Journal of Physics: Conference Series **776** (2016) 012116 doi:10.1088/1742-6596/776/1/012116

Calibrating accelerometer sensor on android phone with Accelerograph TDL 303 QS for earthquake online recorder

R. Riantana[1] , D. Darsono[1], A. Triyono[2] and H.B. Azimut[1]
Physics Department of Sebelas Maret University[1],
Geophysics Station of BMKG Yogyakarta, Indonesia[2]

E-mail: rioriantana@yahoo.com

Abstract. Calibration of the android censor was done by placing the device in a mounting at side of accelerograph TDL 303 QS that will be a means of comparison. Leveling of both devices was set same, so that the state of the device can be assumed same anyway. Then applied vibrations in order to have the maximum amplitude value of both censor, so it can be found equality of the coefficient of proportionality both of them. The results on both devices obtain the Peak Ground Acceleration (PGA) as follows, on the x axis (EW) android censor is obtained PGA -2.4478145 gal than at TDL 303 QS obtained PGA -2.5504 gal, the y-axis (NS) on the censor android obtained PGA 3.0066964 gal than at TDL 303 QS obtained PGA 3.2073 gal, the z-axis (UD) on the android censor obtained PGA -14.0702377 gal than at TDL 303 QS obtained PGA -13.2927 gal , A correction value for android accelerometer censor is ± 0.1 gal for the x-axis (EW), ± 0.2 gal for the y-axis (NS), and ± 0.7 gal for the z-axis (UD).

1. Introduction

Vibrations around us may be caused by random sources resulting directly from human activity as well as natural causes, independent from humans (earth-quakes) [1,2]. Vibrations are usually measured on the ground's surface, at specific measuring points, using measuring instruments designed specifically for that purpose, called accelerometers, and the measurements are then, via analog to digital converters and data acquisition cards, registered on a computer disc [3,4].
D'Emilia [5] have done evaluating of aspects affecting measurement of three-axis accelerometers. The result is comparing between two three-axis accelerometers, aiming to highlight the effects of simple solutions for conditioning electronics, interfacing and Analog-Digital Conversion, on the metrological performance of censor itself. A comparison between two solutions for test rig, as for the positioning of the motion with respect to the vertical direction, the motion law and the reference definition [5].
Riantana [6] have done creating Accelerometer Censor Application On Android Mobile as Earthquake Online Recorder using a web server to collect data from the vibration readings in the field by android phone in real time. So that the vibration data in all android phones can be stored by structured and can be visualized using a monitoring graph on web. The system has not been tested and calibrated with standard devices used by BMKG to monitoring the activity of the soil surface vibration. If the system can be tested and calibrated it is estimated the system would save costs up to 99% of the procurement accelerograph TDL.303 QS. So the cost is only 1% of the previous cost. Cost to procurement one

Journal of Physics: Conference Series **776** (2016) 012116 doi:10.1088/1742-6596/776/1/012116

Accelerograph TDL 303 QS is about 25.000 USD, while the cost to procurement this system is just about 250 USD for one point station. Surely this would be very beneficial if the system can be used as an alternative to the existing system [6].

2. Methods

We have calibrated android phone by using Accelerograph TDL 303 QS standart equipment for earthquake meansurement. We did it at Meteorology Climatology and Geophysics Council of Yogyakarta city, Indonesia. Figure.1 shows the flowchart of calibration. Calibration is done by placing both of censor side by side to same level. Then applied vibrations in order to have the maximum amplitude value of both censor, so it can be found equality of the coefficient of proportionality both of them.

