

Developing New Possibilities of Human-Computer Interaction with MEMS-Sensors and a Cube-like Display



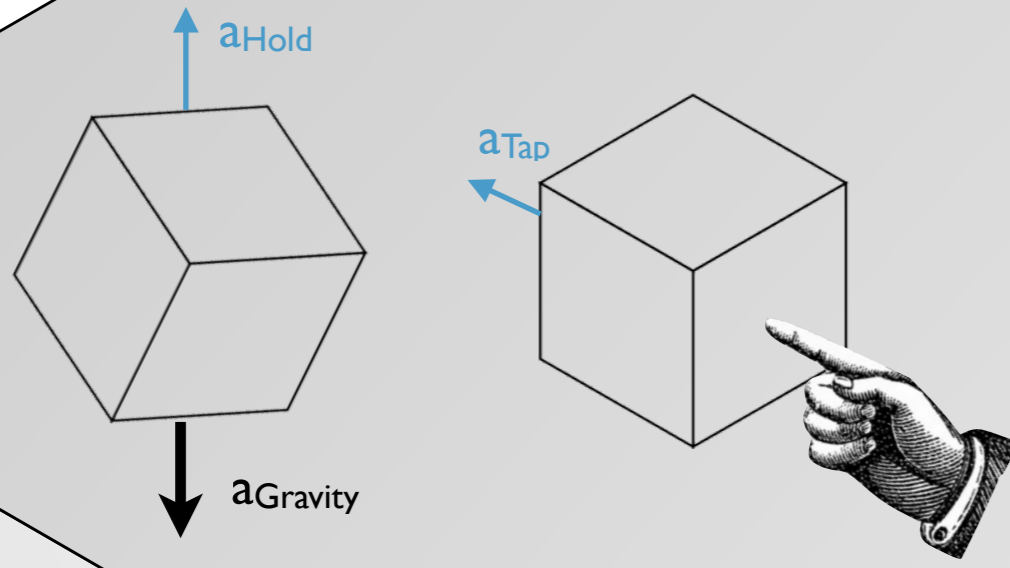
