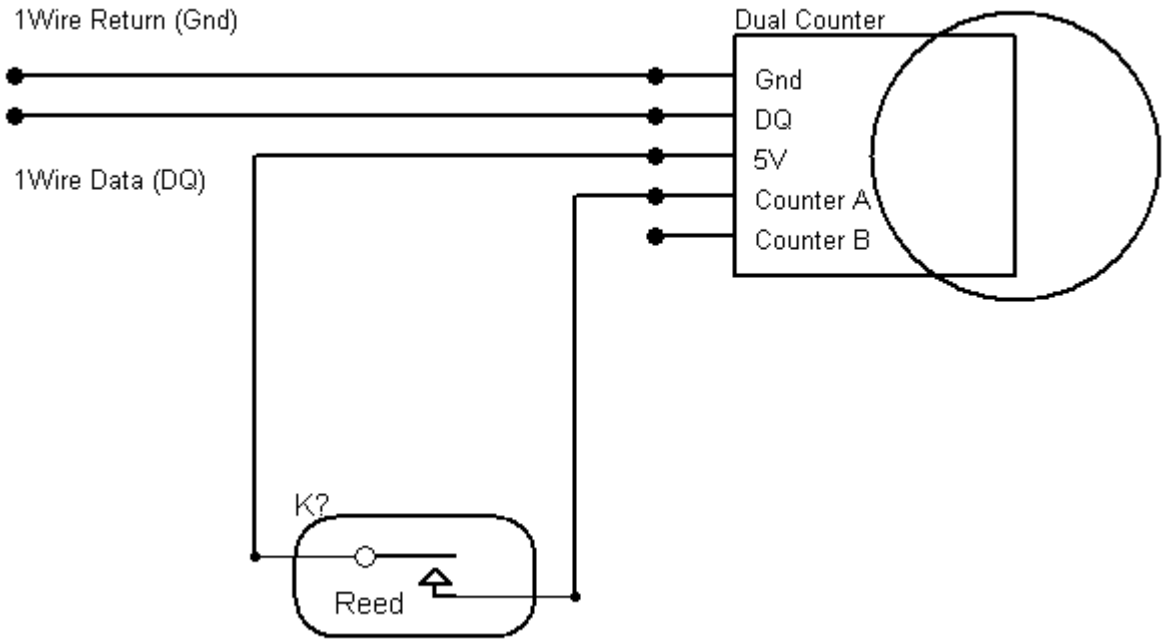
Our home made anemometer will feature this assembly. We will build a small ball bearing mount to attach the assembly and a couple of magnets and a reed sensor. Don't panic; the reed sensor is nothing more than the small glass reed removed from a reed relay that you can purchase from your local Radio Shack.

To interface this anemometer we will use a small 1-Wire board available from a company called Hobby Boards. You will be hearing more about Hobby Boards later in this article as well as throughout the series.

The Dual Counter shown in Figure 3 is a very small board that measures about 3/4" x 1". It has a small battery that will allow the onboard DS2423 to retain its counts for years.

Figure 3

Schematic 1 shows the basic hookup for connecting a reed to the counter. The cool thing about the onboard DS2423 is that it has built-in denounce so you don't have to worry about any additionally circuitry. Notice that we are only using 1/2 of the counter so later we can connect some other sensor like a rain gauge or another anemometer.



Features of the Home Made Anemometer

- This is the most sensitive anemometer out of the three. I ran several tests outside, and on very calm days this was the only anemometer turning. The cup assembly has the lowest mass so it takes much less air flow to get it moving and it also tended to track the variations in winds much better than the others.
- This device is very resistant to water damage due to its simple design.
- Since you are building the unit it will be very easy to repair or replace parts.
- This anemometer has the smallest footprint and weighs the least of all the anemometers so the weather pole used can be quite small.
- Not restricted to 1-Wire. You can use several interface options.

I ran tests up to 50 Mph with my car so this anemometer should holdup nicely under most weather conditions. This anemometer uses the following formula:

Mph = counts over 1.5 second time period * .88

Take a counter reading, wait 1.5 seconds, then take another. Subtract the first from the second and multiply by .88.

