

By Clarke Bowers



ABOUT THE PRESENTER

- Clarke D. Bowers
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- mailto: clarke@cbsoftwareengineering.com
- 35 years of industry experience
- He has architected and developed embedded systems, desktop applications, enterprise data warehouses, web sites and web services; cloud bases and locally hosted solutions
- He holds six patents



You can find this presentation and all the examples at:

https://ldrv.ms/f/s!Ar3pO7 Gh
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AGENDA



Talk

- Raspberry Pi hardware overview
- Raspbian Linux
- Windows 10 Core
- Others operating systems
- Installation, boot and shutdown
- Demonstration
 - Bobble head Santa
 - 3D Compass

Lab 1

- Eclipse IDE Python & C++
- I²C Libraries
- Code examples of
 - Barometer
 - Magnetometer

Lab 2

- Visual Studio C# & .NET framework
- O GPIO & Interrupts
- Cross platform development
- O Code examples of
 - O Magnetometer
 - O Accelerometer







March 21



HARDWARE COMPARISON



Panasonic CF-Cl Laptop

- **2018**
- Broadcom BCM2837B0, ARMv8 1.4GHz, 4-core 64-bit
- No GPU
- 1GB of RAM
- Micro SD slot (no storage included)
- No display
- 4 x USB 2.0
- Full-size HDMI
- Gigabit Ethernet, 802.11.b/g/n/ac Wi-Fi, Bluetooth 4.2
- 40 pin GPIO
- Not included: power supply, batteries, power switch, keyboard, mouse, heat sinks, case
- **\$35**

- **2010**
- Intel Core i5 M520 2.4GHz, 2-core 64-bit
- Integrated 500 MHz GPU
- 2GB of RAM
- 250GB hard drive
- 12.1-inch 1280x800-pixel multi-touch-capable display
- 3 x USB 2.0
- DB15 VGA
- Gigabit Ethernet, 802.11n Wi-Fi, Bluetooth 2.1
- RJ11 Dialup Modem
- Included: power supply, batteries, power switch, keyboard, trackpad, fan
- **\$2,000**



IOT APPLICATION #1: TIDAL PROBE

- Mount Raspberry Pi, GPS, sensors and batteries on buoy
- Measure location, linear acceleration, angular acceleration, temperature and barometric pressure
- Transmit to cloud via G5 cellular



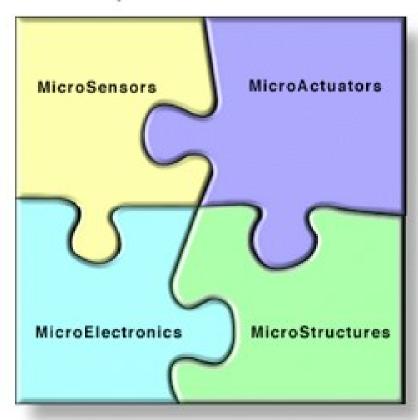
Application for harbor pilots. It tracks the cargo ships location and pulls latest buoy data from cloud for nearby buoys. Displays on map the microclimate marine conditions.



MEMS

- Micro-Electro-Mechanical Systems, or MEMS, is miniaturized mechanical and electro-mechanical elements that are made using the techniques of microfabrication.
- The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters.
- The types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics.
- At least some elements having some sort of mechanical functionality whether or not these elements can move.

Components of MEMS



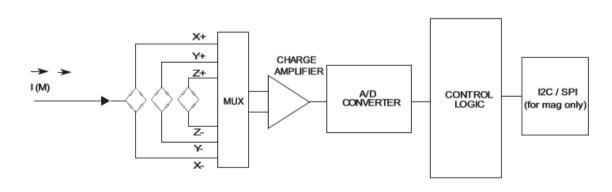


MIXED SIGNAL

- Mixed-signal integrated circuit is any integrated circuit that has both analog circuits and digital circuits on a single semiconductor die.
- Many new or improved applications are possible because firmware running on DSPs (Digital Signal Processing) or micros with analog or mixed-signal silicon analog front ends.
- Many traditionally analog systems now have a firmware component.