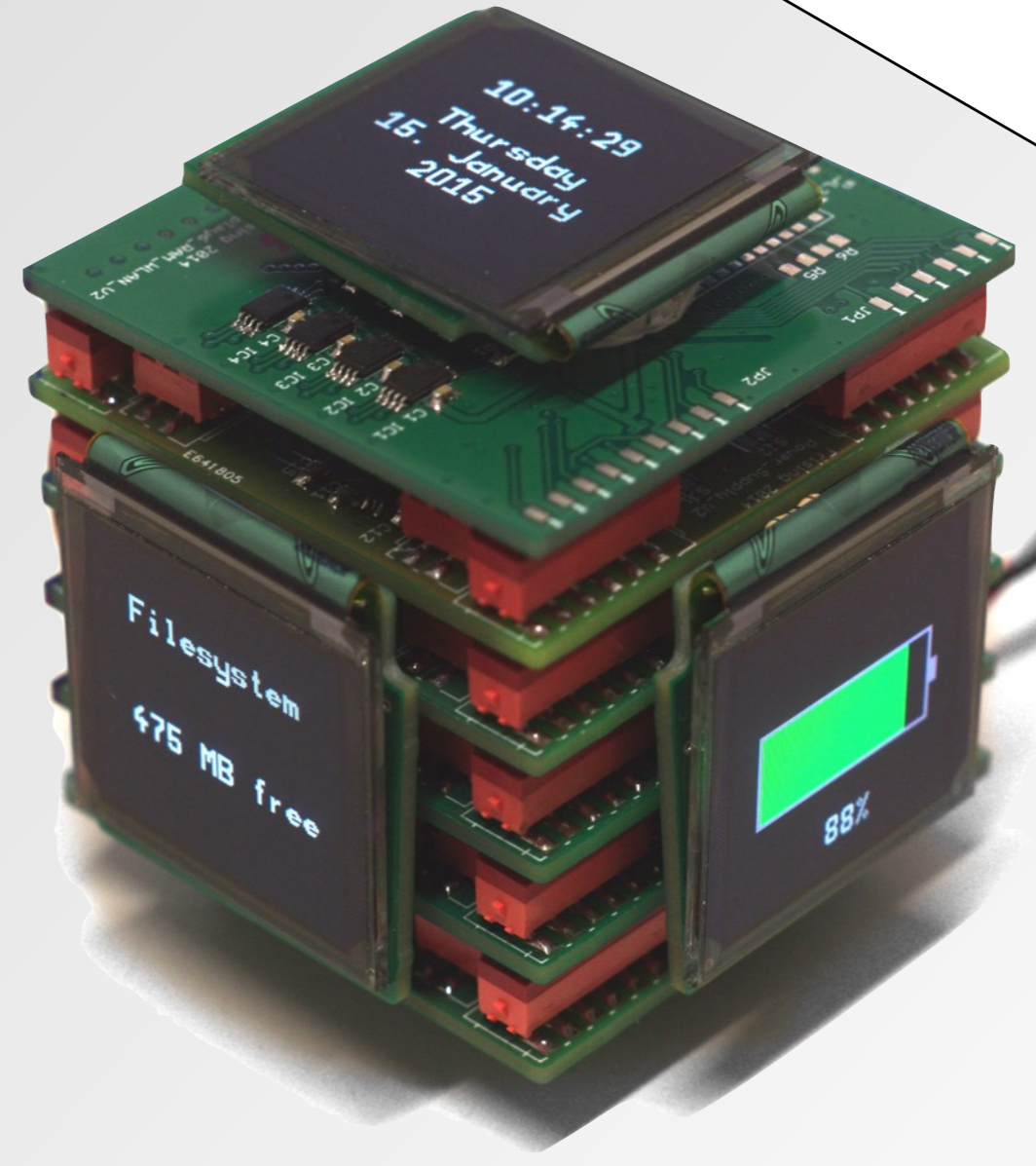
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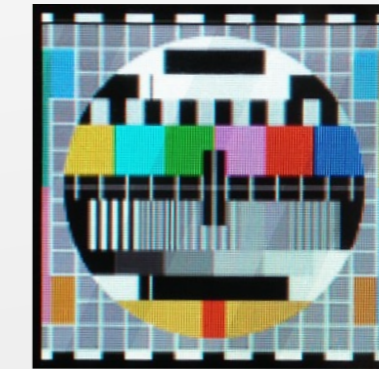
Concept

