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Analysis of Xtrinsic Sense MEMS Sensors

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ABSTRACT: the proposed work deals with the performance analysis of the Xtrinsic MEMS (Micro-Electro-Mechanical Systems) Sensors. The Xtrinsic MEMS Sensor evaluation board is ideal for developing prototype projects and designs that measure motion, altitude, pressure/temperature, as well as detection of magnetic field and physical position, on multiple platforms. In this paper, we have observed performance of Xtrinsic Sensors including the MPL3115A2 high precision pressure/temperature sensor, the MAG3110 low-power 3D magnetometer, as well as the MMA8491Q 3-Axis, digital accelerometer.

KEYWORDS: Xtrinsic MEMS Sensor, MPL3115A2, MAG3110, MMA8491Q

I. INTRODUCTION

In most action movies and animation, video games, characters perform scientifically tricks such as visually manipulating data in 3D and wearing glasses that show rich information overlay describing their surroundings. This imaginative way of interacting with the world is closer to reality than it might think, and can be much more useful than computer vision on a screen. From using accelerometer data to diagnose possible conclusions to tracking altitude in a high-rise building using pressure sensor, or sensing touch or presence over a screen or object, sensor technology can enable a host of valuable applications some thoughts they had only seen in the movies. Micro-electromechanical systems (MEMS) are enabling sensor technology. MEMS-based sensor products provide an interface that can sense, process and even control the surrounding environment. MEMS-based sensors incorporate very small electrical and mechanical components on a single chip. Freescale is a leader in sensor technology that enables cost effectiveness, low power consumption, miniaturization, high performance and integration. Xtrinsic touch-sensing solutions offer the best fit for Human Machine Interfaces (HMI) designs. Touch-sensing technology can reliably replace mechanical buttons and switches to eliminate mechanical wear and tear or help implement advanced HMI with gesture recognition on resistive screens. MEMS-based sensors and touch-sensing technologies are crucial components in automotive electronics, medical equipment, hard disk drives, computer peripherals, wireless devices and smart portable electronics such as cell phones and PDAs. Free scale is not only innovating with sensor hardware, but also looking toward future applications with intelligent contextual sensing and sensor fusion, these approaches combine sensor results to achieve an accurate output that is more detailed, accurate and useful than a reading from a single sensor. There is a great technical and monetary potential in intelligent contextual sensing and sensor fusion. Current smart phones and tablet usually contain a correlation of sensors, including an accelerometer to detect changes in force resulting from a fall, tilt, motion, positioning, shock and vibration, a magnetometer for sensing the earth's magnetic field and a gyroscope for sensing rotational velocity. Pressure sensors are becoming more common in tablets, specifically in location-based services. These sensors form the basis for navigation systems and many user interfaces. The sensor industry is moving toward a goal of measuring 10 axis: a 3 –axis accelerometer, 3- axis gyroscope, 3-axis magnetometer and a pressure/temperature sensor. GPS in a mobile device can tell exactly where it is on the face of the earth, but sensors add another level of intelligence about how the device is moving. In later generations, the sensors themselves contained enough intelligence so they could tell when the device was being tapped or shaken, and wake up the CPU to perform an action. Simple gesture recognition is poised to become even more complex and allow computers to sense and interpret natural human movements as a way of interacting with devices. This new sensing experience requires a new level of sensory intelligence. Sensor fusion, essentially combines the output from two or more sensors to obtain a result that is more intelligent and useful than the output from a single sensor. Take the example of walking through an office building with a mobile device that contains a magnetometer, gyroscope and accelerometer. All these devices need to work together to provide a true picture of the user's location and surroundings. The magnetometer could be thrown off by metal in wall and desks, but if the gyroscope and accelerometer detect that the user is walking in a straight line, they can subtract those effects. The accelerometer measures acceleration plus gravity. Gravity is the same as acceleration from the sensor's perspective. An accelerometer measures tilt very well. The magnetometer and gyroscope can separate the effects of linear acceleration of gravity and help make those decisions [1]. Software innovation will be one of the keys to sensor fusion. A magnetometer, for example, measures the ambient magnetic field of the earth as part of the mapping and compass functions. But phones and other mobile devices contain a lot of ferromagnetic material, for example, in the speakers and ferrous materials for shielding. This metal directly affects the magnetic field in the immediate area of the device. More intelligence is moving from the CPU into sensors. Typical sensors are passive devices. In a system built with typical sensors, the host CPU must constantly poll the sensors and process their readings. Systems with a lot of typical sensors require a lot of CPU overhead and power use. The Xtrinsic MMA955OL intelligent motion-sensing platform has a 32-bit MCU on the sensor itself, which means that an intelligent sensor alone could control an application [1]. In this paper, the proposed system hardware contains the Xtrinsic sense board, Raspberry Pi model B, 4GB SD card, HDMI to VGA cable and USB data sync charger cable.