- Our sensors
 - I2C Bus is digital
 - Sensor is analog
 - ADC (Analog to Digital Converter) bridges from one to the other

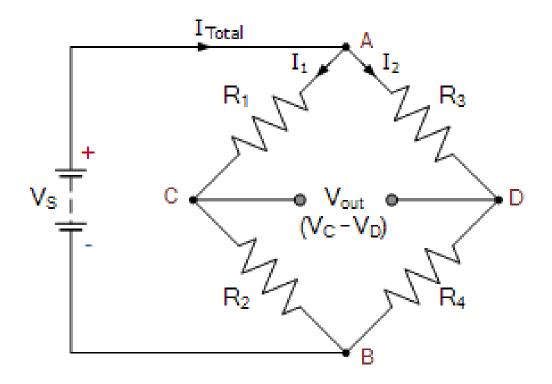
Figure 9. Magnetometer block diagram





WHEATSTONE BRIDGE

- Developed by Charles Wheatstone
- Used to measure very low values of resistances down in the milli-Ohms range.
- Two series-parallel arrangements of resistances connected between a voltage supply terminal and ground producing zero voltage difference between the two parallel branches when balanced.
- Two input terminals and two output terminals consisting of four resistors configured in a diamond-like arrangement as shown.



All our sensors are some type of wheatstone bridge. With three fixed resistors and one resistor which varies linearly with the property of interest.





SENSOR

Magnetometer	Temperature	Gyroscope	Acceleration	Pressure
Magnetoresistan ce material	Thermal resistance material	MEMS metal fragment	MEMS metal fragment	MEMS metal bar
Magnetic moment	Heat	Angular rate	Linear moment	Barometric Pressure
microGauss	degrees centigrade	Degrees per second	Micro-g (gravities)	hectopascals



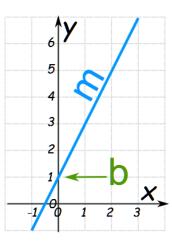


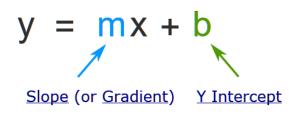
LINEAR SYSTEM

- The wheatstone bridge creates a linear response to the measured property
- Slope is the unit of measure per bit
 - E.g. 0.2 degrees centigrade per bit
- Intercept is the offset from zero
 - Environmental
 - MEMS design
 - Calibration can remove offset

Slope-Intercept Form

The most common form is the slope-intercept equation of a straight line:

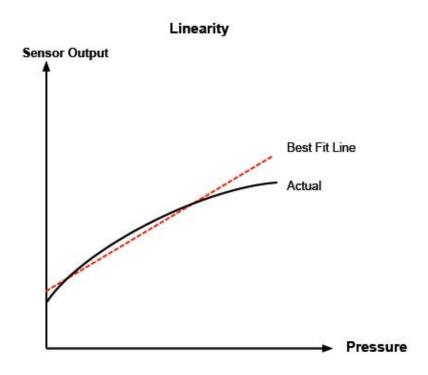






SOURCES OF ERROR

- Chip manufacture
 - The traces on the IC are never perfect
 - Laser trim (removes error)
 - PROM (stores correction)
 - Just specified (live with it)
- Temperature error source
 - Fixed resistors in the bridge will vary some
 - Variable resistor may drift with temperature
- Temperature error correction
 - On die temperature sensor automatically corrects
 - On die temperature provides value & your code corrects
 - Spec tells error & you must measure



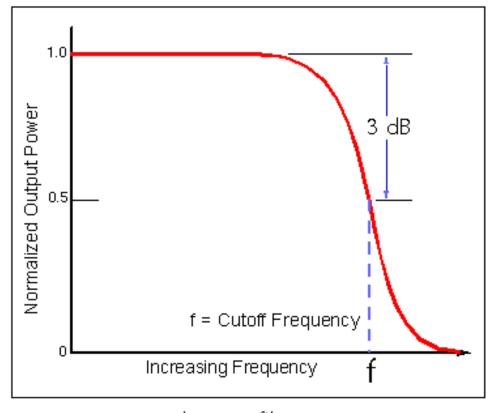
Nonlinearity

- Some material are not perfect straight lines over the range for the part
- Better manufactures specify the guaranteed non-linearity. In other word worst case for it.