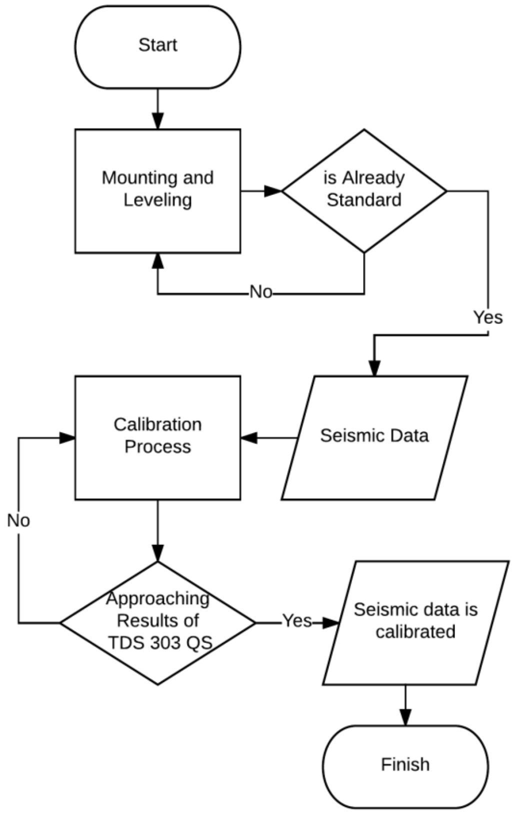


Figure 1. Calibration Flowchart

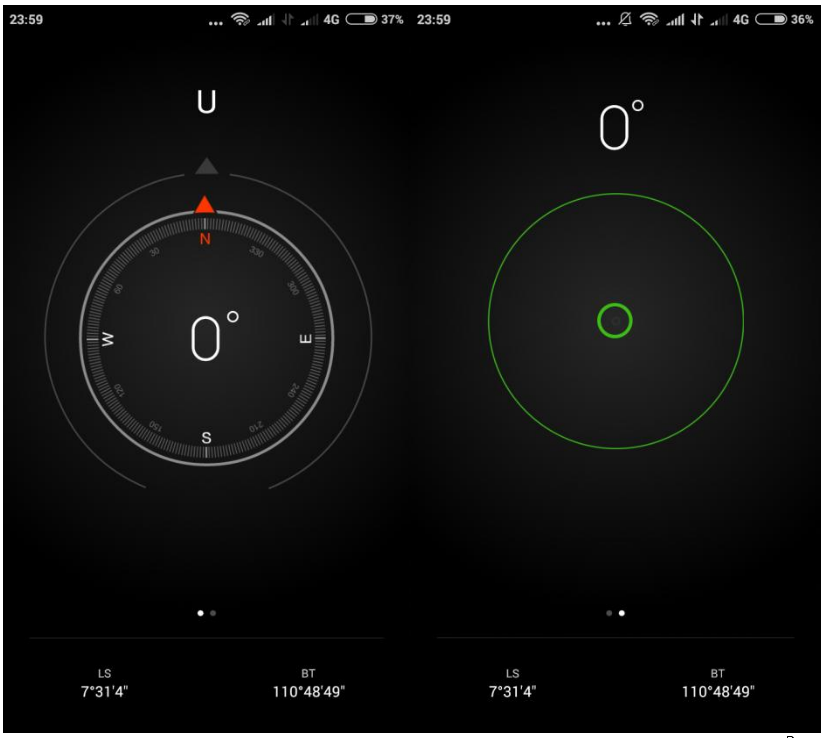
The data collection is done per session by giving a trigger vibrations from the outside. The obtained data were analyzed the balance on a scale of 0 to chart. The result of recording accelerometer android is already on the balance of 0 to further determine the calibration value and the value of Low and High pass Filter. This calibration value will adjust the value of the accelerometer android and accelerograph TDL 303 QS. The wave function filter is used in order to minimize the wave interference, therefore will reducing noise which influences the results.

3. Results and Discussion

In the data processing, used High and Low pass Filter method on android accelerometer. The wave function filter is to get the value of original wave and minimize noise vibration that can affect the results. Calibration process for accelerometer censor on android phone Xiaomi redmi 2 with Accelerograph TDL.303 QS has done by placing the mounting of android phone beside to

Accelerograph TDL 303 QS with same level on both of devices. Figure.2 shows the results of leveling on android phone.

Figure 2. Leveling On Android Xiaomi Redmi 2



Basically, accelerometer censor on the android phone has units of acceleration m/s^2 and accelerograph has units of acceleration cm/s^2 (gal). In the theory to get the same results, android accelerometer unit is converted into cm/s^2 (gal), the value should be multiplied by 100. But in reality that is not linear. Table 1 shows comparison both of device before the accelerometer on android is calibrated. So we need a lot of data in order to get a lot of variety to processed and equalized furthermore to obtain an equation for each axis of the censor, so that the output obtained by the accelerometer android and accelerograph TDL 303 QS value is approach.