Home Made Anemometer Assembly

Before you proceed, please read through all the instructions. You will need the following tools to complete this project:

- Drill - This can be any kind of drill. You will also need 1/8" and 5/16" drill bits.
- Pliers - You will need these to tighten the lock nut.
- Screwdriver - You will need this to tighten the machine screw.
- Soldering Iron - This will be needed for connecting the wires to the reed sensor.
- #6-32 Tap - This is needed to tap a small piece of brass tubing. These can be purchased for a couple of dollars at your local home center.
- 2-Part Epoxy - Needed to attach a couple of the components
- PVC Glue - Needed for connecting various PVC pipe sections permanently.
- HackSaw - This is needed to cut the various lengths of PVC pipe.

Please note that you will most likely need all these tools for all three of the anemometers except for the #6-32 tap.

Step 1
Prepare the Anemometer Hub
Drill a 1/8" hole into the center of the Anemometer hub. There is already a small hole that will act as a guide (Figure 2). Once you have the hole drilled use a #6-32 tap and tap out the hole. As an option, you can drill a slightly larger hole and forgo the threading. Make sure you keep the drill straight as you drill.

Step 2
Prepare the PVC Cap
Drill a 5/16" hole into the center of a 1/2" PVC cap. I recommend you make the hold slightly off center about 1/16" of an inch or so. This will give you a bit more clearance when mounting the reed. You should not be able to press fit the 5/16" bearing into the hole. This is done by placing the cap upside down on top of the bearing and gently tapping the PVC cap. If the bearing does not have a tight fit, use some 2-part epoxy on the edges before inserting. Make sure you don't get epoxy on the center surface area of the bearing or it won't turn freely. The top of the bearing should be flush with the top of the PVC cap as shown in Figure 4.


Figure 4

Step 3
Tap a small bushing
Take a piece of 5/32 brass tubing and using the #6-32 tap add about 1/2 of threads to the end of the rod. The best way to do this is to add a few drops of machine oil. Make sure you tap a single thread, then back it out to clear the material. Once you have 1/2" of the brass tubing tapped cut it off. This will yield you a small 5/32 piece of threaded tubing.

Step 4
Create more bushings
Cut a 1/8" piece of 3/16 brass tubing and a 1/4" piece of brass tubing. Clean the edges so that they are free from burs. It is important that the cuts are straight or the Anemometer will wobble.

Step 5
Dry Fit the Assembly
- Place a #6 stainless steel washer onto a 1-1/4" #6 machine screw (#6/32) then insert the machine screw through the top of the hole you drilled into the anemometer hub.
- Thread the threaded bushing onto the machine screw that is protruding inside the anemometer hub.
- Now place the 1/4" bushing over the threaded bushing.
- Insert the 1/2" PVC cap with the bearing upside down over the bushing.
- Add the remaining 1/8" bushing and then the lock nut. Since this is a dry fit you may want to use a standard #6 hex nut to ease disassembly.

At this point you should be able to rotate the cap freely while holding the hub in your hand. As you rotate the PVC cap you will probably notice that it is not perfectly centered. Mark the point on the cap where it is the furthest from the inside of the Anemometer hub, i.e. the area with the most clearance.

Step 6
Attach the Magnets
Remove the PVC cap and bushings from the assembly. Leave the machine screw in place. About 3/8" down from the edge of the anemometer hub, attach one of the small Neodymium magnets with some two part epoxy. Mix only a small amount of epoxy since you can only mount one magnet at a time. Do not get any epoxy on the protruding machine screw. Once the epoxy has hardened place a second magnet on the opposite side of the hub in the same position. Use the protruding machine screw to help you line up the second magnet. Again, mix up some 2 part epoxy and glue in place. It is important that the magnet is not more than 3/16" thick or there won't be enough clearance for the reed that we will install later.

Step 7
Prepare the Reed
If you purchased a reed relay from Radio Shack you need to remove the glass sensor from the relay. This is a very simple process. Bend both of the contact leads so that they are in line with the relay. One of the contact leads will be protruding through an opening that is large enough for the glass element to pass through. Simply pull on this lead and the reed will separate from the relay. One end of the reed has a small plastic spacer. Leave this in place and bend that lead as shown in Figure 5B. With a couple pieces of 1/16" heat shrink solder two 24" lengths of wire to each lead as shown in Figure5C.

