① Tablet and its specifications

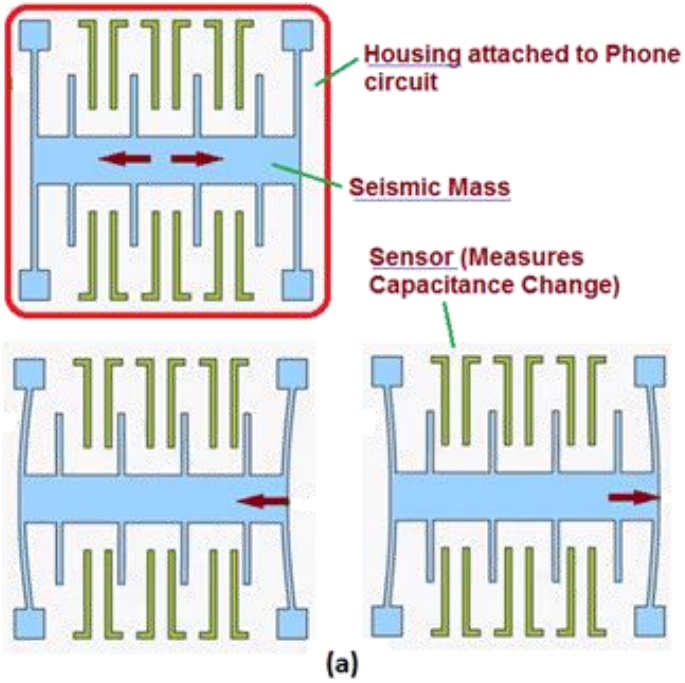
Asus Nexus 7 (2013)

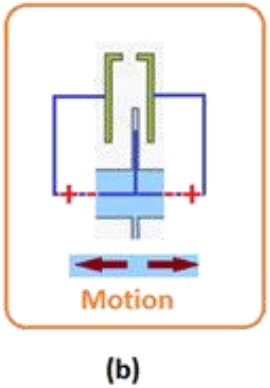
Specifications	
Display	7 in 、LED backlight
Resolution	1920 x 1200
CPU	Dual core 1.5 GHz
Working memory	Internal memory: 2GB
Storage capacity	eMMC: 16GB
Battery duration	About 10 hours
Battery charging time	About 3.5 hours
Internal sensors	GPS Electric compass **Accelerometer** **Gyroscope** **Light sensor** **Magnetic field**
Weight	290 g

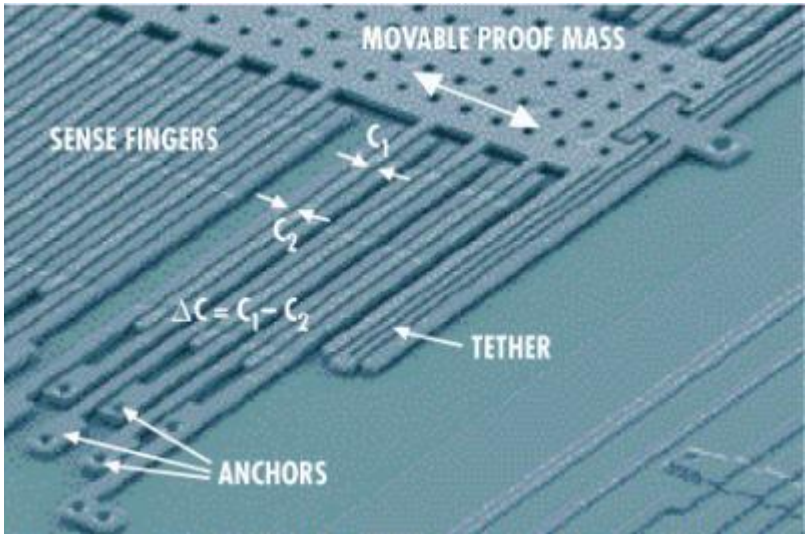
② Measurement principle

Accelerometer
- X,Y,Z acceleration
- Unit: m/s^2

- Measure acceleration in X,Y,Z
- Z direction represent gravity (if on table)
- Used to determine vertical orientation
- Moving springs used as sensor
- Capacitance effectively measured
- Used to determine display orientation