- ◆ Handheld-device
- ◆ Shape of a cube
- ◆ Display on every side
 - ➔ Making the whole surface a GUI
- ◆ Control via acceleration sensor
 - ➔ Rotation of the cube
 - ➔ Taps on the cube's surface
- ◆ Battery-powered
 - ➔ Inductive charging system
- ◆ Wireless module
 - ➔ Connection to other devices
 - ➔ Connection to the internet



Displays

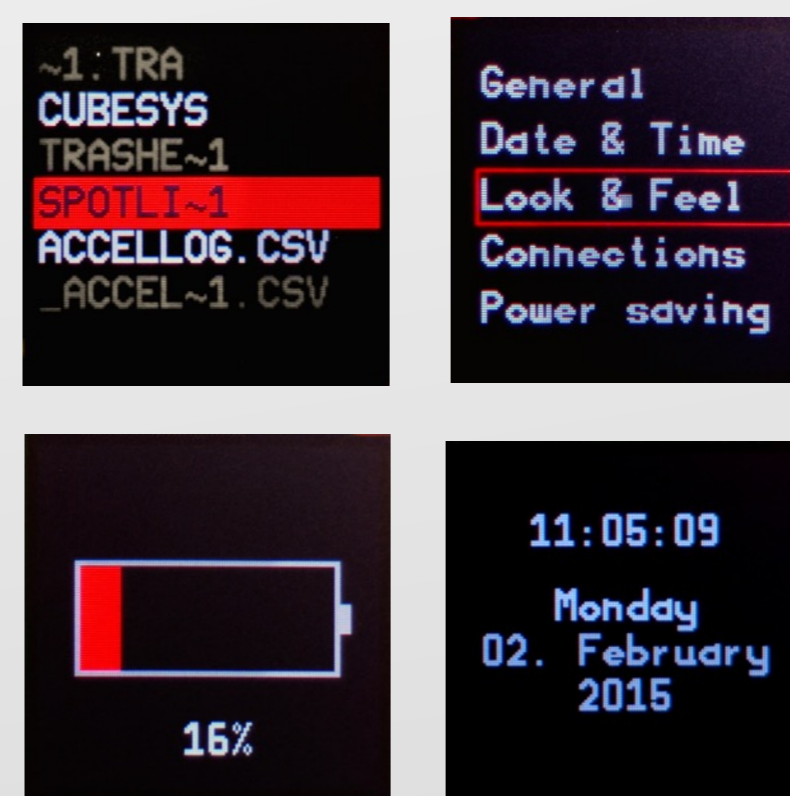
- ◆ OLED-displays
 - ➔ High viewing angles
- ◆ 1:1 ratio (square)
- ◆ 128 x 128 pixels
- ◆ 6 bit color depth
- ◆ Internal RAM
 - ➔ Enables partial update of the screen
- ◆ Parallel interface (18 bit)
 - ➔ Common for all displays



Microcontroller-Platform

- ◆ XMOS XS1 microcontroller-platform
- ◆ 16 logical cores on 2 interconnected chips
 - ➔ Can execute up to 1000 MIPS together

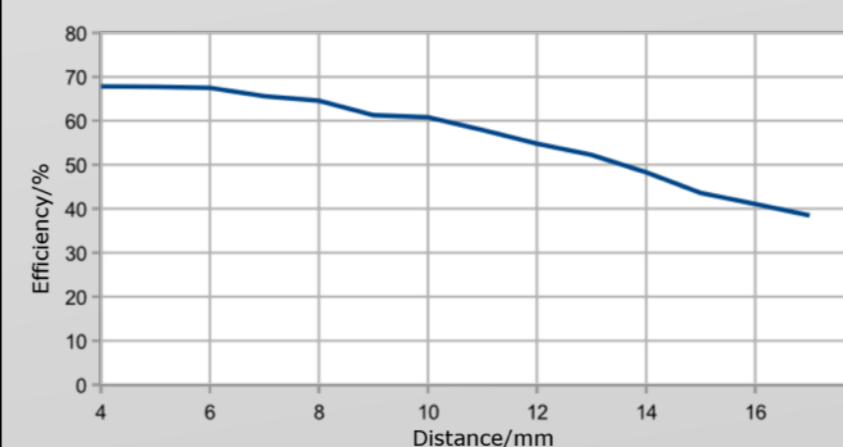
Graphics



- ◆ Main menu is divided in 6 areas
 - ➔ An area shows basic information on one side when closed.
 - ➔ It can be opened by tapping on it.
 - ➔ In opened mode, an area displays more detailed information and can expand to multiple sides.
- ◆ Content rotates according to the device orientation.
- ◆ Cursor is used to navigate. (always points upwards)
- ◆ Black background
 - ➔ Saves energy