Step 8
Attach the Reed to the PVC Cap
Attach the reed to the cap as shown in Figure 6. It is important that the magnet passes over the spot indicated by the arrow. You can always change the lengths of the 3/16" bushings after the reed is in place. There is a great deal of leeway for the placement as the Neodymium magnets are very powerful. You can use a small twisted wire to hold the reed in place while the epoxy dries.

That's it for the mechanical assembly of the homemade anemometer. At the end of this article I will talk about the hookup and testing.

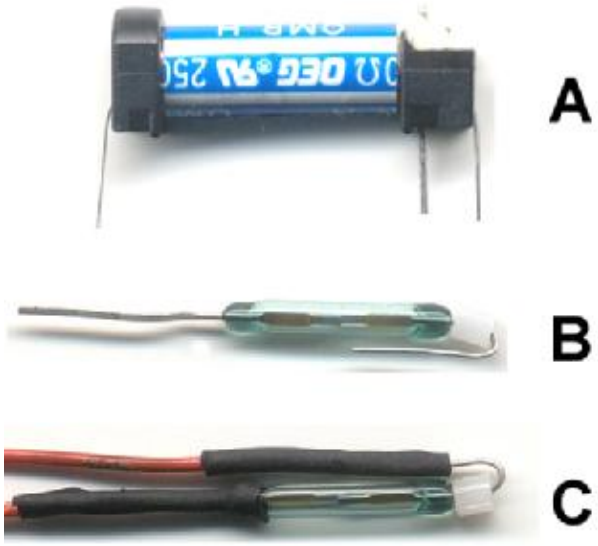


Figure 5

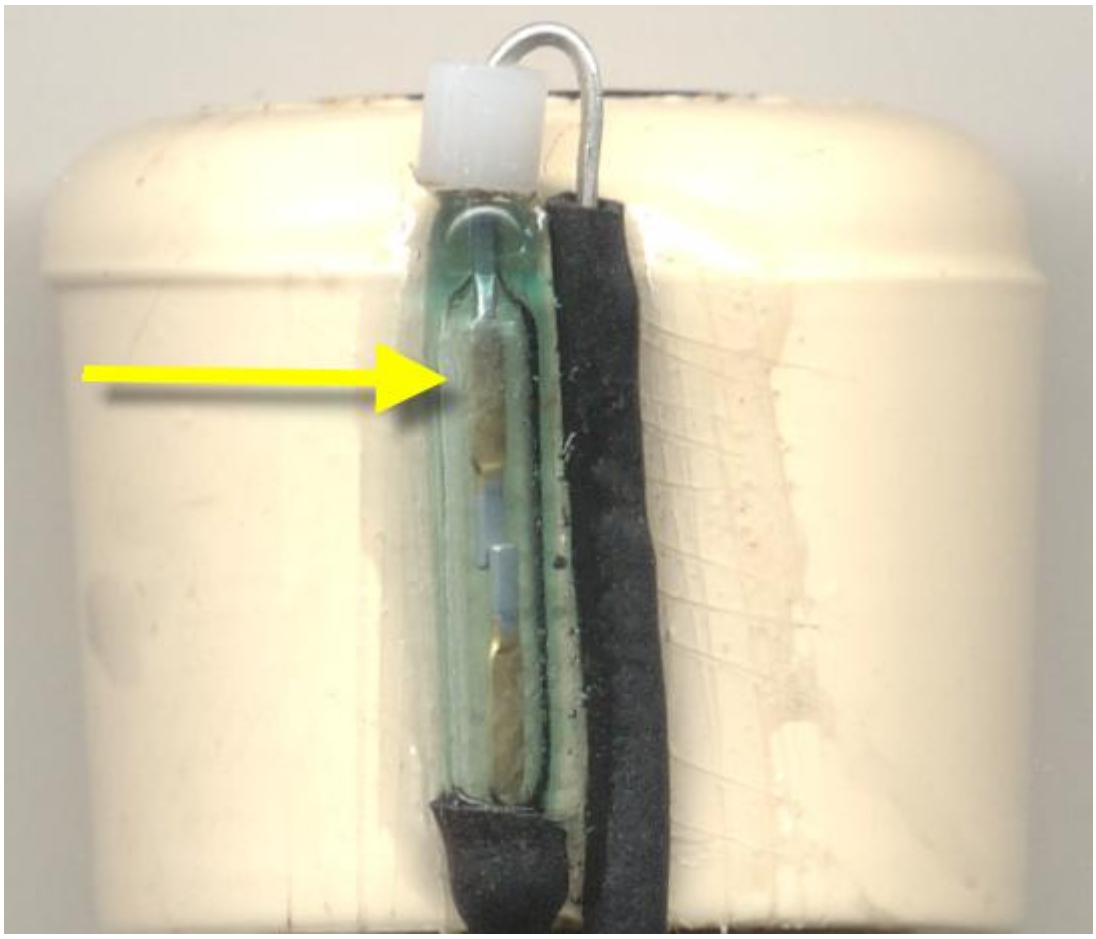


Figure 6

Anemometer Kit

Figure 7

For those of you who don't want to build an anemometer from the ground up your next option is to purchase a complete kit. A company called Fascinating Electronics sells the perfect anemometer kit to get your home weather station started.

The kit costs $49.90, and this is one nice kit. You get everything you need to build the anemometer. We will use the Hobby Boards counter board as before to interface to our PC. Of the three units this is the most rugged anemometer. It features real aluminum cups and the design makes for a really water tight system. Like our home made anemometer it comes with a reed that is triggered twice with each revolution. The hook up is identical as well: simply connect the anemometer reed to the counter as shown in schematic 1.

Features of the Complete Kit

- This device is very resistant to water damage due to its simple design.
- Of the three this is the most rugged design.
- Aluminum cups.
- This is the most professional looking device tested.
