

Whether the weather be wet...

“One of the things Ford Prefect had always found hardest to understand about human beings was their habit of continually stating and repeating the obvious, as in It's a nice day, or You're very tall, or Oh dear you seem to have fallen down a thirty-foot well, are you alright? At first Ford had formed a theory to account for this strange behaviour. If human beings don't keep exercising their lips, he thought, their mouths probably seize up. After a few months' consideration and observation he abandoned this theory in favour of a new one. If they don't keep on exercising their lips, he thought, their brains start working. After a while he abandoned this one as well as being obstructively cynical and decided he quite liked human beings after all, but he always remained desperately worried about the terrible number of things they didn't know about.” – Douglas Adams (1979), *The Hitchhiker's Guide to the Galaxy*

Whether the weather be wet
Or whether the weather be fine
We weather the weather
Whatever the weather
Whether we like it or not!

Anonymous

(I'm Andrew Trotman)

Christmas 2013

DIGITECH

USB Wireless Weather Station w/ Solar Powered Sensors & Touch Screen



The weather station's LCD screen displays the following information:

- TEMP: 22.3°
- HUMIDITY: 43%
- DAY TEMP: 23.4°
- NIGHT TEMP: 37°
- WIND: 15.8 mph
- RAIN: 345 mm
- PRESSURE: 1009.9 hPa
- PRESSURE HISTORY: A bar graph showing pressure trends over the last 24 hours.
- TIME: 12:38
- DATE: L 1.07
- WEATHER: A sun behind a cloud icon.

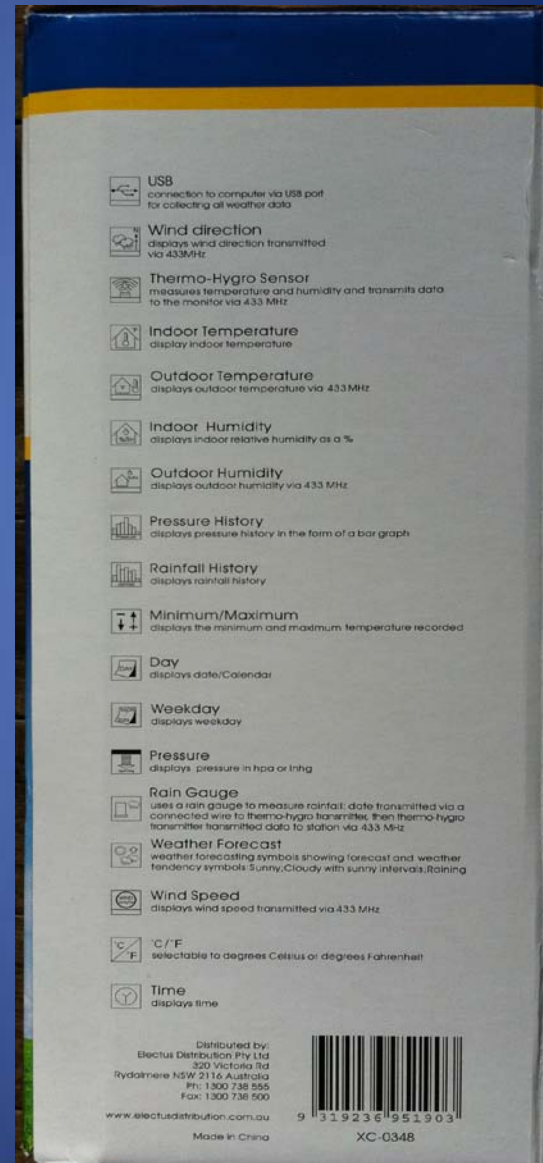
DIGITECH

- Solar powered sensors
- Touch screen LCD panel
- Wind speed, direction and chill
- 50m transmission range
- USB interface
- Easy weather software included