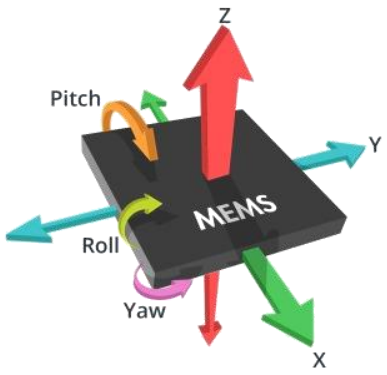




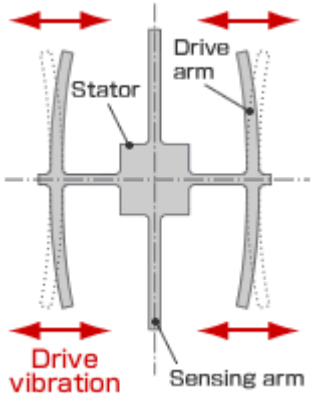


② Measurement principle

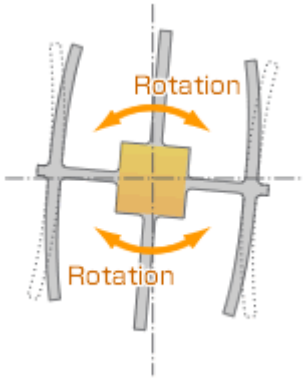
Gyroscope
- X,Y,Z angular velocity
- Unit: rad/s



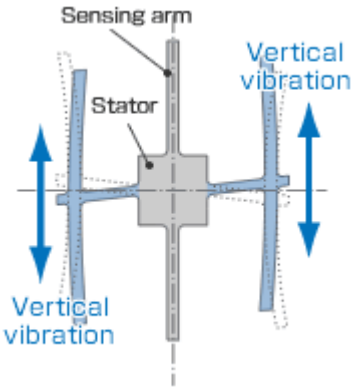
- When still X,Y,Z all 0
- Measuring principle similar to accelerometer
- Independent on direction
- Non-zero values when moved
- X = Yaw, Y = Pitch, Z = Roll



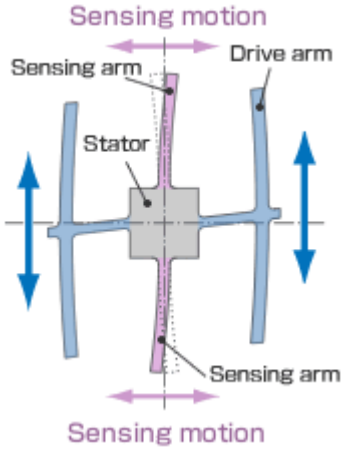
1. Normally, a drive arm vibrates in a certain direction.



