

LFE Medieninformatik • Markus Zimmermann

Touch Sensing with Time Domain Reflectometry

Advisor: Raphael Wimmer

Professor: Prof. Dr. Heinrich Hußmann

Student research project





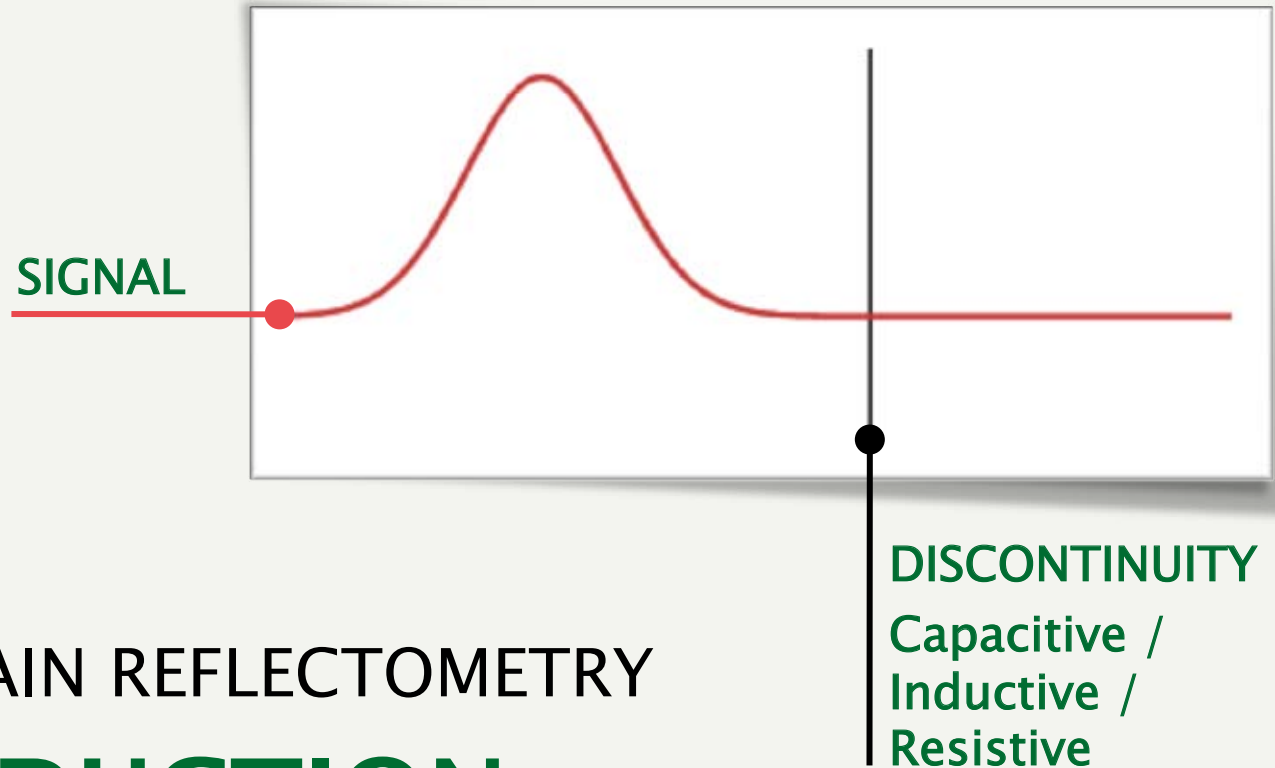
MINIATURISED DEVICES

REQUIREMENTS FOR PROTOTYPES:

SMALL / ANY SHAPE / TANGIBLE / TOUCH RECOGNITION

MOTIVATION

Source: Oleg Alexandrov [1]



TIME DOMAIN REFLECTOMETRY

INTRODUCTION

Literature: Rako2007, Agilent2006, Cole1977, Schmitt1999



PRESENT USAGE

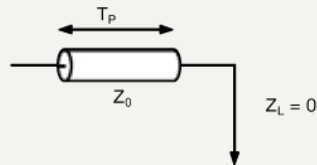
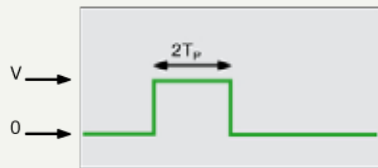
- **Wiring maintainance**
communication, aviation
- **Agricultural and geotechnical**
moisture, slope movement
- **Semiconductor/circuit analysis**
- **New Approach:**
Touch Sensing