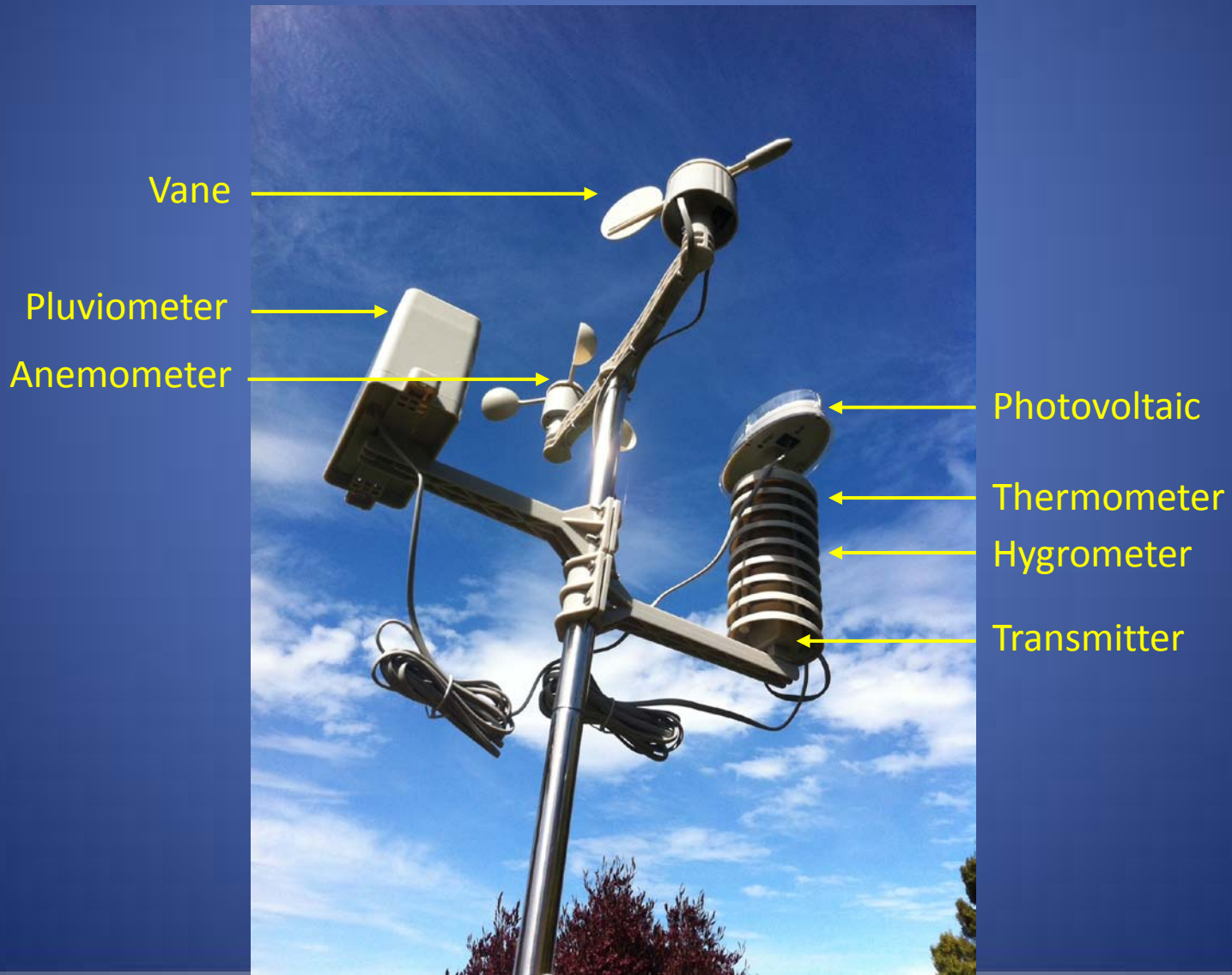


USB Wireless Weather Station

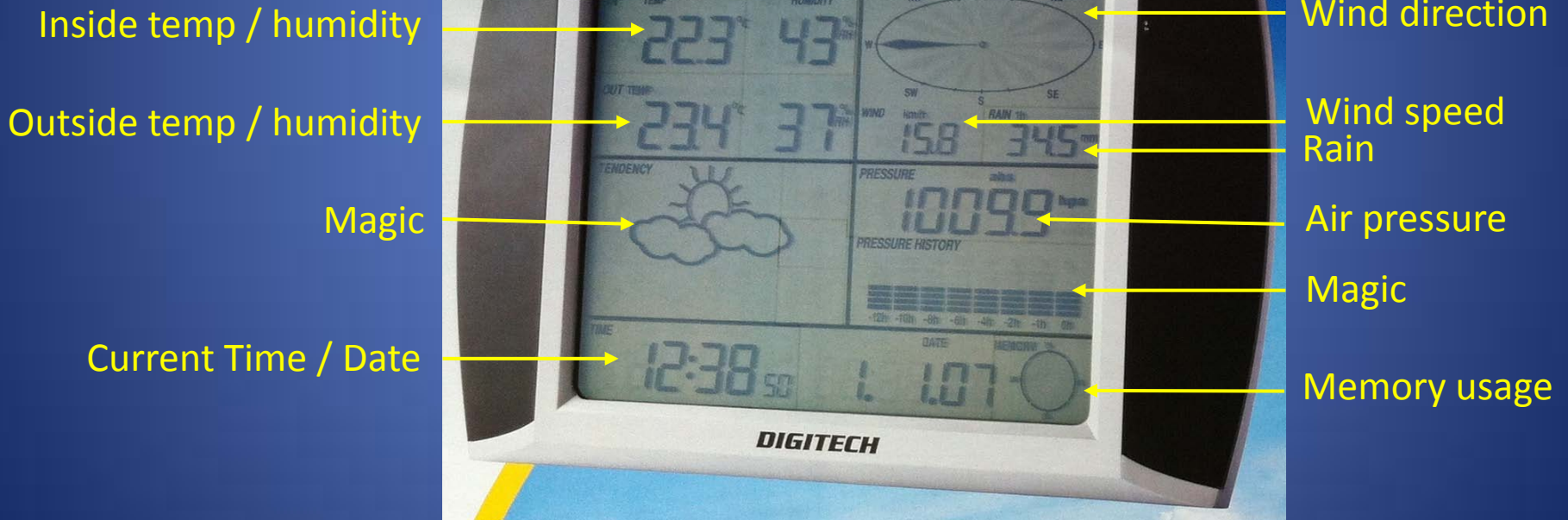
- Temperature
- Humidity
- Cumulative rainfall
- Wind speed
- Wind direction
- Absolute air pressure



Remote Sensor



Base Unit



Thermometer



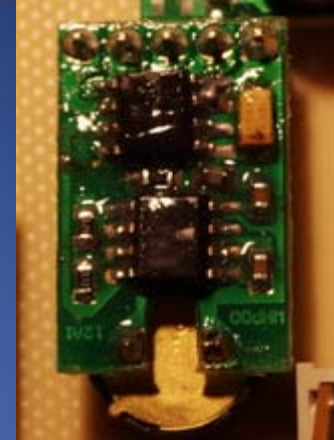
<http://en.wikipedia.org/wiki/Thermistor>

- Thermistor
- The relationship between resistance and temperature is (1st order) linear
- $\Delta R = k \Delta T$
- k = temperature coefficient of resistance
 - If we know R at a given temperature, and we know k then we can solve for T .
- The weather station is accurate to 0.1°C For more accuracy (0.02° over 200°C range) the Steinhart–Hart equation is used:

$$1/T = A + B \ln(R) + C(\ln(R))^3$$

Hygrometer

- Probably a capacitive humistor
 - The dielectric plate of a capacitor is made from a material that absorbs moisture and releases it into the capacitor thus changing its capacitive behavior
 - To measure humidity, measure the capacitance of the device
 - Modern versions come on a chip that does all the hard work



<http://sandaysoft.com/forum/viewtopic.php?f=4&p=5391>

Pluviometer

- Simple bucket-tipping seesaw mechanism. Each 0.2794 mm of rain causes a tip.
- Each “tip” sends a magnet past a reed switch
- A microcontroller counts “ticks”