- It has a matching very heavy duty wind vane that can be purchased.
- Not restricted to 1-Wire. You can use several interface options.
- 1-1/2" PVC mounting gives you many options for mounting.

The only down side I have found with this anemometer is that since the hub assembly has so much mass it takes a bit more wind then the other two devices tested to get moving. Normally this will not be a problem as we are talking about 1mph, and at those low speeds it's a moot issue any way.

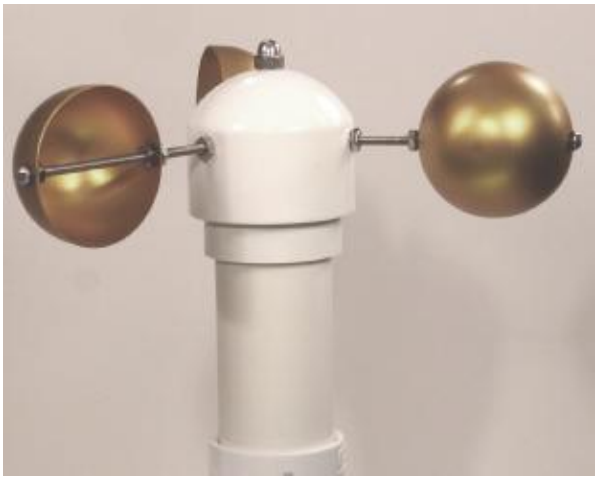


Figure 8

The assembly of this kit will take you 1-2 hours. The anemometer, once finished, mounts on 1-1/2" PCV pipe as shown in Figure 8.

Figure 9

Use a couple of 1-1/2" U-Bolts to attach a 1' section of PCV pipe to your weather pole and all you need to do is slip the anemometer on to the pipe as shown in Figure 9.

Fascinating Electronics sells a T Mount for mounting the anemometer as well as an electronic weather vane. This weather vane features a full 360 degree reading with no dead zones. We will be looking at this instrument in detail next month.

This anemometer uses the following formula:

Mph = counts over 1.67 second time period + 2

Take a counter reading, wait 167 seconds, then take another. Subtract the first from the second and add 2. The result will be the Mph.

Complete Wind Instrument

A while back Dallas offered a small weather instrument to demonstrate the use of their chips as sensors. This was a perfect solution for those wanting to build there own weather station. They no longer offer the device but a company called AAG Electroncica does. The unit that AAG offers is actually an improved version of the original.