II. XTRINSIC SENSE MEMS SENSOR

A. XTRINSIC MAG3110

The Xtrinsic MAG3110 magnetometer operates at the highest resolution and lowest noise in an ultra-small size. A combination of tunnel magneto resistive sensor (TMR) technology, high-resolution analog design and dedicated embedded logic results in a phenomenal performance. The Xtrinsic MAG3110 magnetometer measures the magnetic field in all three axis with ranges up to 1000μT, at data rates up to 80 Hz, with resolution down to 0.1μT and with noise as low as 0.05μT. The combination of the magnetometer with the accelerometer provides a full tilt-compensated electronic compass capability. Applications include e-compass, enhanced user interface, GPS assists and location-based services, and enhanced gaming interfaces. The MAG3110 is ideally suitedfor smart phones, tablets and any portable devices requiring an electronic compass capability [4].

B. XTRINSIC MMA8491Q

An Xtrinsic MMA845xQ family of pin compatible 14-, 12- and 10-bit accelerometer provides scalable, configurable and accurate motion analysis. To operate with extremely low power, the MMA845xQ accelerometers have six user configurable sample rates that can be set over a wide range of 1.5 to 800 Hz. The power scheme contains four different power modes from high resolution to low power, offering best in class saving in supply current and extremely high resolution for very small motion detection. Pin compatibility with register mapalignment maximizes hardware re-use between 10-bit and 14- bit designs where there is zero development cost to migratefrom 10-bit to 14-bit performance designs where there is zero development cost to migrate from 10-bit to 14-bit performance. The MMA845xQ accelerometer is feature-rich with a wide range of real-time motion detection such as orientation, directional shake and tap, jolt, freefall and pedometer applications. The MMA8451Q 14/8-bit first in, first out (FIFO) holds up to 32 samples of either low pass filtered (LPF) or high passes filtered (HPF) data, depending on user selection [4].

C. XTRINSIC MPL3115A2

The Xtrinsic MPL3115A2 pressure sensor is the smartchoice for precise pressure/temperature and altitude detection. It provides highly precise pressure/temperature and altitude data with variable sampling rate capability up to 140 Hz, extremely high accuracy, 30 cm resolution (20-bit resolution measurement) with flexible output in either meters or Pascal/Celsius. Other smart features include temperature compensation, embedded direct readings for altitude, pressure and temperature. No extra software is needed, saving a lot of development time. The Xtrinsic MPL3115A2 pressure sensor is an industry first because it performs all of this compensation on-board, educing the need for the host MCU to continually convert raw altitude, pressure and temperature data through compensation algorithms. This smart integration result in significant power saving with the MPL3115A2 operating in
standby mode at 2mA and low–power mode at 8.5mA at 1Hz. Other low-power consumption benefits include the MPL3115A2 selectable sample rates and the 32 sample firstin/ first-out (FIFO) memory buffer with configurable interrupts to offload communications with the host processor. It has verylow power consumption, smart features and requires zero data processing for mobile devices, medical and security applications [4].

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III. XTRINSIC-SENSE BOARD AND RASPBERRY PI

The sensor board comes equipped with three of Freescale's new-generation an Xtrinsic MEMS sensor. The MPL3115 (U1) is designed for accurate measurement of temperature and pressure, the MAG3110 (U2) for detection of magnetic fields, and the MMA8491 (U3) for measurement of physical positions.