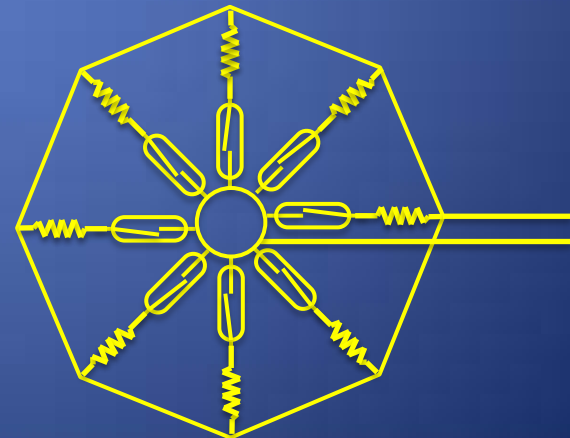
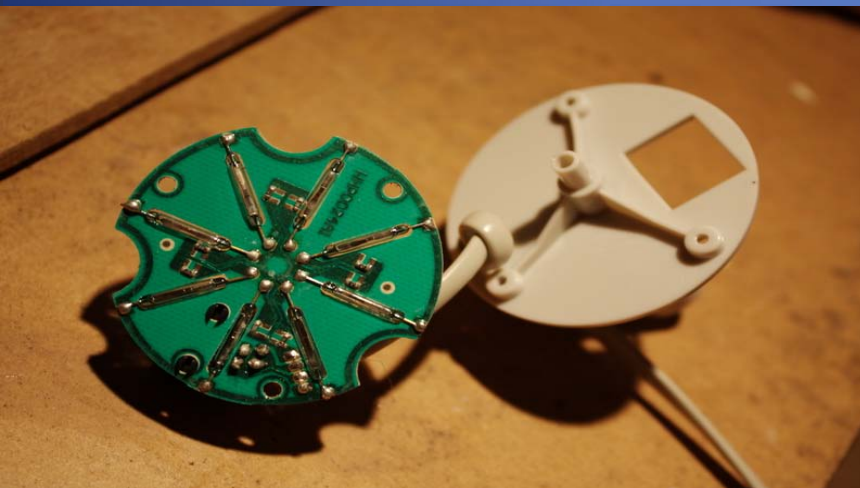
Anemometer

- As the cups rotate a magnet passes a reed switch and creates a pulse. A microcontroller counts pulses per second. This board (apparently) pulses twice per rotation.



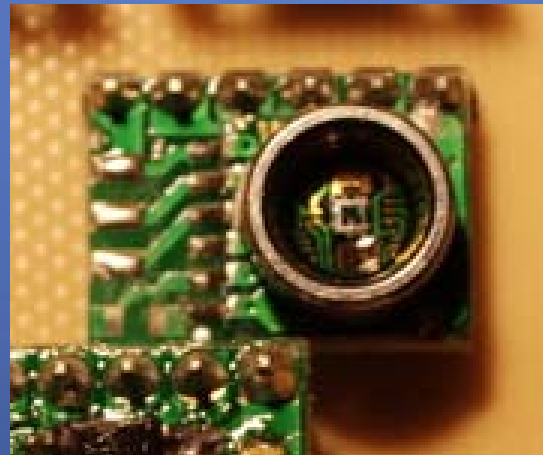
Vane

- Digital to analog converter
- Reed switches arranged in an octagon
 - The magnet is on the “pointer”
- When the wind blows at most two switches close
- Each switch is connected to a different ohm resister
- Measure the voltage drop of the circuit to get direction



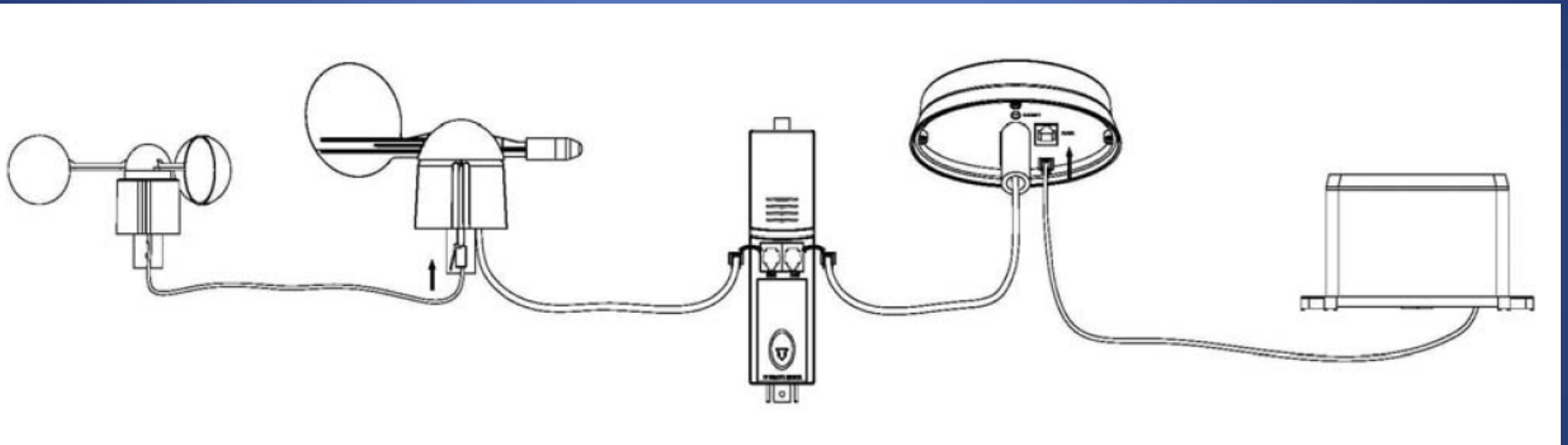
Barometer

- Located in the base station
- Piezoresistive
 - As the pressure changes the resistivity changes



<http://sundaysoft.com/forum/viewtopic.php?f=4&p=5391>

Wire It Up



XC0348 Instruction Manual - TOUCH SCREEN WEATHER STATION WITH SOLAR TRANSMITTER Operation Manual
(http://www.jaycar.co.nz/products_uploaded/XC0348%20Instruction%20Manual.pdf)