Figure 10

Hobby Boards is a US distributor of the AAG unit. I prefer to work with them because the owner Eric Vickery has been very responsive. Hobby Boards also offers several other 1-Wire sensors, many of which we will be looking at in the upcoming articles in this series.

Features of the AAG instrument

- Very sensitive to wind speed and direction.
- Self contained unit contains three instruments; wind speed, wind direction and temperature.
- Simple 1-Wire interface. It is possible to install and use this device without soldering a single wire.

The AAG weather instrument comes partially assembled. You will need to open up the main housing in order to install the wind direction vane. This will take you 15-30 minutes. You will also need to coat all of the external seams with some sort of sealant to keep water from entering the instrument. The PCB inside the housing is coated for protection but the RJ12 connectors are not. I have had more than a few issues with water. Eventually I used a gutter sealant and that seemed to solve all my water issues. Once assembled, the anemometer cups are located at the top and the wind vane on the bottom as shown in Figure 10.

To mount this instrument you will need to purchase a U-Bolt. I use a 1-1/2" U-Bolt. This size will work for just about any diameter mast up to 1-1/2" in diameter.

Figure 11

You will need to drill two holes in the aluminum mounting rod that comes with the AAG instrument as shown in Figure 11.

You should download the assembly instructions for the instrument. They are outdated and refer to the older V2.0 unit, but contain most of the information you will need for the mechanical assembly.

The instrument uses three Dallas 1-Wire chips used to collect weather data. A DS2423 is used to collect wind speed data. A DS2450 is used to calculate wind direction data with a resolution of sixteen compass points. A DS18S20 is used for temperature measurements. The instrument can be made to operate off of 5v but is set by default to use 1-Wire parasite power. In parasite power mode you only need two wires connected to the unit to retrieve the data from any of the sensors. I will be going into more detail about the use of 1-Wire sensors as well as other alternatives next month.

The instrument works flawlessly, but I do have a few comments about the effectiveness of the various sensors. I run several temperature devices on my weather pole and have found that the AAG temperature tends to run 2-10 degrees hotter than the others when the sun is shining. This is due in part to the fact that the unit has no ventilation and that the housing is made of white plastic so it creates a small solar oven inside. For this reason I rarely use the AAG DS18s20 for temperature readings. The wind vane is ultra sensitive to wind and never seems to stop turning. A bit more surface area and more mass is needed to make the vane more stable.

The AAG anemometer uses the following formula:

Mph = counts over 1.5 second time period * .68

Take a counter reading, wait 1.5 seconds, then take another. Subtract the first from the second. Multiply the difference by .68

There are several ways of interfacing to the various sensors needed to build a weather station; the three most common are:

- PC to 1-Wire interface
- PC to microcontroller interface.
- Microcontroller to 1-Wire/Other

Figure 12

Each has its advantages and as the series progresses we will go into each type of system in detail. For this article I will keep things simple and will be concentrating only on the PC to 1-Wire interface.

So far most of what I have gone over relates to the mechanical construction or make up of each unit. It is now time for us to hookup each unit and do some tests. In order to simplify things in this article I chose to use a 1-Wire network for each of the three devices. This makes the actual software needed for each of the three nearly identical.

In order to connect 1-Wire devices to your PC you will need a 1-Wire to serial adapter. This is a DS9097U shown in Figure 12. They can be picked up for under $30 and will allow your PC to connect to any 1-Wire device. I have added direct support for this adapter to Zeus. You will not need any drivers or runtimes to support it. All the test applications written for this article require this adapter and will not work with any others.

The AAG unit has two RJ12 connectors with only four of the six pins wired in each. One of these connectors will have a small jumper installed. For now leave the jumper in place. An 8' coiled RJ11 cable was also included with the AAG. Plug one end of this cable into the remaining RJ12 connectors and plug the other end into the DS9097 adapter. This is all you need to do to start testing the AAG unit.

Important
The cable that comes with the AAG instrument is not the same as a standard telephone line cable. If you wish to use a normal telephone line cable you will need an adapter. One way to do it is to use a line cable link and two line cables as shown in Figure 13. This will effectively allow you to connect two line cables thus double reversing the two center pins on the connectors.