FILITRING

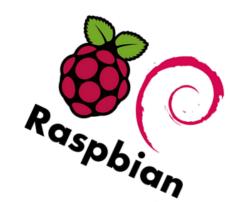
- Low Pass (LPF)
 - Remove high frequency noise and signals
- High Pass (HPF)
 - Remove low frequency noise and signals
- Band Pass (BPF)
 - Remove high and low frequencies
 - Infinite Impulse Response (IIR) filter
 - Finite Impulse Response (FIR) filters
 - narrow transition bands



low pass filter



RASPBIAN LINUX



- Unix -> Linux -> Debian -> Ubuntu -> Raspbian
 - Release 9.4 (stretch)
 - Open source, https://www.raspbian.org/
- Raspberry Pi organization has three operating systems versions: NOOBS, NOOBS Lite, Raspbian, Raspbian with Desktop. https://www.raspberrypi.org/downloads/
 - NOOBS, New Out Of the Box Software
 - Easy operating system installer contains Raspbian and LibreELEC.
 - Alternative operating systems links: Ubuntu Mate, Snappy Ubuntu Core, Libreelec, Pinet, OsMc, Risc Os
 - which are then downloaded from the internet and installed.
 - Windows 10 Iot Core is shown as an option on NOOBS, but will not install!
- How to install: https://www.raspberrypi.org/documentation/installation/installing-images/windows.md
 - SD Card Formatter: https://www.sdcard.org/downloads/formatter-4/
 - Use Win32DiskImager to make a bootable SD card https://sourceforge.net/projects/win32diskimager/
 - Default user login: pi, password: raspberry
- Beware Raspbian from Raspberrypi.org now includes cripple-ware

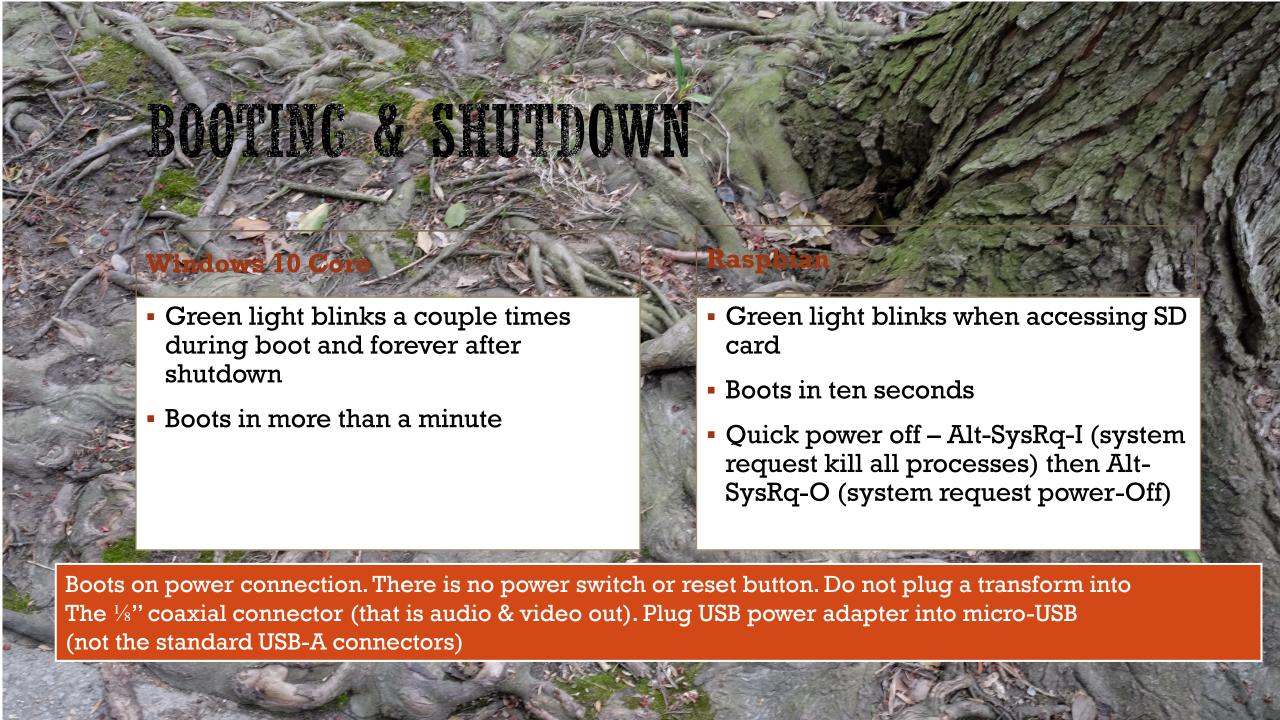


DEBIAN TOOLS INSTALL

- sudo apt-get install packageName
 - X-man is a manual
 - X-dev are developer tools
 - *lib*xxx are static link libraries
- sudo apt update & upgrade
- Raspbian requires ARM EABI armhf from the raspberrypi.org repositories. Do not load from Debian