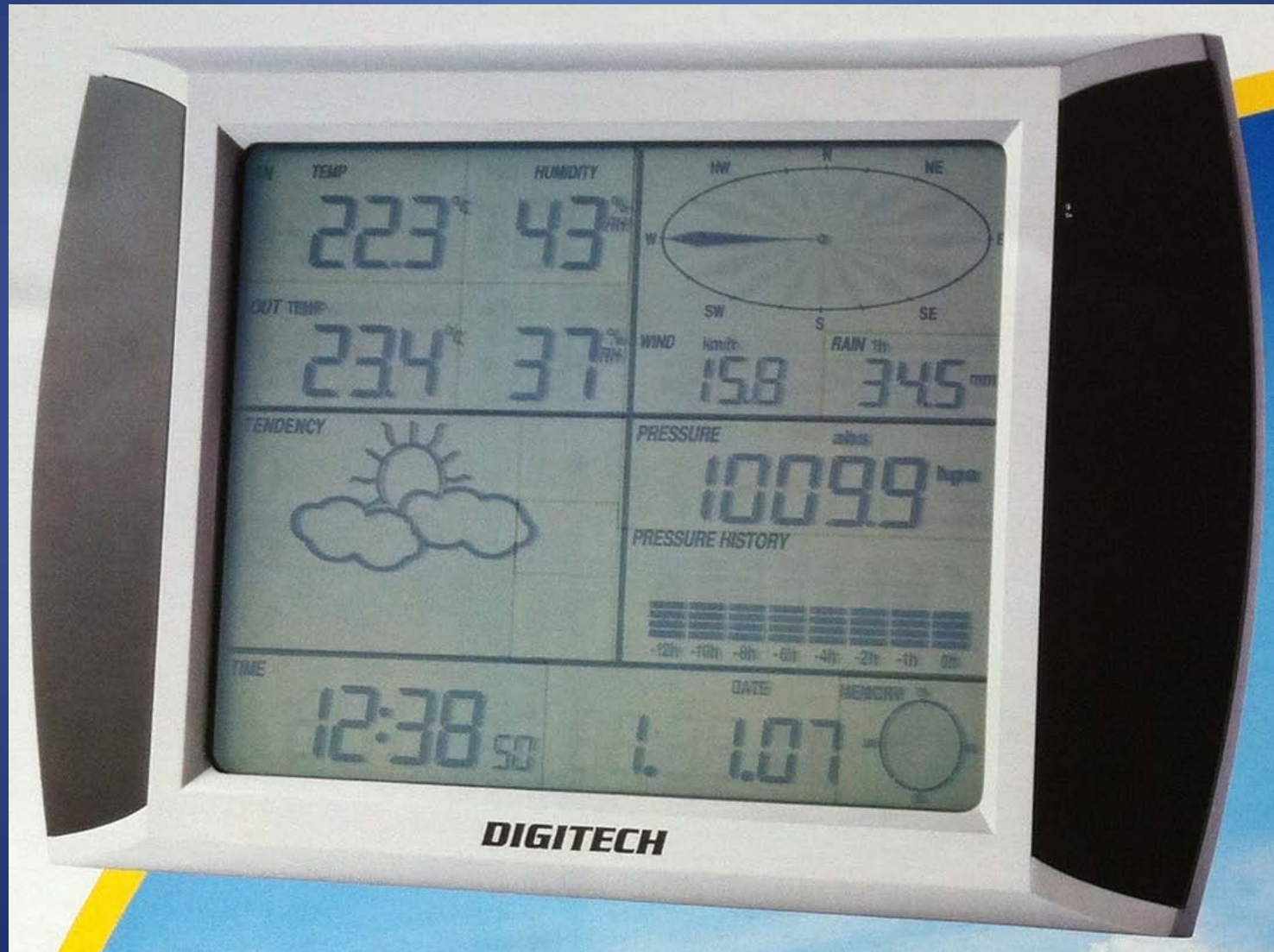
Screw It Up



Wireless Protocol

- 10 byte packet sent every 48 seconds at 433 MHz
 - Device identifier
 - Temperature
 - Humidity
 - Average wind speed
 - Gust wind speed
 - Rainfall counter
 - Battery indicator
 - Wind direction
 - Checksum