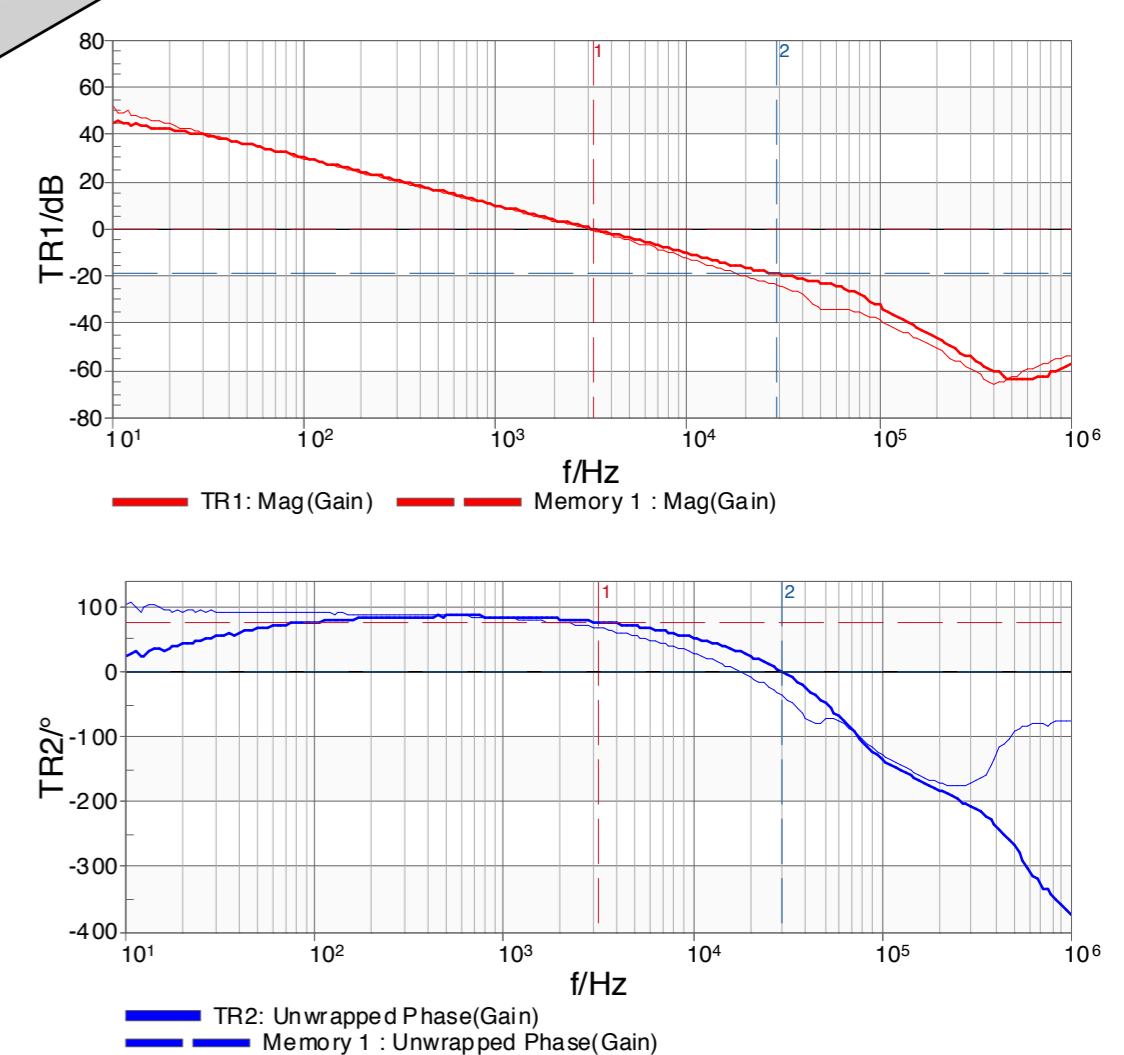
Power-Control

Charging Efficiency



- ◆ Internal battery: Li-Pol 3,7V 560 mAh
- ◆ Display panel voltage: 16,5V
- ◆ Display logic voltage: 3,3V
- ◆ Controller core voltage: 1V

Bode-Plot of +16,5V Step-Up-Switcher



Sensor

- ◆ 3-axes acceleration-sensor
- ◆ Sampling rate: 3200 Hz
- ◆ Measuring range: ±8 g

Orientation-Registration

- ◆ Holding the cube in hands under earth gravity applies an acceleration of +1 g to it, pointing in the opposite direction.
- ◆ Acceleration vector separates in 3 parts. (x-, y- and z-axis)
- ◆ Reconstructing the vector using trigonometric functions.