2. Direction of rotation



3. When the gyro is rotated, the Coriolis force acts on the drive arms, producing vertical vibration.

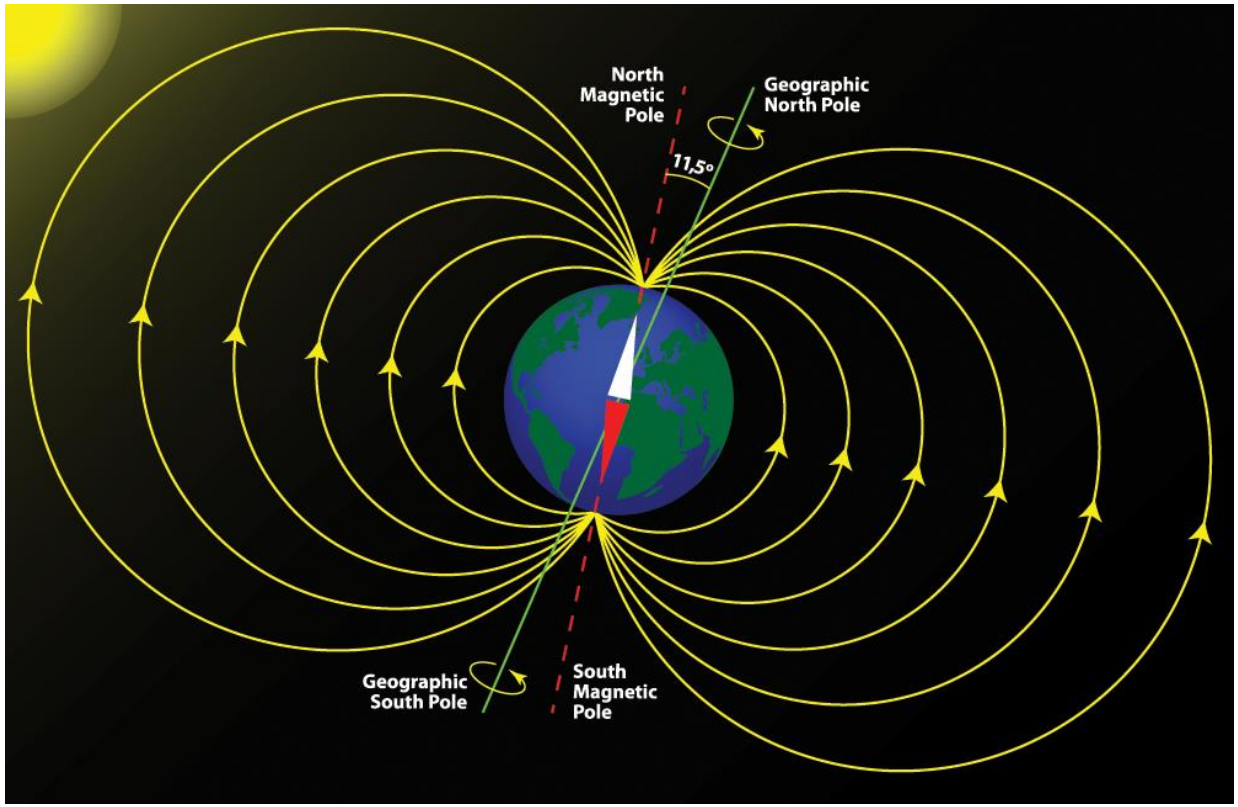


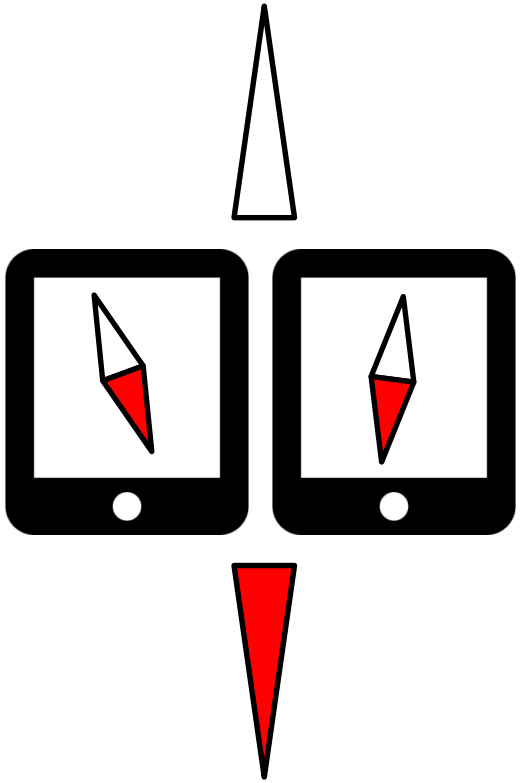
4. The stationary part bends due to vertical drive arm vibration, producing a sensing motion in the sensing arms.