Table 1 Comparison of the maximum amplitude on android phone before calibration with accelerograph TDL 303 QS

Axis	Accelerometer Android (uncalibrated)	Accelerograph TDL 303 QS (gal)
x (EW)	-0.1682934	-2,5504
y (NS)	0.2412843	3,2073
z (UD)	- 0.72002377	-13,2927

After a few takes of data and application the equations to android phone, then obtained the equation for each axis of the accelerometer censor Xiaomi redmi 2 as follows:

$$X = (even\_value(x) - 0.02) \quad (1)$$

$$X = \begin{cases} X < -0.018 \rightarrow X * 13 \\ X > 0.018 \rightarrow X * 13 \end{cases} \quad (2)$$

$$Y = (even\_value(y) - 0.01) \quad (3)$$

$$Y = \begin{cases} Y < -0.018 \rightarrow Y * 13 \\ Y > 0.018 \rightarrow Y * 13 \end{cases} \quad (4)$$

$$Z = (even\_value(z) - 0.687) * 10 \quad (5)$$

The calibration equation above is only for Android devices Xiaomi redmi 2. For other types of Android device need different calibration equations. Figure 3 shows retrieval data test of android graph and TDL 303 QS graph before calibrated. Recording speed on android accelerometer in the server about 50 records per second, whereas the speed record at TDL 303 QS accelerograph is 100 records per second. This makes the results graph vibration formed on the recording accelerometer android is not the same record lenght than accelerograph TDL 303 QS. However, this android accelerometer censor can capture a maximum vibration approaches the maximum vibration from accelerograph TDL 303 QS. Table 2 Shows comparison of maximum amplitude of both devices after calibration. Figure 4 shows the comparison of android graph and TDL 303 QS graph after calibrated. In the last recorded data retrieval for the maximum amplitude of both devices are as follows:

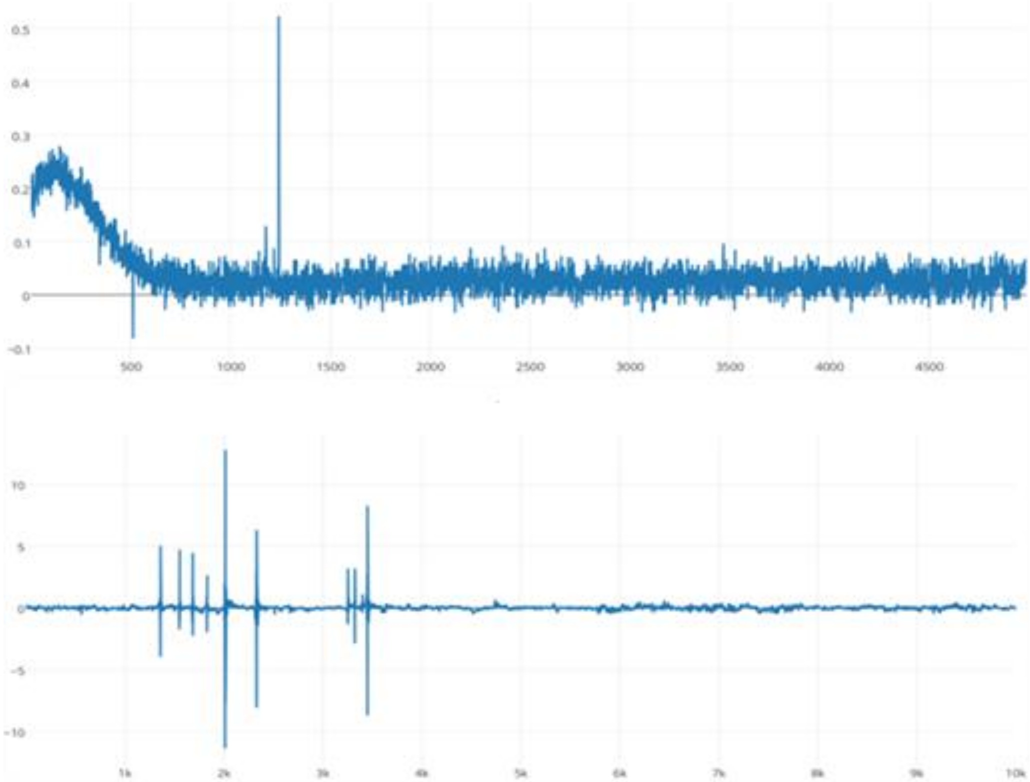


Figure 3 Test retrieval data of X axis on Android Accelerometer graph (top) and TDL 303 QS graph (bottom) before calibrated