Figure 13

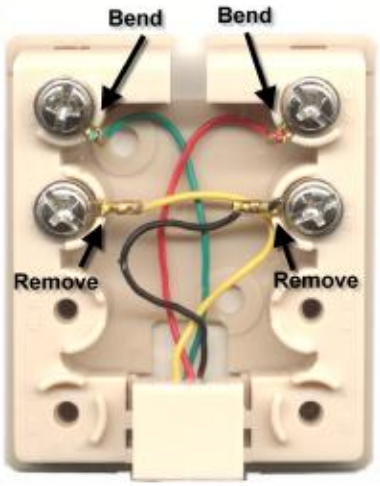


Figure 14

The other two anemometers require a little more prep. As you recall we are using a 1-Wire Dual counter available from Hobby Boards as our interface.

In order to facilitate a connection to the PC we will use a RJ11 Surface mount box available from most home centers. We are going to place the dual counter inside this box so make sure you get a standard sized box, not one of the small ones. In order to prep the box you need to remove the yellow and black wires. The green and red wires will need to be bent as shown in Figure 14.

Cut a small length of wire, about one inch will do, and connect it to the box's green lug and then to the DQ terminal on the counter board. Cut another piece of wire and attach the red lug to the Gnd terminal on the counter board. You can now connect the anemometer reed leads to the 5v and A terminals as shown in Figure 15.

You can now use a standard telephone line cable to connect the surface mount box to the DS9097 and you are ready to test.

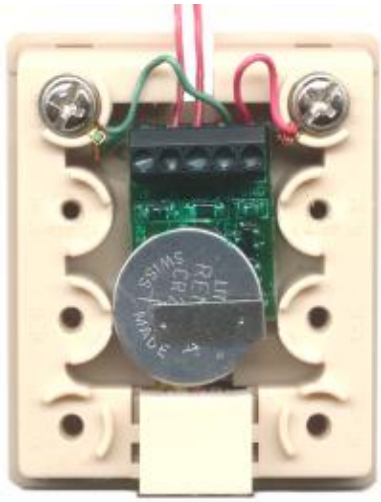


Figure 15

Testing

I have included a couple of programs for testing the anemometers. The first program called WindSpeed2 (shown in Figure 16) will allow you to test each of the anemometers presented in this article.

The first thing you will need to do is to set the com port that you have connected to the DS9097 adapter. Use the Com Port option in the Settings menu. Next you will need to set the unique ROM registration number for the DS2423 connected to your anemometer. To do this you select the Search ROMs option in the Settings menu. The program will display all the ROM registration numbers for each Dallas device on the 1-Wire network. If no devices are displayed you are not properly connected to the network. You will have to go back and check your connections as well as your com settings. Once you have valid devices displayed select the eight hex ROM numbers associated with the DS2423 and hit the SetRom button.

The program will begin collecting data from the DS2423 sensor and displaying the result via the gauge. Be sure to set the appropriate calibration factor for the particular anemometer you are using.

The WindSpeed program is unique in the fact that it constantly monitors the wind speed sensor and updates the various indicators by looking at the amount of time that has passed as it averages the various long-term and short-term readings. This allows instantaneous displays of readings down to .1mph

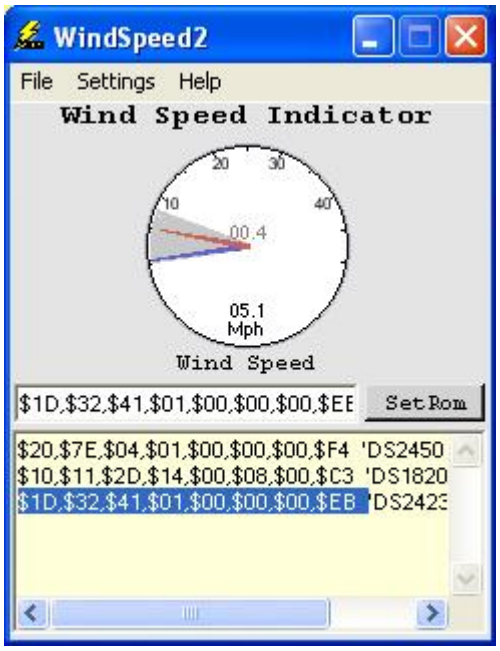


Figure 16

Going Further

I have included a complete mini AAG weather station that monitors and displays all three sensors from an AAG instrument shown in Figure 17. The download for these applications can be found on the Kronos Robotics Web site at:

http://www.kronosrobotics.com/Projects/catchwind.shtml

Also available and included at the site is the source code and Pocket PC versions of the software.