② Measurement principle

Magnetic sensor
- Magnetic field X,Y,Z
- Unit: μT

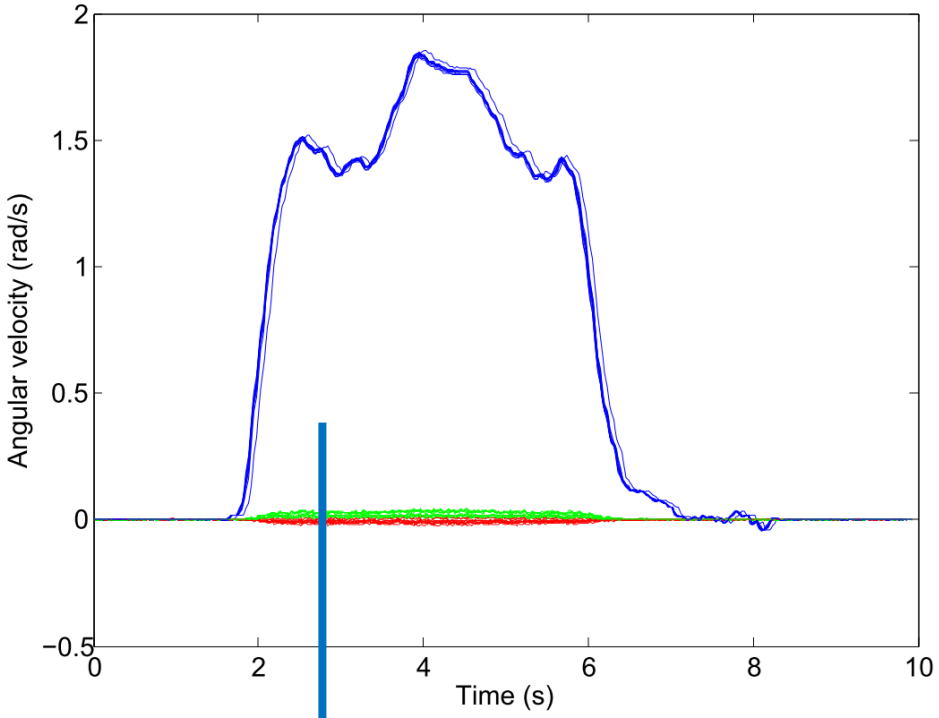
- By using earth magnetic field direction is determined
- External magnetic fields easily leads to errors (magnet…)
- To determine orientation OS also used data from GPS
- Also, earth magnetic field has local variations
- By using magnetic sensor only direction inaccurate (see below)

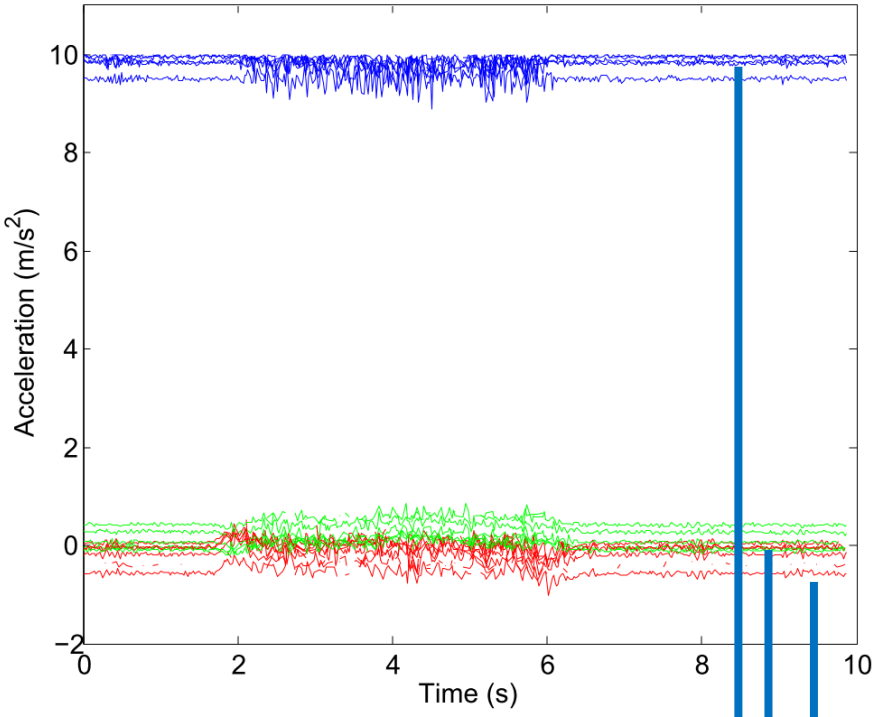




③ Validation and calibration

Experiment: turn 10 tablets altogether by 360 degrees





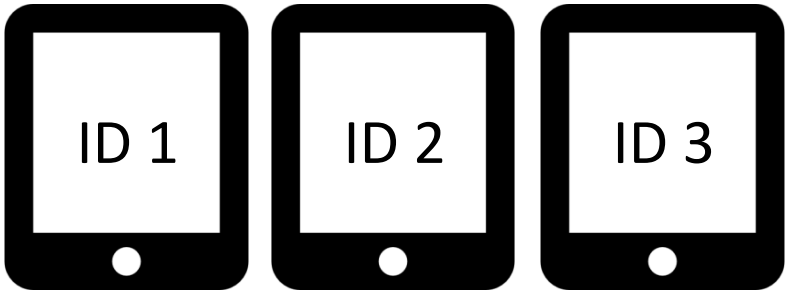
Integral gives angle of rotation; resulting in
⇨ **359.78 degrees**