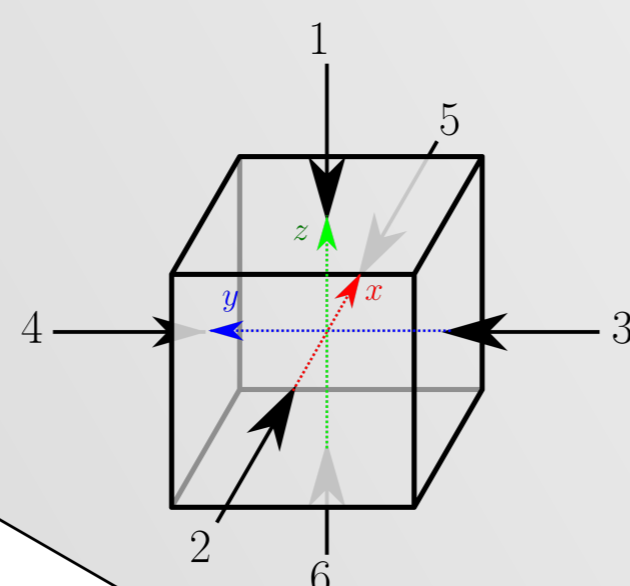
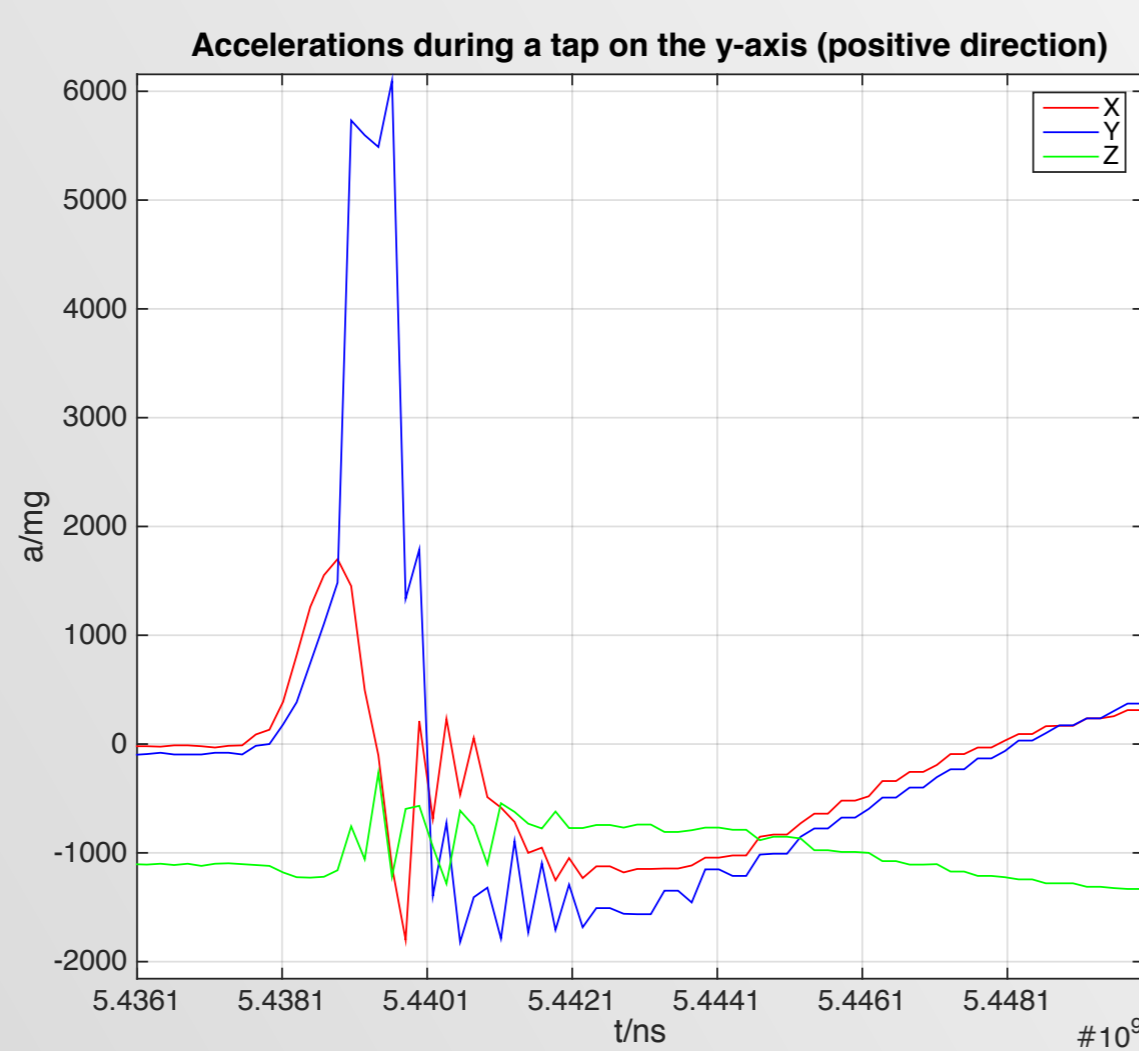
$$\Theta = \arctan \frac{a_x}{\sqrt{a_y^2 + a_z^2}}$$