Zeus has a complete low level 1-Wire library using the DS9097 adapter. There are also several high level libraries for interfacing to various sensors directly. I have also included some simple console based programs to demonstrate this interface.

Next month I will delve into the 1-Wire interface in more detail. We will look at additional environmental sensors as well.

I have created a forum devoted to building weather stations and home automation. I will be posting additional projects as well as update notices:

http://www.kronosrobotics.com/forums/

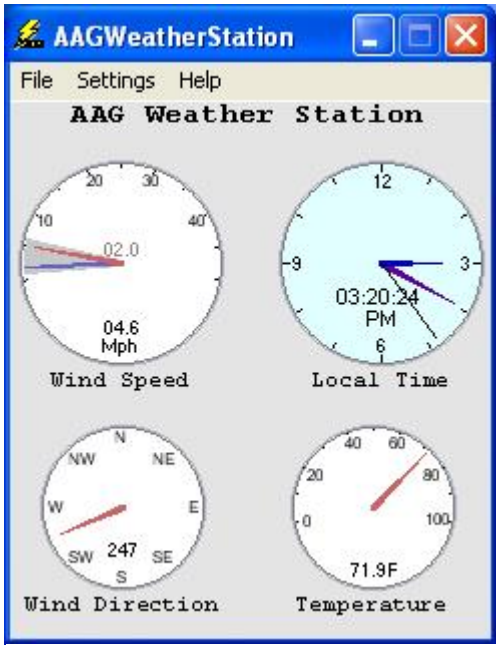


Figure 17

Parts

Home Made Anemometer Parts

Anemometer Cub and Hub Assembly
http://www.forcefieldmagnets.com/catalog/product_info.php?products_id=31

2 Neodymium magnets
http://www.forcefieldmagnets.com/catalog/product_info.php?cPath=23_37&products_id=37

Bearings (Team Associated # 6589)
http://www2.towerhobbies.com/cgi-bin/wti0001p?&I=LX2881&P=7

Radio Shack
Reed Relay #275-232

Home Center
1/2" PVC Cap
1/2" PCV Tubing
#4 1-1/4" Stainless Steel Machine Screw
#4 Stainless Steel Washer
#4 Lock Nut
#5 Hex Nut
5/32" Brass Tube
3/16" Brass Tube

Other Parts

Hobby Boards

Dual Counter - (DC2.5-R1-A)
http://www.hobby-boards.com/catalog/product_info.php?cPath=22&products_id=42&osCsid=604c964735bac8f6ef94a96eb892fb02

AAG Weather Instrument - (WIND-R3-A)
http://www.hobby-boards.com/catalog/product_info.php?cPath=22&products_id=92&osCsid=604c964735bac8f6ef94a96eb892fb02

AAG Weather Instrument Assembly Instructions
http://www.hobby-boards.com/catalog/links/wind-r3/Assembly%20Instructions.pdf

1-Wire to Serial Adapter (DS9097U-A)
http://www.hobby-boards.com/catalog/product_info.php?cPath=23&products_id=28

AAG Electronica

AAG Weather Instrument - (TAI8515)
http://www.aagelectronica.com/aag/en-us/dept_1.html

1-Wire to Serial Adapter (DS9097U)
http://www.aagelectronica.com/aag/en-us/dept_6.html

Fascinating Electronics

Standard Anemometer Kit (WEA-ANKIT-A)

http://www.fascinatingelectronics.com/weatherinst.html

Home Center

RJ11 Surface Mount Box
I used a GE TL26101
Can be purchased from most home centers.

Links

Hobby Boards
http://www.hobby-boards.com

Fascinating Electronics
http://www.fascinatingelectronics.com/index.html

Kronos Robotics
http://www.kronosrobotics.com/xcart/customer/home.php

KRMicros
http://www.krmicros.com/Development/ZeusPro/ZeusPro.htm

AAG Electronica
http://www.aagelectronica.com/aag/