Acceleration is different in each device…!

③ Sensors and accuracy/precision

Sensor	Accelerometer	Gyroscope	Magnetic field
Maximum sampling	About 200Hz	About 200Hz	About 50Hz
Precision	High	High	Medium
Accuracy	Low (hardware) High (OS corrected)	High	Low

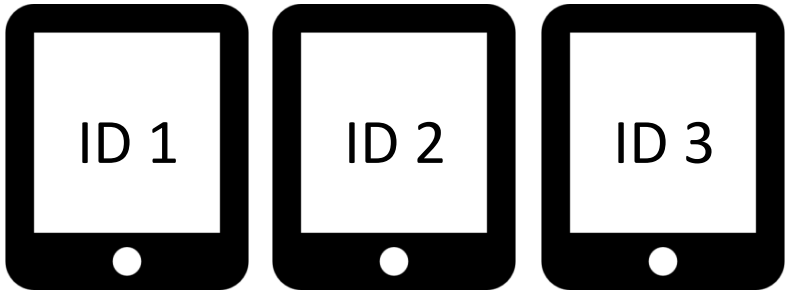
Z direction (when still)



9.6 m/s² 9.0 m/s² 10.3 m/s²

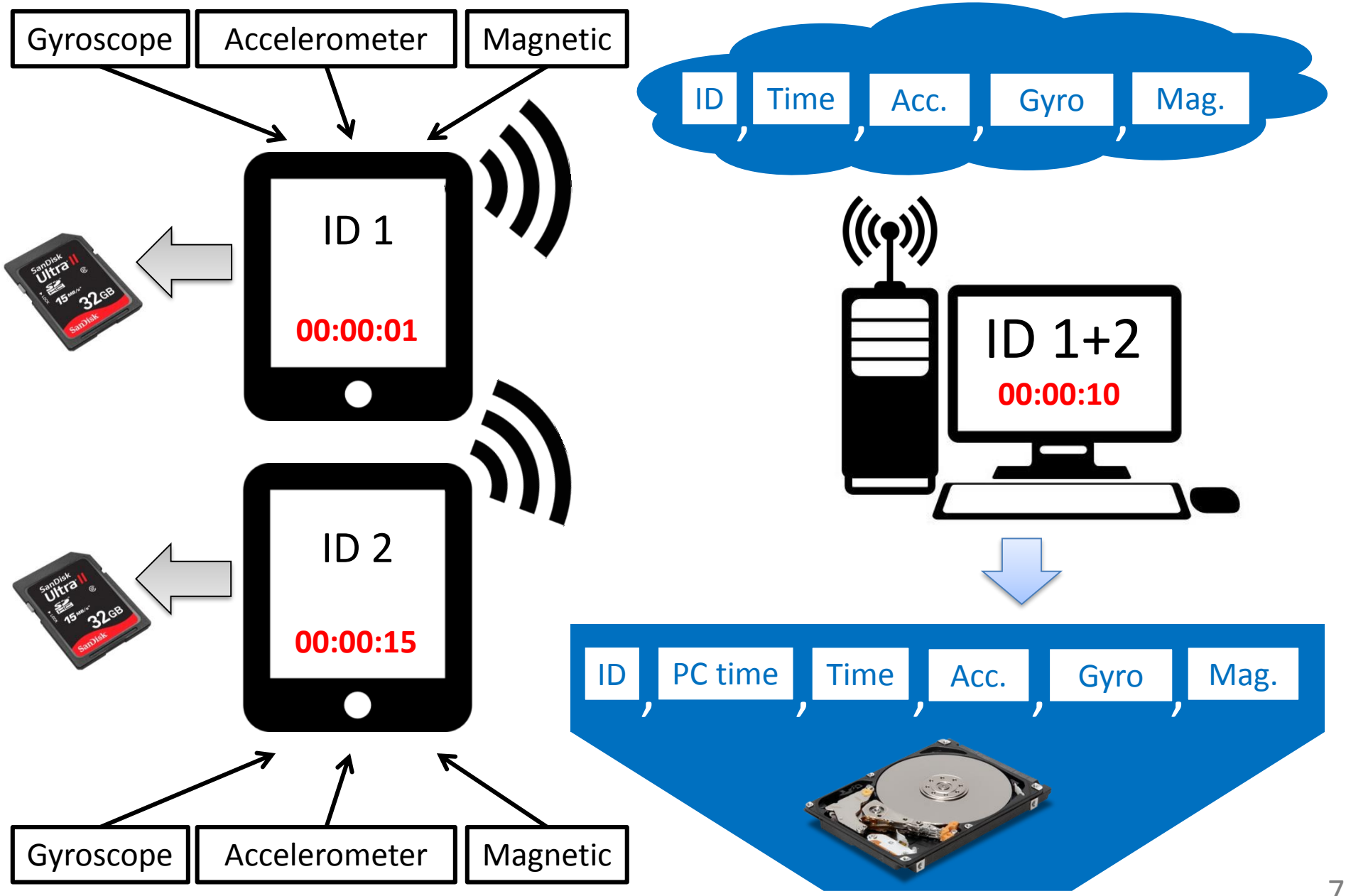
OS filter

Linear acceleration (still)