$$\Psi = \arctan \frac{a_y}{\sqrt{a_x^2 + a_z^2}}$$

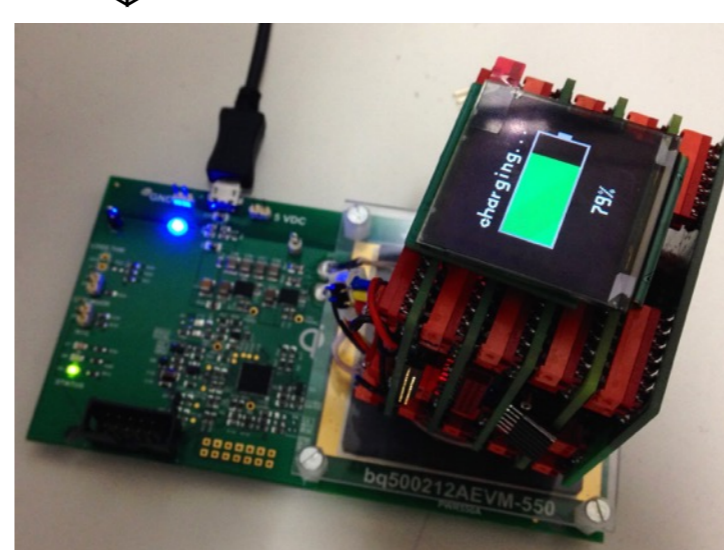
$$\Phi = \arctan \frac{\sqrt{a_x^2 + a_y^2}}{a_z}$$

Tap-Registration

- ◆ Taps on the surface result in very short, strong accelerations.
- ◆ Assigning the tap to a side of the cube by identifying:
 - ➔ Dominant axis during the tap
 - ➔ Direction of the peak



We would like to thank the following companies for their support:



Cursor	Frequency	Trace 1	Trace 2
Cursor 1 :	3.202 kHz	0,000 dB	76,805 °
Cursor 2 :	29.801 kHz	-19,238 dB	113,687 °
Delta :	26,599 kHz	-19,238 dB	-76,805 °