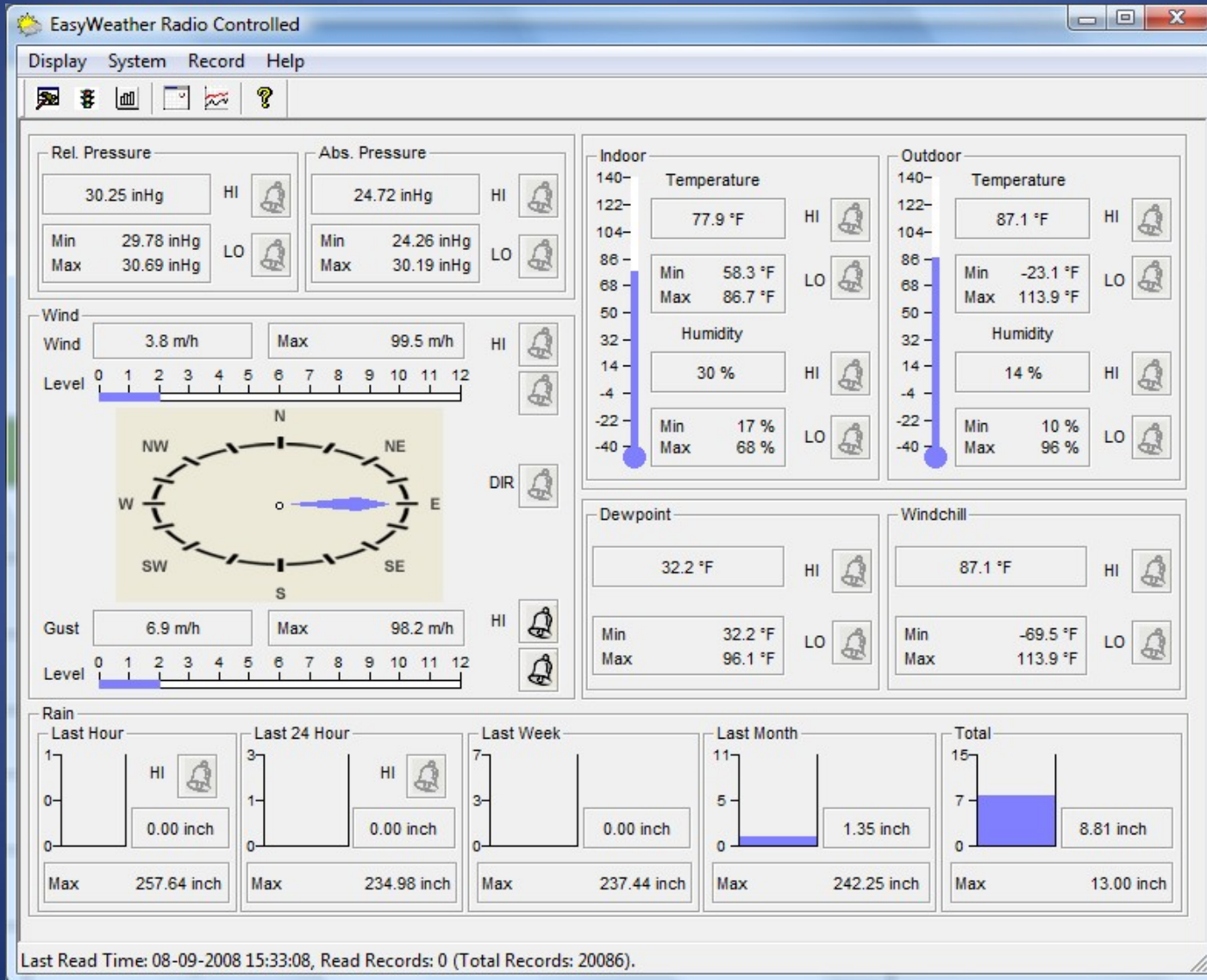
Base Station



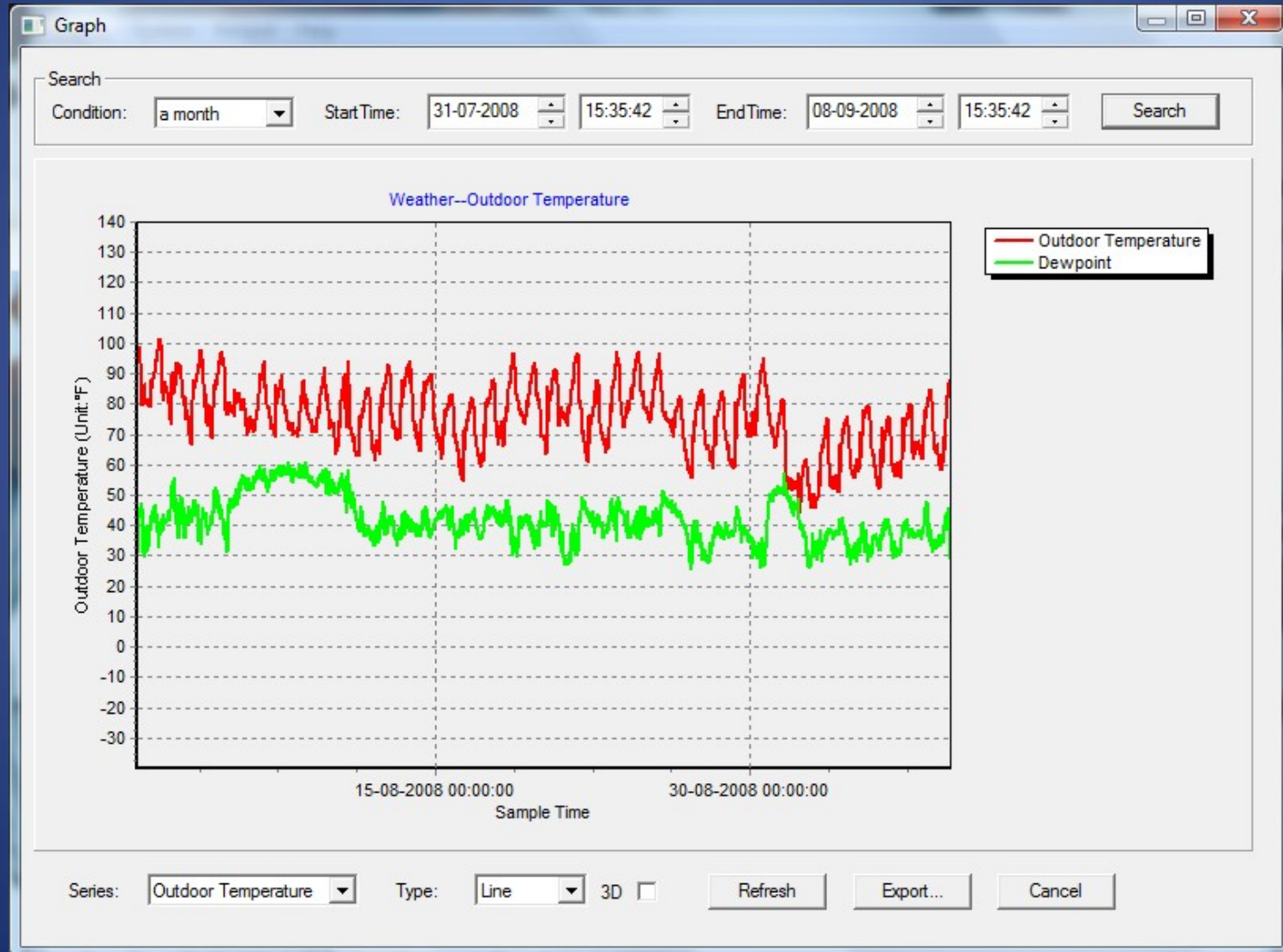
USB Wireless Weather Station

- The base station can be connected to a PC
 - Via USB
- Software provided on CD-ROM

EasyWeather



EasyWeather



What I Want (Requirements)

- The weather without leaving bed
 - Weather on my phone
 - HTML output (weather in your browser)
- Not “24 hour high”
 - Preferred “today vs. yesterday”
 - Is it warmer today than yesterday?
 - How much rain did we have today?
 - Is the barometric pressure going up or down?
- Human readable interpretations
- Short-term weather forecasting
 - Do I need a coat today

Hacking the USB Protocol

- USB HID device
 - Plug it in to a USB port
 - lsusb
 - “WH1080 Weather Station / USB Missile Launcher”
- Luckily others had already hacked the protocol
 - It's a Fine Offset WH1080 (in a DIGITECH box)
 - <http://code.google.com/p/weatherpoller/wiki/USBProtocol>
 - <http://www.jim-easterbrook.me.uk/weather/mm/>

i.MX6Q

- Our i.MX6Q board is also USB HID
 - We have some experience with HID
- Open a connection
- Sent a “report request”
- Receive a “report”

WH1080 USB HID Protocol

- Send 8 bytes (1 x USB 1.0 packet)
 - The device has 64KB “RAM”

| Byte | Value | Meaning |
|------|--------|----------------------|
| 0 | 0xA1 | READ |
| 1 | AddrHi | High byte of address |
| 2 | AddrLo | Low byte of address |
| 3 | 0x20 | End of message |
| 4 | 0xA1 | READ |
| 5 | AddrHi | High byte of address |
| 6 | AddrLo | Low byte of address |
| 7 | 0x20 | End of message |