Package Name	Tool
gpiod, libgpiod-dev	GPIO
python-all	Python
i2c-tools, libi2c-dev	I2C tools & libs
eclipse, eclipse-cdt	IDE, C++
python-smbus	I2C Python
node, nodejs	Node

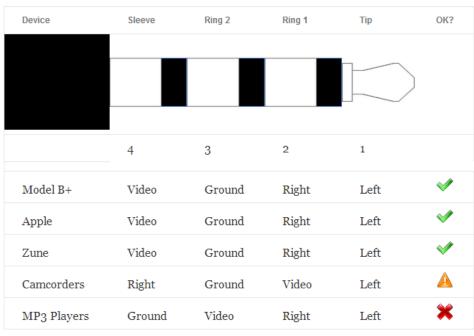




COMPOSITE VIDEO & AUDIO

- Do not plug a transform into the ¹/₈" coaxial connector (that is audio & video out)
- 3.5mm jack is FOUR pole audio and composite video (not a 3 pole for ear buds). Ring 2 must be ground!
- Raspberry Pi Display Resolution if monitor is disconnected
- The Raspberry Pi may not maintain Display Resolution if monitor is disconnected. The EDID of the monitor is used to set the resolution of the system when one is connected. When disconnected, the Raspberry Pi firmware defaults to what is in the config.txt in the root of the SD card.
- tvservice -s
 - https://www.raspberrypi-spy.co.uk/2014/07/raspberry-pi-model-b-3-5mm-audiovideo-jack/
 - https://bhavyanshu.me/tutorials/force-raspberry-pi-output-to-composite-video-instead-of-hdmi/03/03/2014/

Raspberry Pi Model B+ 3.5mm Audio/Video Socket



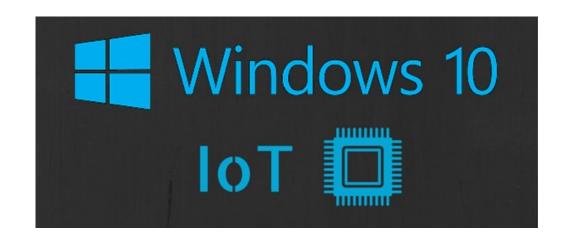
www.raspberrypi-spy.co.uk



WINDOWS 10 CORE

Additional Insider Preview downloads

RaspberryPi 3B+ Technical Preview Build 17661



- Windowsondevices.com (redirects to https://developer.microsoft.com/en-us/windows/iot)
- Long Term Servicing Branch, 10 year support but you must register your application every six months.
 - New release every six months
- Windows IoT Core is a version of Windows 10 that is optimized for smaller devices with or without a display that run on both ARM and x86/x64 devices. The Windows IoT Core documentation provides information on connecting, managing, updating, and securing your devices, and more.
- The release for the Raspberry Pi 3B+ (the downloadable ISO can be found here) is a technical preview and there is currently no timeline for a release version. For a better evaluation experience and for any commercial products, please use the Raspberry Pi 3B or other devices with supported Intel, Qualcomm or NXP SoCs. From https://docs.microsoft.com/en-us/windows/iot-core/release-notes/currentcommercial>
- OS Install Location (https://www.microsoft.com/en-us/software-download/windowsiot)
- Cost \$0.00



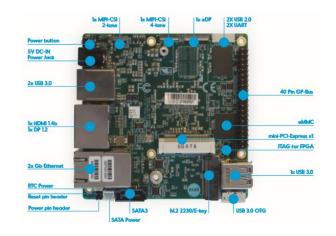
RASPBIAN HARDWARE



Name	Processor	Cost	Comments
APC	VIA ARM Cortex-A9	\$49 to \$59	APC is a fundamental redesign of the PC based on the Neo-ITX form factor
Raspberry Pi 2 & 3	Broadcom ARM	\$35	All versions are supported including the 3 B+ (the only version currently for sale). The Broadcom Wi-Fi chip is supported.
Raspberry Pi Zero	Broadcom ARM	\$5 - \$10	Supported both Wi-Fi and Bluetooth versions