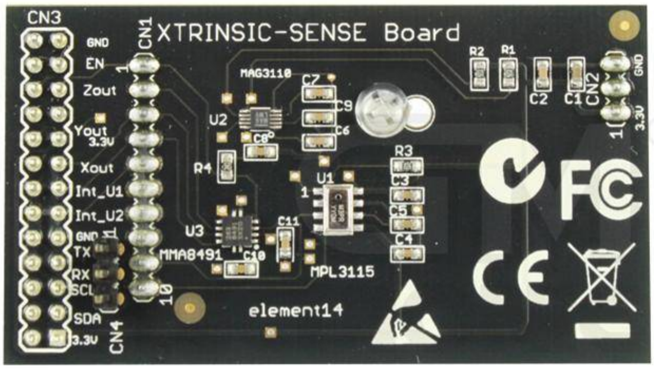

Figure 1. The Xtrinsic-Sense MEMS Sensor Evaluation Board

The Raspberry Pi is characterizing a BCM2835 system on chip (SoC) this includes an ARM1176JZF-S 700MHz processor, Video Core IV GPU, and 512 MB of RAM (M odel B). It also includes two USB ports and a 10/100 Ethernet controller. The Raspberry Pi has an easy access 26-pin GPIO I/O header. Connect the Xtrinsic-Sense Board to the Raspberry Pi board as shown below figure 2.

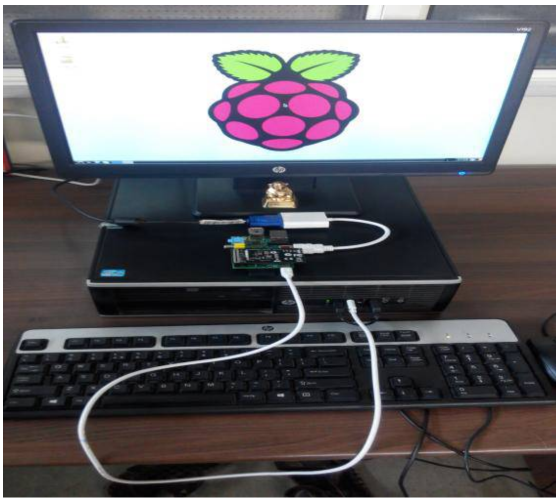

Figure 2. Experimental setup

To configuration of Raspberry Pi, it will need an SD card, HDMI to VGA cable, Keyboard, Mouse, Ethernet Cable and Power adapter. In order to use Raspberry Pi, it will need to install an operating system onto an SD card. An operating system is the set of basic programs and utilizes that allow computers to run; example includes Windows on a PC. Insert an SD card that is 4GB or greater in size into a computer and format the SD card so that the Raspberry Pi can read it. Download the new out of box software (NOOBS) and unzip the downloaded file. Copy the extracted files onto the SD card it just formatted. Insert the SD card into Raspberry Pi and connect the power supply. Raspberry Pi will now boot into NOOBS and should display a list of operating systems that it can choose to install. If it displays remains blank, it should select the correct output mode for display by pressing one of the number keys on it keyboard like HDMI mode, HDMI safe mode, composite PAL and composite NTSC mode. The board will need to be positioned on the first 26

GPIO pins which connect CN3 connector of the Xtrinsic sensor board and the edge of the Xtrinsic Sense board should be near the Raspberry Pi's indicator LED.

The main task is to enable the I2C drivers for the Raspberry Pi. It can either do this by modifying the blacklist modprobe file (which enables I2C permanently) or by doing a modprobe which only enables it until it reboot are Pi. First I opened up LXTerminal from the desktop, and opened the blacklist file with command nano [5].

A. I2C CONFIGURATION

The board communicates with the Raspberry Pi via the I2C interface. So the first step is getting this enabled by editing the modules file: sudo nano /etc/modules and add the following command line if isn't there already: i2c-bcm2708 Use CTRL-X, then Y, then return to save the file and exit. Then it needs to edit the modules blacklist file: sudo nano /etc/modprobe.d/raspi-blacklist.conf and put a # symbol at the beginning of i2c command lines so that it looks link this: #blacklist i2c-bcm2708 se CTRL-X, then Y, then return to save the file and exit. Thei2C module will load automatically next time you reboot but to save rebooting at this point it can just load the module manually: sudo modprobe i2c-bcm2708 Download example files. The example scripts are provided as a git repository. The easiest way to download these is to ensure it has git installed:sudo apt-get update sudo apt-get –y install git and then clone the repository: git clone http://git.oschina.net/embest/rpi_sensor_board.git