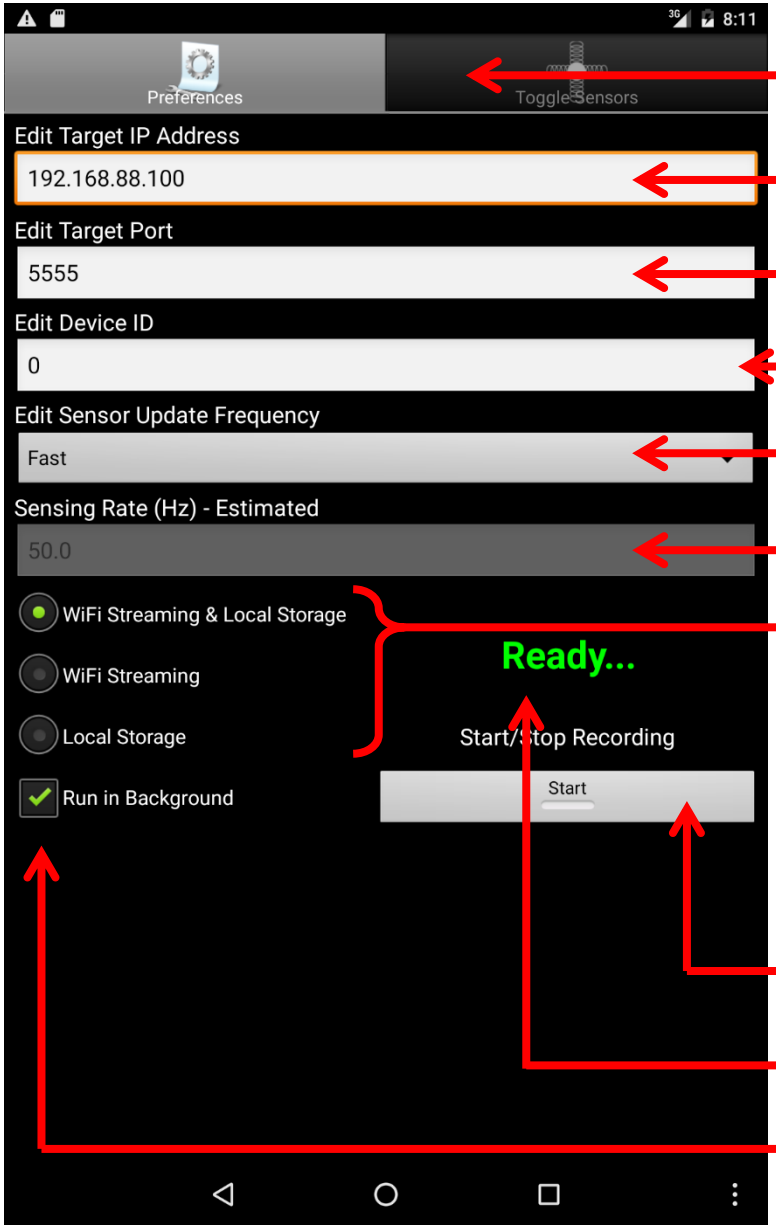


0.0 m/s² 0.0 m/s² 0.0 m/s²

④ Synchronization between tablets



⑤ Tablet settings



Menu (preferences)

IP address of storage PC (if used)

PC port (warning: firewall exception)

Tablet ID number (from 1 to 99)

Sampling and streaming/storing rate

User given sampling rate

Storage options:

- WiFi streaming and local storage
- WiFi streaming only
- Local storage only (root\sdcard\MyIMUData)

Start/Stop recording

Recording status

Keep app running in background (run works also during sleep mode)

