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

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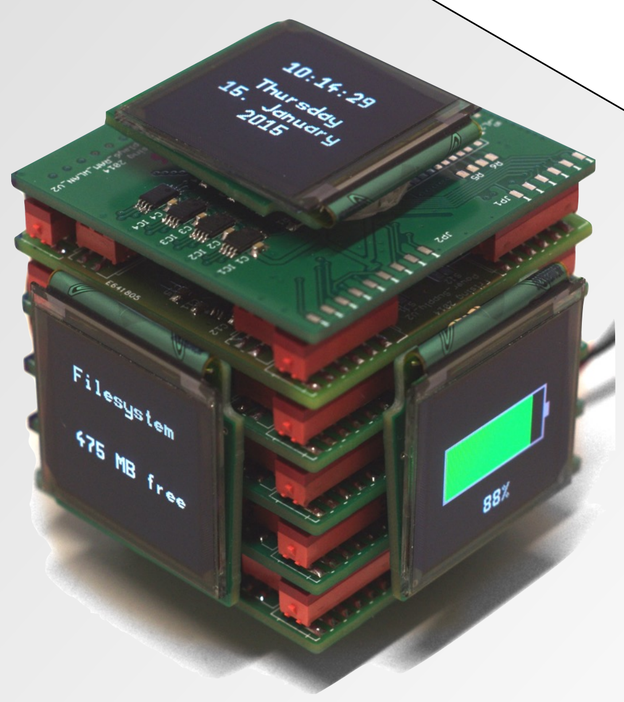
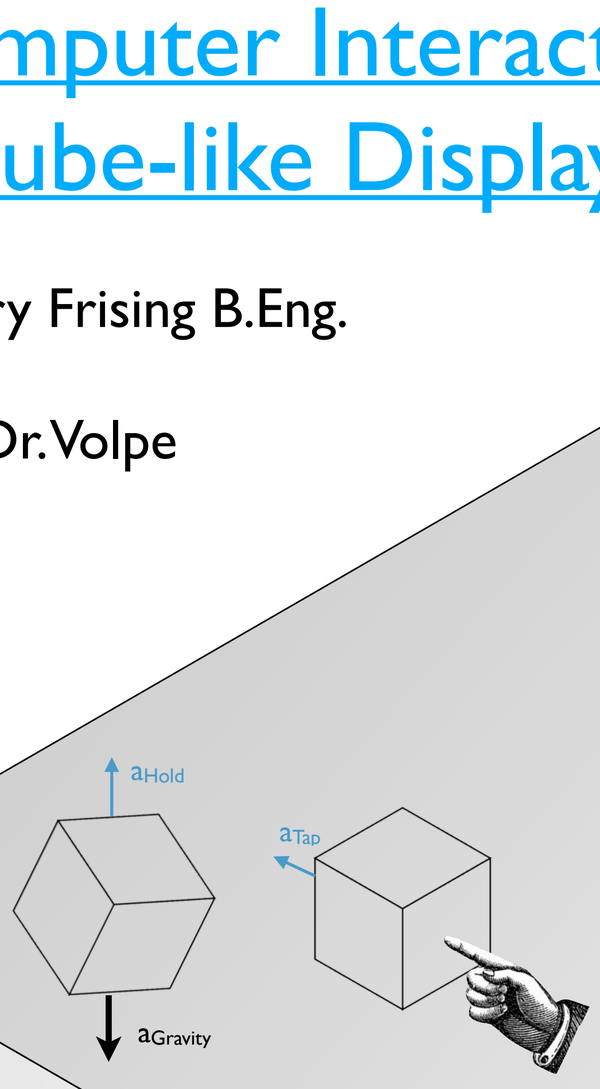
Concept

- 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





Sensor

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

Microcontroller-Platform

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

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

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.

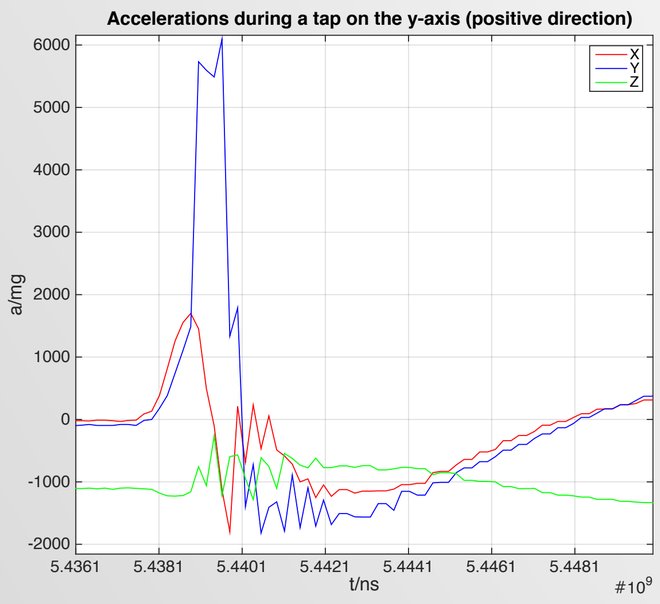
$$\Theta = \arctan \frac{a_x}{\sqrt{a_y^2 + a_z^2}}$$