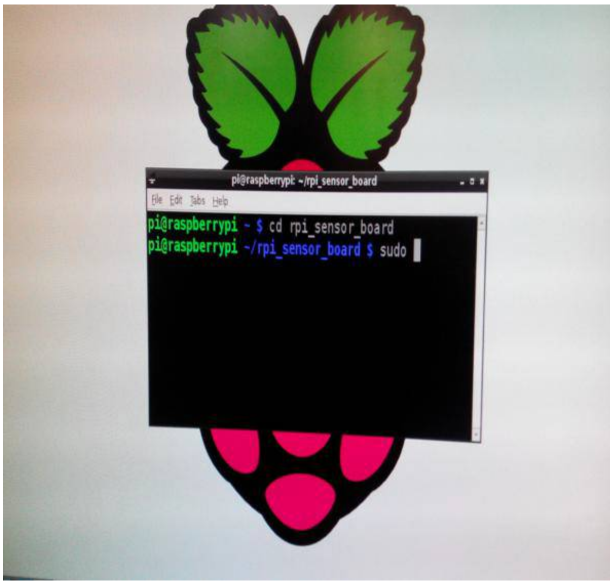

Figure 3. I2C configuration

B. SENSOR TERNIMAL TESTS

These following tests are run by executing python scripts: • **MAG3110.py:** Test the Xtrinsic MAG3110 3-axis,digital magnetometer, console will output the 3-axis magnetometer value. (The MAG3110 can be calibrated by first running the mag3110_calibrate.py script. Calibration data will be stored in mag3110_calibration.data.)

• **MPL3115A2.py:** Test the Pressure/Temperature and Altitude, console will output the Pressure/Temperature and Altitude.

• **MMA8491Q.py:** Test the Xtrinsic MMA8491Q 3-axis multifunction digital accelerometer; console will output the 3-xis accelerometer data. Test the MAG3110 sensor by entering the following at the Raspberry Pi's terminal prompt: pi@raspberrypi ~ $ cd rpi_sensor_board sudo python mma3110_calibrate.py The expected console output will look similar to the following figure 4:

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Figure 4. MAG3110 sensor calibration output console

Calibrate MAG3110 sensor, first horizontally rotate board for 360 degrees. Calibrate data are x-axis values -3095, y-axis values 134 and z-axis values 0. A compass heading (yaw) canbe determined by using just the x- axis and y-axis magnetometer measurements, but as observed, these are offset from zero by the magnetic "hard iron" interfering field, which results from both permanently magnetized ferromagnetic materials on the PCB and from a zero-field offset in the magnetometer sensor itself. It can rotate in a spin magnetometer reading; compute the corresponding x-axis value -79µT, y-axis value 2µT and z-axis value -54µT. The heading then can be easily computed using the atan2 () function. It can see in the figure 5 the magnetic field value changes as it rotates the board. It is a bit difficult to rotate it around the whole 360 degrees because of all cables attached.

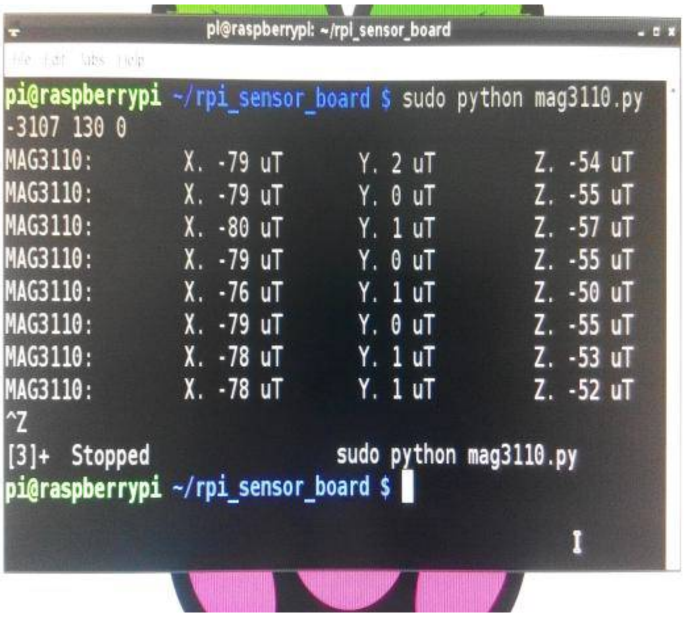

Figure 5. MAG3110 sensor output console

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The MAG3110 magnetometer measures the 3-axis components of the local magnetic field which will be the sum of the geomagnetic field and the magnetic field created by components on the circuit board. This is the basic principle ehind electromagnets, to measure magnetic field with a magnetometer.
Test the MPL3115A2 sensor by entering the following at Raspberry Pi's terminal prompt: sudo python mpl3115a2.py
The expected console output will look similar to the following figure 6:

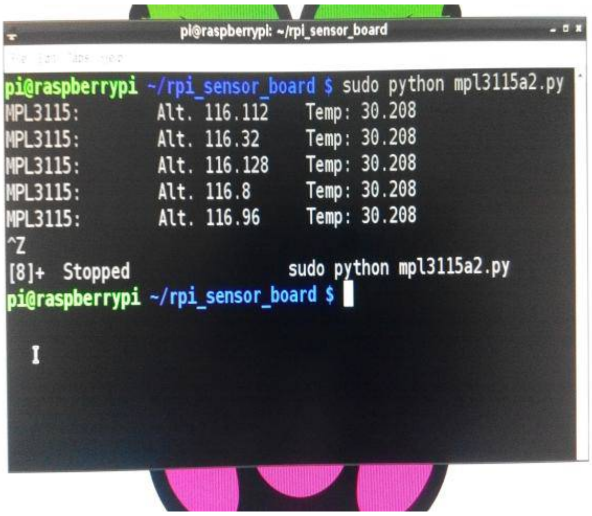

Figure 6. MPL3115A2 sensor output console

The sensor outputs are digitized by a high resolution 24-bit ADC and transmitted over I2C driver, measuring it's easy to interface with most microcontrollers. The MPL3115A2 sensor provides 20-bit accurate 116.112 meter altitude that covers all surface elevations on the Earth and 12-bit 30.208 temperature measurements in degrees Celsius. Test the MMA8491Q sensor by entering the following at Raspberry Pi's terminal prompt: sudo python mma8491q.py The expected console output will look similar to the following figure 7:

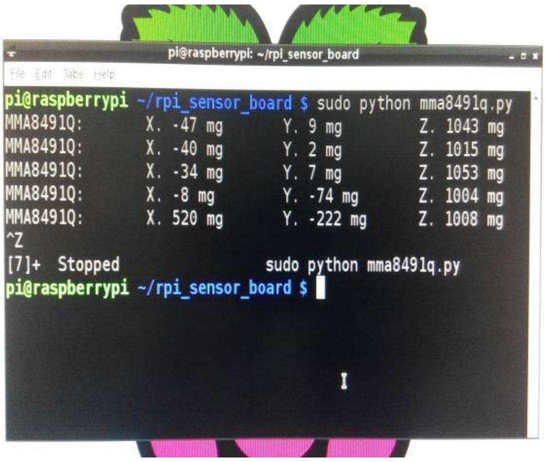

Figure 7. MMA8491Q sensor output console

The Xtrinsic MMA8491Q accelerometer for tilt sensing x-axis values -47mg, y-axis values 9mg and z-axis value 1043mg tilt threshold detects outputs.

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IV. CONCLUSION

In this paper, we have observed the XTRINSIC SENSE MEMS Sensor evaluation board. It is based on Raspberry Pi board, which allows communication with the Xtrinsic sense board to develop a proposed work using python platform. It is in the performed the characterization of the three different Xtrinsic sensors like MAG3110, MPL3115A2 and MMA8491Q. The MAG3110 is capable of measuring local magnetic field with a magnetometer. The MPL3115A2 is accurately measured altitude and temperature. The MMA8491Q sensor can detect the six different position orientation positions reference to Earth gravity.

REFERENCES

[1] Riccardo Antonello, Roberto Oboe, "Exploring the Potential of MEMS Gyroscopes," IEEE Industrial Electronics Magazine, March 2012, pp.14-24
[2] R. N. Dean, A. Luque, "Applications of microelectromechanical systems in industrial processes and services," IEEE Transactions Industry Application, vol. 56, no 4, pp.913-925, April 2009
[3] W. J. Fleming, "Overview of automotive sensors," IEEE Sensors, vol. 1, no 4, pp. 296–308, December 2001.
[4] element14 community. Available: http://www.element14.com/ community/docs/DOC-65488/I/element14-user-guide-for-xtrinsic-senseboard.
[5] raspber rypi-spy.co.uk. Available: http://www.raspberrypi-spy.co.uk/2014/06 /farnell-xtrinsic-mems-sensor-board-for-raspberry-pi/
[6] Kazuaki Ito, Riccardo Antonello, "Performance Improvement of Motion Control Systems with Low Resolution Position Sensors using MEMS Accelerometers," 2013 IEEE
[7] MAG3110 datasheet, http://cache.freescale.com/files/sensors/doc/ datasheets/MAG3110.pdf
[8] MMA8491 datasheet, http://www.farnell.com/datasheets/1691495.pdf
[9] MPL3115A2 datasheet, http://cache.freescale.com/files/sensors/doc/ data_sheet/MPL3115A2.pdf