Table 2 Comparison of the maximum amplitude on android phone and accelerograph TDL 303 QS after calibration

Axis	Accelerometer Android (gal)	Accelerograph TDL 303 QS (gal)	Correction (gal)
x (EW)	-2,4478145	-2,5504	± 0.1
y (NS)	3,0066964	3,2073	± 0.2
z (UD)	-14,0702377	-13,2927	± 0.7

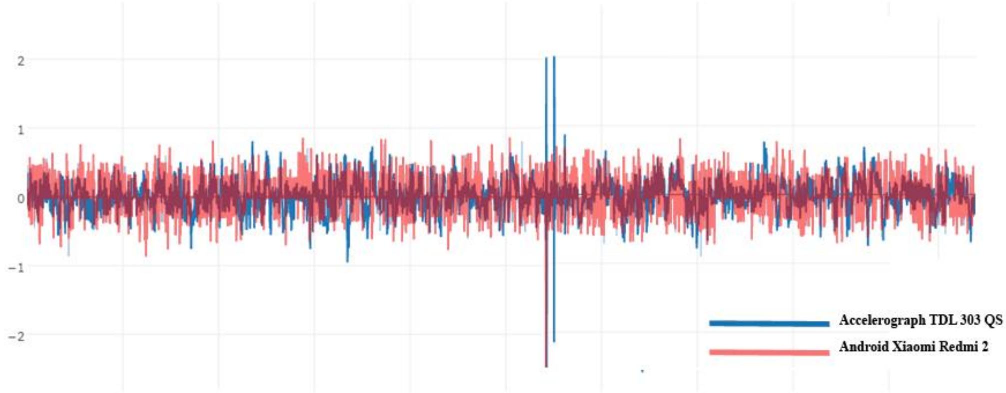


Figure 4 The comparison of X Axis on Android Accelerometer graph and TDL 303 QS graph after calibrated

4. Conclusion

Comparing process of the data, we have a calibration equation :

$$x = even\_value(x) - 0.02 \quad (6)$$
$$x = x * 13 \{x \mid x < -0.018 \text{ or } x > 0.018 \mid x \in \mathbb{R}\} \quad (7)$$
$$y = even\_value(y) - 0.01 \quad (8)$$
$$y = y * 13 \{y \mid y < -0.018 \text{ or } y > 0.018 \mid y \in \mathbb{R}\} \quad (9)$$
$$z = ((even\_value(z) - 0.687) * 10 \quad (10)$$

Correction value for android accelerometer censor is ± 0.1 gal for x-axis (EW), ± 0.2 gal for y-axis (NS), and ± 0.7 gal for z-axis (UD).

5. References

[1] Sasaki K, Iinuma H, Kimura N, Ogitsu T, Yamamoto A, Nakayama, Mibe T, Saito N, and Obata T, 2011 *IEEE Trans. Appl. Supercond*. **21** (3) pp. 1748–1751.
[2] Sun XT, Jing XJ, Xu J, and Cheng L, 2014 *IEEE Trans. Industr. Electron*. **10** pp. 5606–6114.
[3] Cattaneo PW, 2002 *Nucl. Instrum. Methods Phys. Res*. Section A **481** (1-3) pp. 632–636.
[4] Al-Naimi K, Villette S, Kondoz A, and Heikkinen AP. 2006 *Vision Image Signal Process* **153** (5) pp. 610–617.
[5] d'Emilia G, Gaspari A, and Natale E. 2016 *Measurement* **77** pp. 95–104.
[6] Riantana R. 2015 *Jurnal Fisika dan Aplikasinya* **11** No 3 pp. 114-119.