WH1080 USB HID Protocol

- Device responds with 32-bytes

| Byte | Meaning |
|-------|--|
| 0 | Minutes since previously stored reading |
| 1 | Base station humidity (%) |
| 2-3 | Base station temperature ($x * 0.1 = ^\circ\text{C}$) |
| 4 | Remote sensor humidity (%) |
| 5-6 | Remote sensor temperature ($x * 0.1 = ^\circ\text{C}$) |
| 7-8 | Absolute pressure ($x/10 = \text{hPa}$) |
| 9 | Average wind speed (low byte) ($x * 0.1 = \text{m/s}$) |
| 10 | Gust wind speed (log byte) ($x * 0.1 = \text{m/s}$) |
| 11 | Wind speed high byte (top nybble=gust, bottom nybble = average) |
| 12 | Wind direction ($x * 22.5 = \text{angle } ^\circ \text{ from north}$) |
| 13-14 | Rain bucket "fullness" ($x * 0.3 = \text{mm}$) |
| 15 | Status (bit 7 = bucket overflow, bit6 = can't reach remote sensors) |

WH1080 USB HID Protocol

- First 256 bytes of memory are “special” and include
 - Device unique ID
 - Sample rate (minutes between stored readings)
 - Number of stored readings
 - Address of current reading
 - A load of max, min, display, and alarm settings
- Can store 4080 readings in 64KB
 - 85 days at one reading every 30 minutes
 - There is a USD HID write report to reset stuff (see references)

Hack Time (Exploration)

- Web cgi/bin app
 - On my Windows laptop talking HTML to my phone
 - Temperature, humidity, average wind speed, gust wind speed, wind angle, rainfall, absolute pressure
 - Hourly rainfall: get three readings and subtract the first from the third (similarly for 24 hour)
 - Wind direction: divide by 22.5 and table lookup to get the direction name
- What else...

Wind Strength (Beaufort Scale)

- Invented in 1805 by Rear Admiral Sir Francis Beaufort and first used on HMS Beagle
- 13 point scale (0..12)
 - Qualitative wind conditions to effects on sails, from “just sufficient to give steerage” to “that which no canvas sails could withstand”
- 1946
 - $V = 0.836 \times B^{3/2} \text{ m/s}$
- This is where “force 10 winds” comes from
 - Calm, Light air, Light breeze, Gentle breeze, Moderate breeze, Fresh breeze, Strong breeze, Moderate gale, Gale, Strong gale, Storm, Violent storm, Hurricane
 - For Hurricanes use the Saffir–Simpson wind scale

Apparent Temperature

- Wind chill
 - When $T < 10^{\circ}\text{C}$ and $V > 4.8 \text{ km/h}$
 - Developed by the Joint Action Group for Temperature Indices (JAG/TI)
 - In use in US, UK, Canada from 2001
 - Computed from model of skin heat transfer assuming bare face, facing the wind, and walking at 5 km/h

$$T_a = 13.12 + 0.6215T - 11.37V^{0.16} + 0.3965TV^{0.16}$$

- Somewhat controversial

Apparent Temperature

- Heat index
 - Steadman, R. G., 1979 *J. Appl. Meteor.*, **18**, 861–885.
 - When humidity is high perspiration is less effective
 - So It feels hotter
 - When $T > 27^{\circ}\text{C}$, $H > 40\%$, DewPoint $> 12^{\circ}\text{C}$
 - Compute from a model including 20 parameters such as skin, clothing, temperature, humidity, activity, etc.
 - Assuming suitably dressed, in shade, no wind, etc

$$T_a = c_1 + c_2T + c_3R + c_4TR + c_5T^2 + c_6R^2 + c_7T^2R + c_8TR^2 + c_9T^2R^2$$

Dew Point

- “The dew point is the temperature at which the water vapor in air at constant barometric pressure condenses into liquid water at the same rate at which it evaporates” (Dew point (visited 2014) Wikipedia)
- In other words, if the temperature gets lower than the dew point water condenses and we get dew or frost

Weather Forecasting

- Negretti & Zambra (1915) Zambretti Forcaster
 - 3 disk system using
 - Wind direction
 - Sea level adjusted barometric pressure
 - Barometric direction (rising, falling, steady)
 - Season (summer / winter)
 - Adjusted (by others) to include:
 - Earth Hemisphere
 - Direction of equator (warmer wind)



Zambretti Forecasts

- Settled fine
- Fine weather
- Becoming fine
- Fine becoming less settled
- Fine, poss showers
- Fairly fine, improving
- Fairly fine, poss showers early
- Fairly fine, showery later
- Showery early, improving
- Changeable, mending
- Fairly fine, showers likely
- Rather unsettled clearing later
- Unsettled, prob improving
- Showery, bright intervals
- Showery, becoming more unsettled
- Changeable, some rain
- Unsettled, short fine intervals
- Unsettled, rain later
- Unsettled, rain at times
- Very unsettled, finer at times
- Rain at times, worse later
- Rain at times, becoming v. unsettled
- Rain at frequent intervals
- Very unsettled, rain
- Stormy, poss improving
- Stormy, much rain

What else?

- Sunrise / Sunset
 - Planety (*sic.*) of Open Source solutions
 - But you need to know your longitude and latitude
 - Which I do know (coz my phone told me)
- Moon phase
 - If you know it on some given day all you need to do is know the number of days since then and the periodicity of the moon
 - <http://www.ben-daglish.net/moon.shtml>



Apple Web App (iPhone / iPad)

- Supply an icon

```
<link rel="apple-touch-icon" href="/custom_icon.png">
```

- Supply a start up image

```
<link rel="apple-touch-startup-image" href="/startup.png">
```