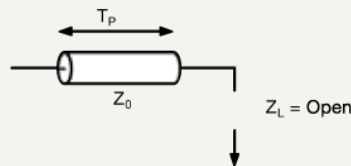
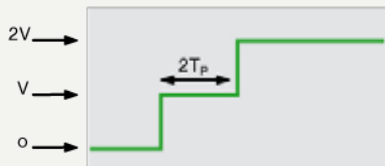
REFLECTIONS

TERMINATION

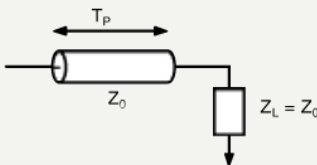
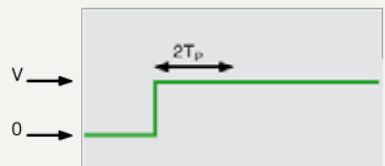
- Short Circuit



- Open Circuit

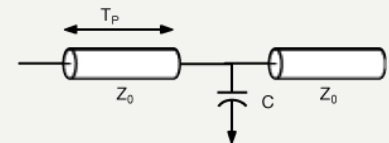
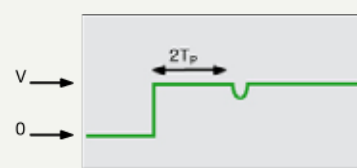


- Matched Load

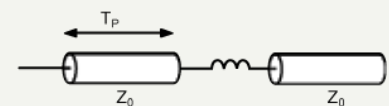
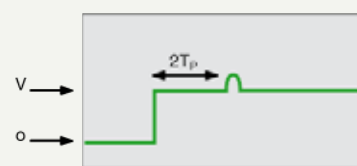


DISCONTINUITIES

- Shunt Capacitance



- Series Inductance



- Combinations of capacitive and inductive

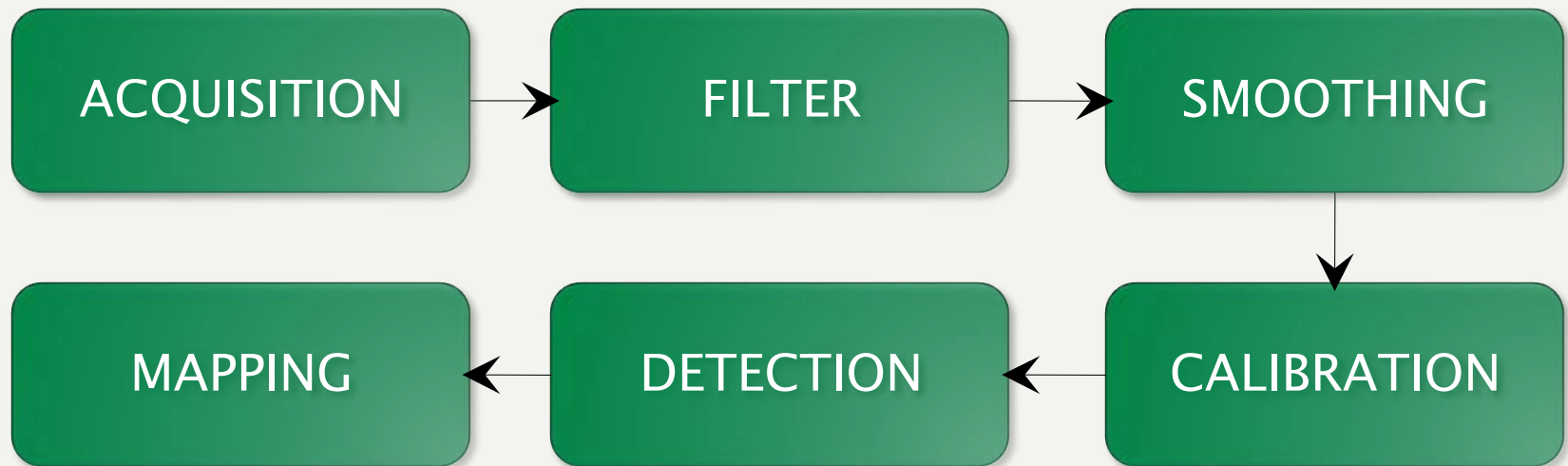
Source: Tektronix [2]