W10 IOT CORE HARDWARE



Name	Processor	Cost	Comments
<u>UP</u> ²	Intel Pentium, Atom, Celeron & Apollo	\$150 to \$400	
DragonBoard 410c	Qualcomm Snapdragon 400	\$75	Product of Arrow Electronics
MinnowBoard Turbot	Intel Atom	\$150 to \$200	Open source hardware
Raspberry Pi 2 & 3	Broadcom ARM	\$35	3 B+ is only preview without Wi-Fi chip support. Windows 10 prefers a TPM chip & GPU. Pi has neither. Pi 2 is discontinued.
Raspberry Pi Zero	Broadcom ARM	\$5 - \$10	Not supported by Windows 10



WINDOWS DEVICE PORTAL

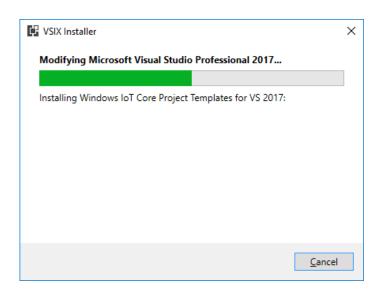
IOTCoreDefaultApplication	Foreground	•	Running	Actions
IOTUAPOOBE	Foreground	0	Stopped	Actions
Barometer	Background	•	Stopped	Actions
IoTOnboardingTask	Background	•	Stopped	Actions

- Remote administration and development for Windows 10 IoT Core
- Ip4 address port 8080
- List installed applications
- Start, Stop or set to auto-start application



WINDOWS TOOLS INSTALL

When the credentials dialog opens, make sure you use yourrpi3machinename\Administrator for the user name. The default password is p@ssw0rd. You need to connect with the computer name in front of the username. The zero can easily be mistaken as an 'O' so calling that part out.

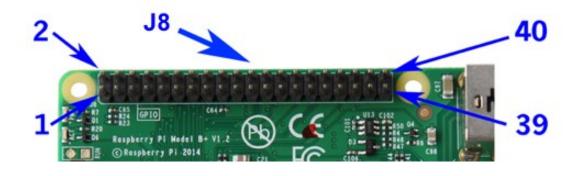


- VS2017 Community Edition
- Install Windows IoT Core Project Templates for VS 2017 (VS Extensions & Updates)
- Install latest Windows development SDK (MSDN downloads)
- Windows 10 IoT Dashboard
- Join the Windows Insider Program (https://developer.microsoft.com/en-us/windows/iot/Downloads)



GENERAL PURPOSE I/0

- All services based on Broadcom SoC capabilities
- J8 40 pin connector 0.1" centers on Raspberry Pi (http://pi4j.com/pins/model-3b-plus-rev1.html)
- 3.3 & 5.0 VDC and ground
- I²C (Inter-Integrated Circuit) Bus
 - Single master
 - 126 slave devices
 - kHz speeds
- Other: UART (RS232), Pulse-Code Modulation (a.k.a. I²S, Inter-IC Sound)



- SPI (Serial Peripheral Interface) Bus
 - Multiple masters
 - Multiple slaves (independent or cooperative slaves)
 - Limited by TTL signal levels
 - DMA (Direct Memory Access)
 - MHz speeds
- **GPIO** (27 pins)
 - Write (set) high or low
 - Read signal level (high or low)
 - Interrupt on transition (either way)

Beware, hardware is not transactional. You cannot roll it back. Do not leave new code running unattended!

OZZMAKER BERRYIMU

- Quick start,
 http://ozzmaker.com/berryimu-quick-start-quide/
- Inertial measurement unit (IMU), STµ LSM9DS1, <u>3D digital linear</u> acceleration sensor, a <u>3D digital</u> angular rate sensor, and a <u>3D digital</u> magnetic sensor
- Bosch BMP280 digital pressure sensor, https://ae-bst.resource.bosch.com/media/tech/media/datasheets/BST-BMP280-DS001-19.pdf



- I2C bus
 - 400 KHz, fast mode operation
- 6-pin connector for top of PI J8
- Side four pin jumper to PI J8
- All five interrupt pins available on bottom