- Go full screen

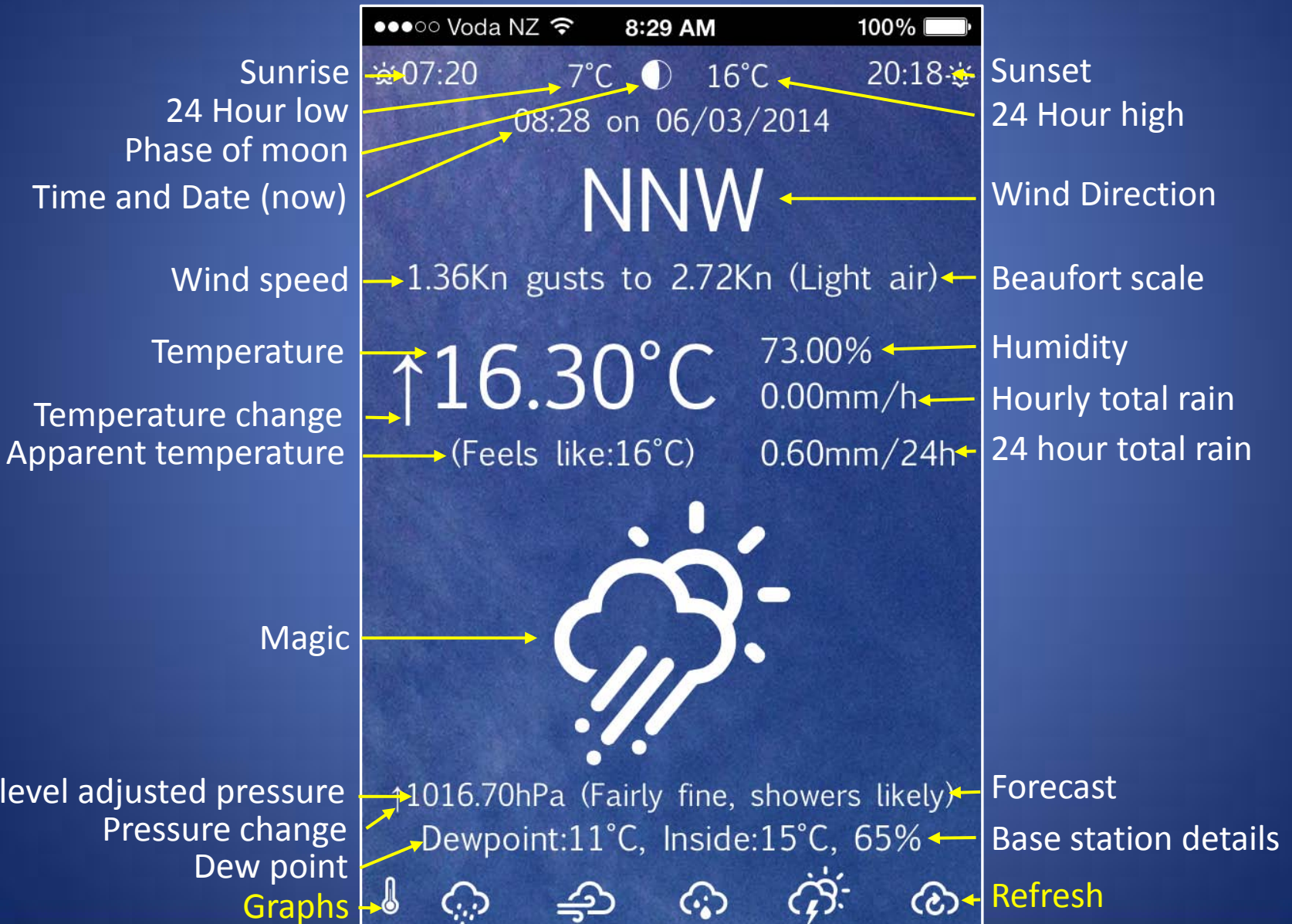
```
<meta name="apple-mobile-web-app-capable" content="yes">
```

- Configure status bar

```
<meta name="apple-mobile-web-app-status-bar-style"
      content="black">
```

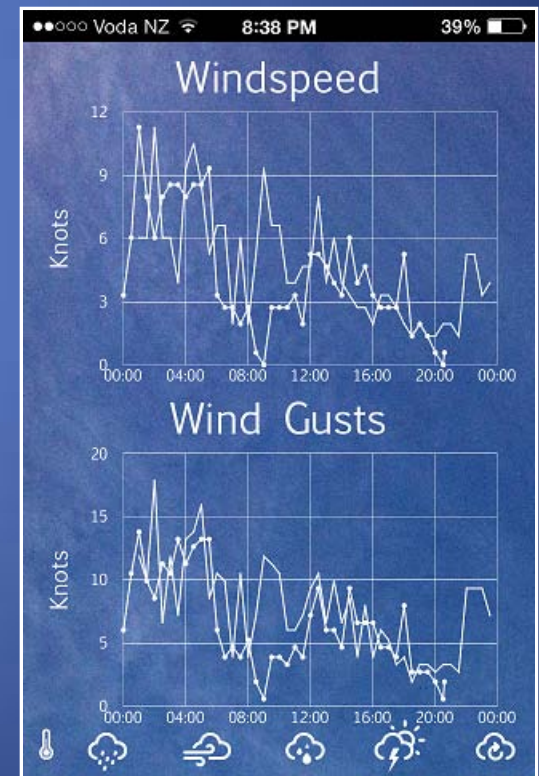
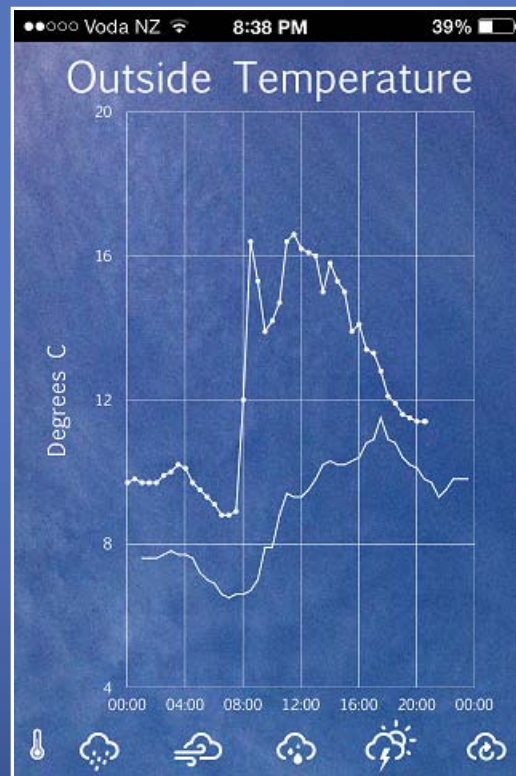
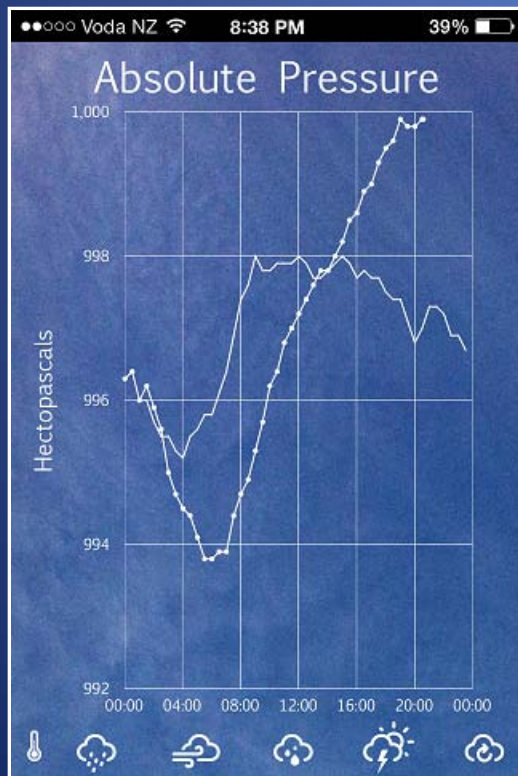
- Oh, and work out how to fix the catastrophic hang!
 - Which turns out to be a serious iOS bug