⑤ Tablet settings

Menu (sensors)

Accelerometer (hardware)

Gyroscope (hardware)

Magnetic field (hardware)

GPS position (hardware)

Orientation (computed by Android OS)

Linear acceleration (no gravity, from OS)

Gravity (computed by OS)

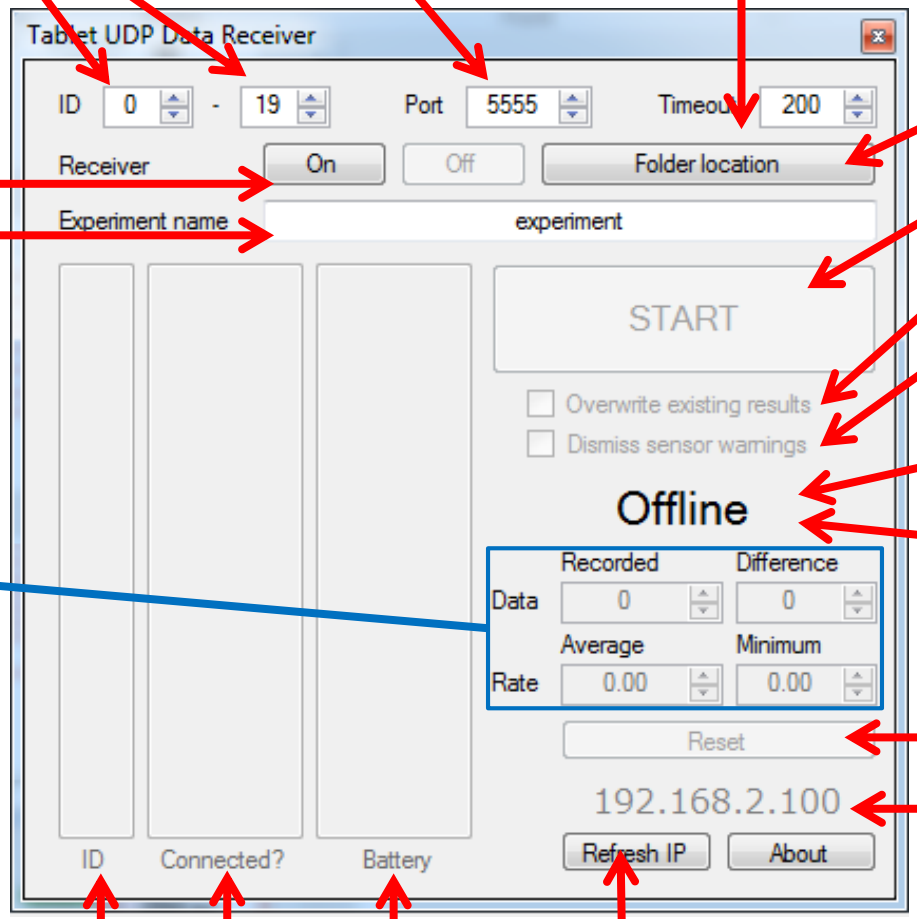
Rotation vector (computed by OS)

Pressure (only in some devices, hardware)

Battery temperature (hardware)

Check if you want to include checked sensors (by default only main hardware data are stored). Sensors need to be re-checked every time the app is reloaded.