HARDWARE: TEKTRONIX 1502



CHARACTERISTICS

- 1975
- **Peak:**
140 ps risetime
- **Resolution:**
10 mm separable



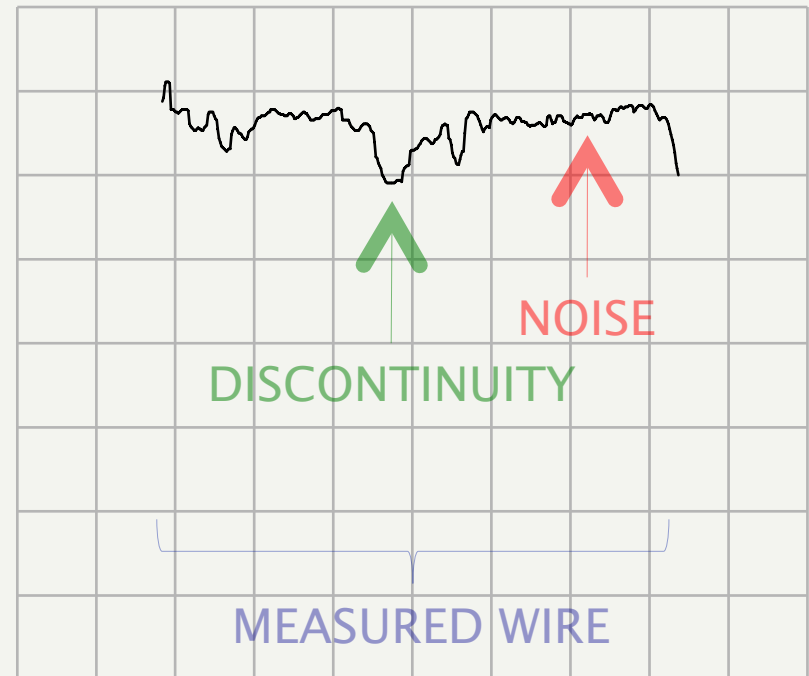
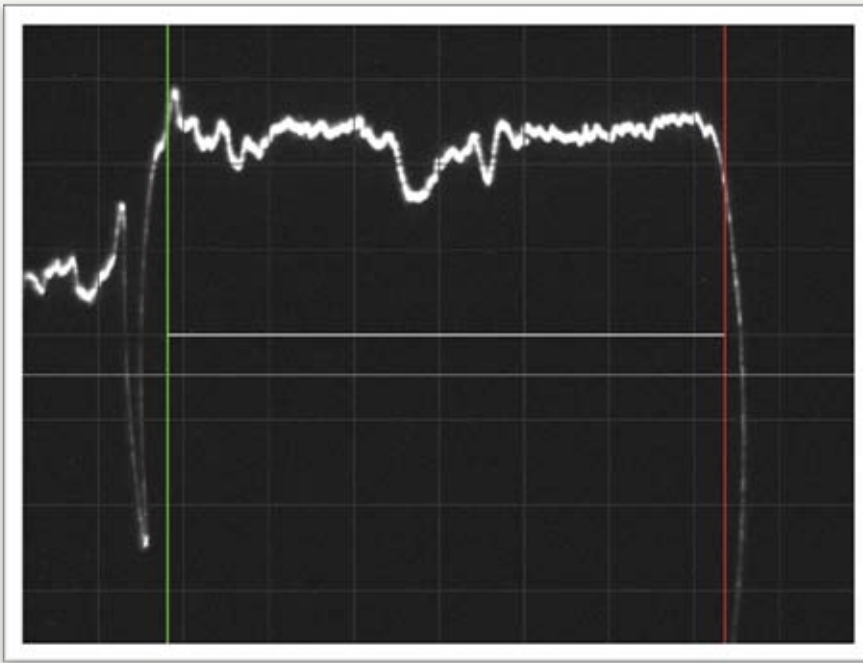
STAGES