Web App



Web App

- Uses Google Charts API for web graphs



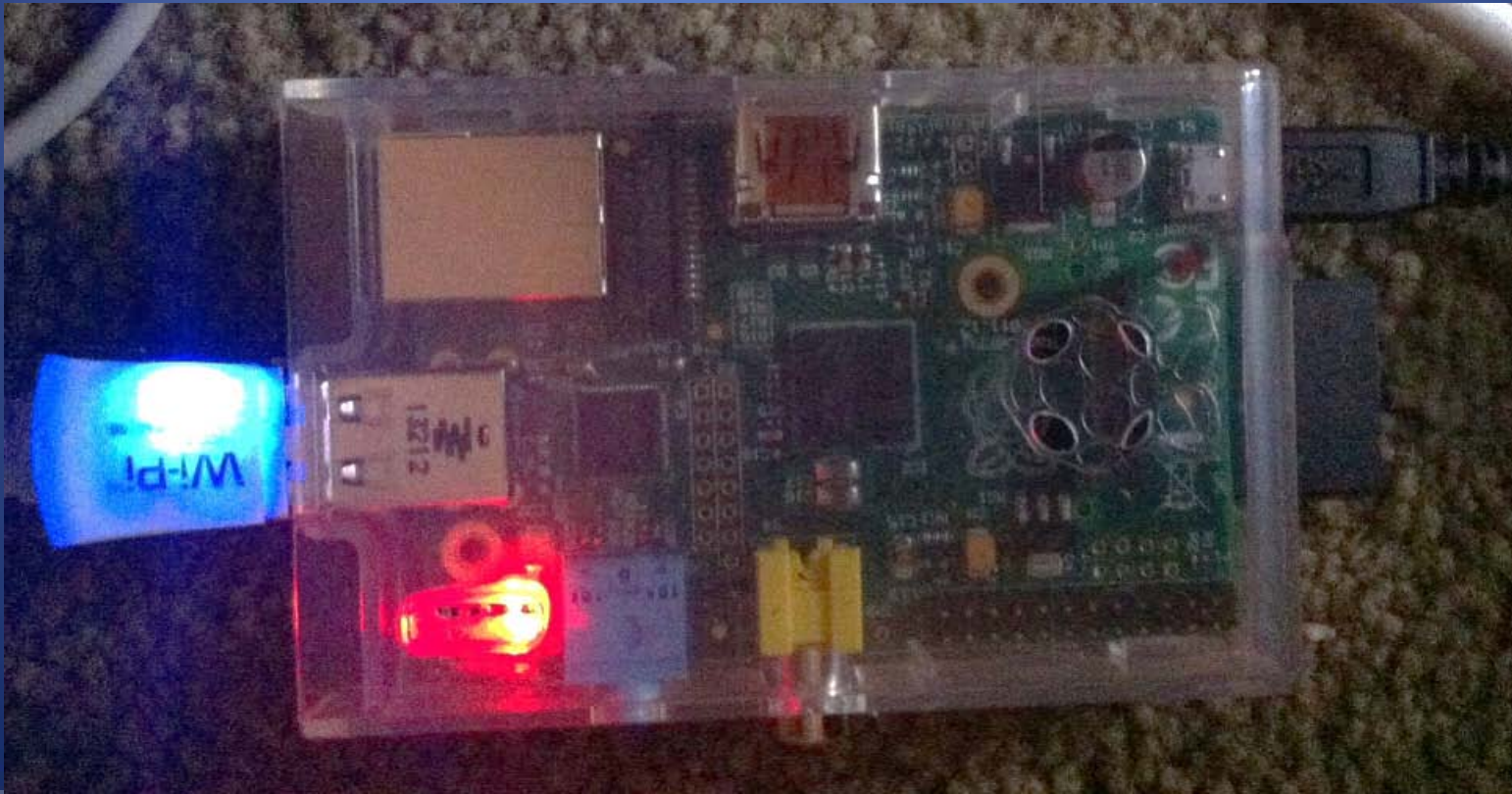
Celebration

- It works! Now to celebrate...



Raspberry Pi

- Port to Linux
 - Raspbian, Apache, gcc



Access From Anywhere

- Digging holes
 - Router's firewall
 - ADSL modem's firewall
- IP address
 - noip.com
 - Provide domain names
 - Provide dynamic-DNS service
 - If your modem changes its IP address (e.g. a re-connect) it automatically contacts the dDNS host and notifies it of the change
 - Free service
 - But you must fill in a captcha every month to keep your domain name

Conclusions

“One of the things Ford Prefect had always found hardest to understand about human beings was their habit of continually stating and repeating the obvious, as in It's a nice day”

- We talked about the weather

“If human beings don't keep exercising their lips, he thought, their mouths probably seize up.”

- So ask me some questions

“he always remained desperately worried about the terrible number of things they didn't know about.”

- Ask about the new stuff you now know about