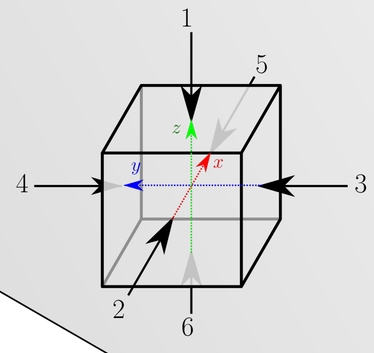
$$\Psi = \arctan \frac{a_y}{\sqrt{a_x^2 + a_z^2}}$$

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

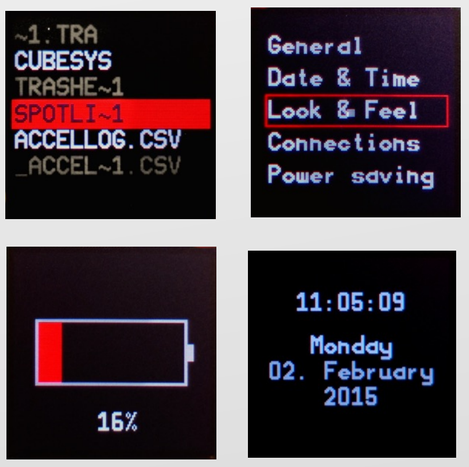
Tap-Registration

- 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





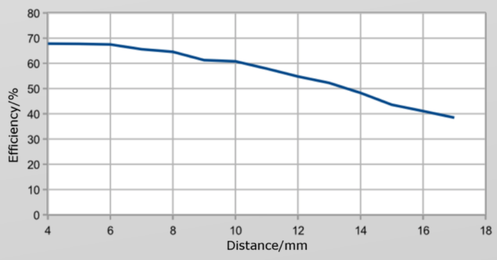
Graphics



- 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

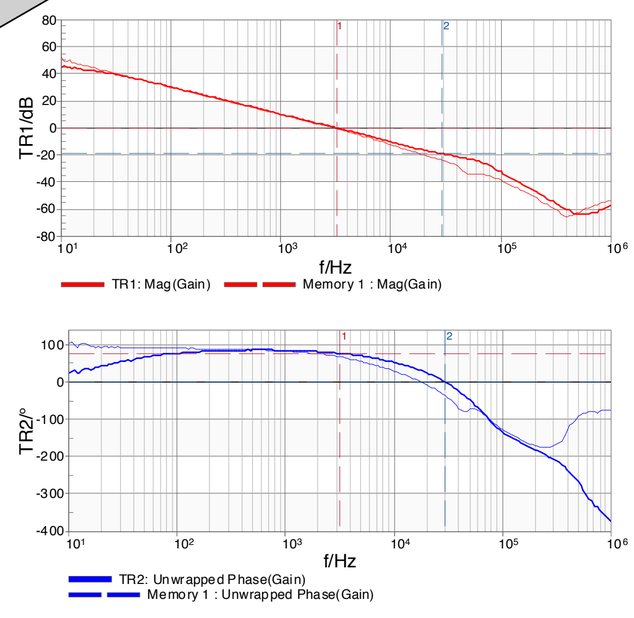
Charging Efficiency



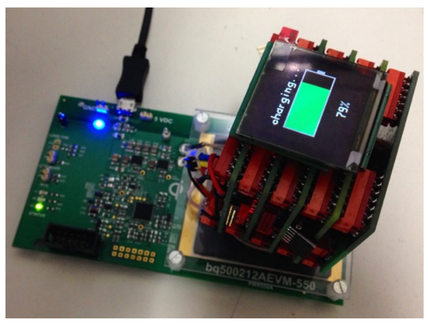
- Qi-compliant inductive charger
- Charging coil behind one of the displays

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

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



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 f°
Delta :	26,599 kHz	-19,238 dB	-76,805 °



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