⑤ Receiver settings



Tablet ID range from/to

Receiving port *

Timeout (used to decide if a tablet is working or not, also consider streaming frequency)

Storage folder

Turn on/off receiver

Experiment name

Start/stop recording

Overwrite data

Neglect sensor warning (error given if sensor off)

Connection status

Receiving frequency (only when online)

Record statistics:
- Saved data
- AVG frequency
- Lowest frequency
- Min/Max difference

Reset statistics

PC IP address

Warning:
Latest version interface is slightly different.

Tablet ID

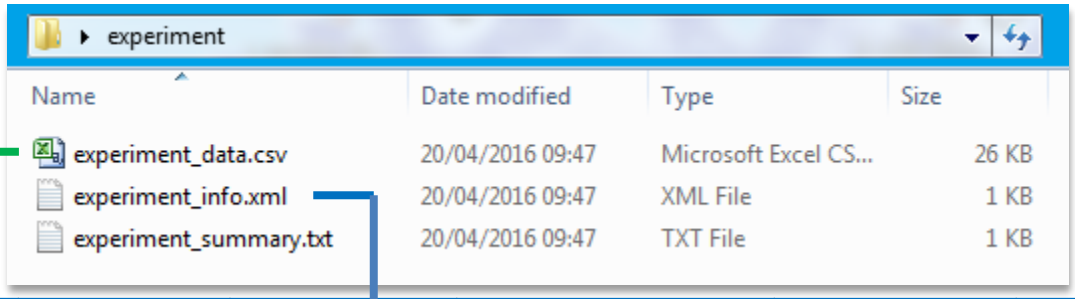
Connection
（True = Connected, False = Offline）

Battery charge

Refresh IP

* Firewall exception should be added if port or data are not received (5555 suggested)

⑤ Storage file



NodeId	ExpTimeStart	PCTimeStart	UnixTimeStart	ExpTimeStop	PCTimeStop	UnixTimeStop
0	0	35274.395	1461113231.63322	1.289090157	35275.704	1461113232.92231
1	0	35274.388	1461113232.40186	1.329349995	35275.706	1461113233.73121
2	0	35274.393	1461113232.04276	1.309210062	35275.705	1461113233.35197

1	0	35274.39	1461113232.40186	3	-0.345	-0.224	10.162	4	-0.002	0	0.003	5	30.84	20.999	66.06
2	0	35274.39	1461113232.04276	3	-0.548	0.313	9.997	4	-0.001	0	0.001	5	52.379	-4.379	59.879
0	0	35274.4	1461113231.63322	3	-0.415	0.301	10.149	4	0	-0.001	0	5	-18.48	26.819	44.099
1	0.02014	35274.4	1461113232.42200	3	-0.298	-0.269	10.169	4	0	0.001	0.004	5	30.84	21.12	65.939
2	0.02014	35274.41	1461113232.06290	3	-0.524	0.27	9.935	4	0.003	-0.001	0.001	5	52.26	-4.619	59.819
0	0.02014	35274.42	1461113231.65336	3	-0.405	0.339	10.135	4	0.002	0.001	0	5	-18.48	26.759	43.86
1	0.04028	35274.42	1461113232.44214	3	-0.293	-0.257	10.131	4	-0.001	0	0.004	5	30.719	21.12	65.88
2	0.04029	35274.43	1461113232.08305	3	-0.517	0.329	9.959	4	0	0	0.001	5	52.319	-4.739	59.698
0	0.04028	35274.44	1461113231.67350	3	-0.407	0.313	10.168	4	0	0	0	5	-18.66	26.999	43.86

ID ExpTime PCTime UnixTime

Accelerometer (x,y,z) Gyroscope (x,y,z) Magnetic field (x,y,z)

6 = GPS position
7 = GPS speed
8 = GPS UTC time

81 = Orientation
82 = Linear acceleration
83 = Gravity

84 = Rotation vector
85 = Pressure
86 = Battery temperature

* In tablet stored data ExpTime and PCTime are not used, battery status is saved instead (0…100).
UnixTime is stored in column 3 and subsequent sequence is the same.