SIGNAL ANALYSIS

1. ACQUISITION

**FIREFLY
CAMERA CAPTURING**

**OPENCV
IMAGE ANALYSIS**



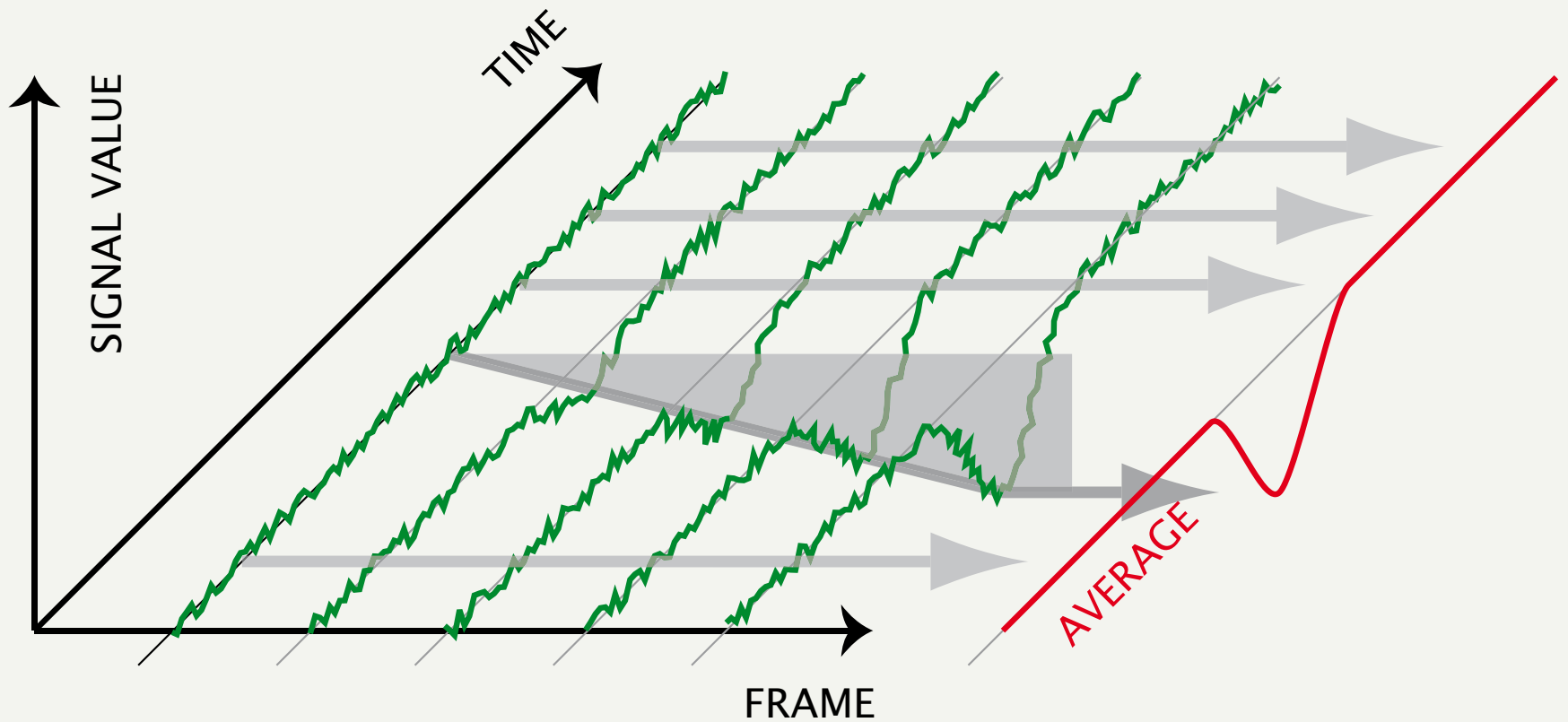
2. MOVING AVERAGE FILTER



- HF peak **attenuation**
- Extrema better **locatable**
- Imagewise **jitter** remains



3. ADAPTIVE AVERAGE SMOOTHING



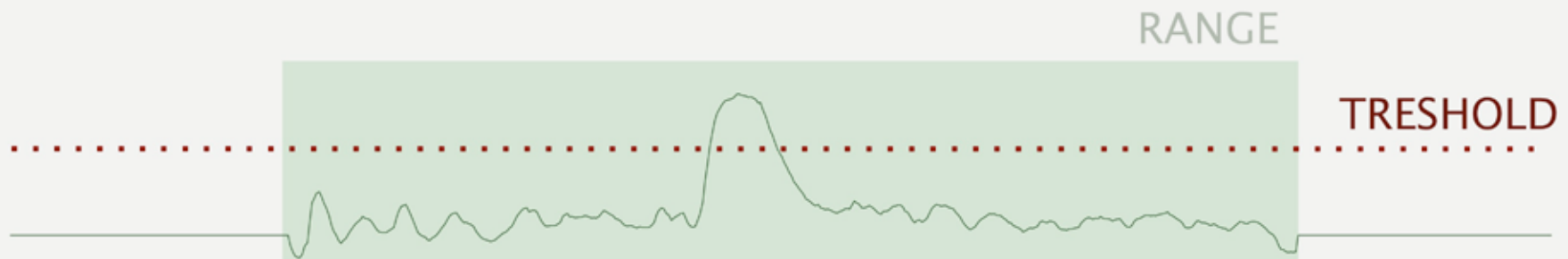
4. CALIBRATION

CLEAN SIGNAL

- **Combination** of multiple filter stages
- Baseband signal: **delta** of current and idle state signal

RANGE & THRESHOLD

- **Range**: length of measured conductor
- **Threshold**: signal-to-noise ratio

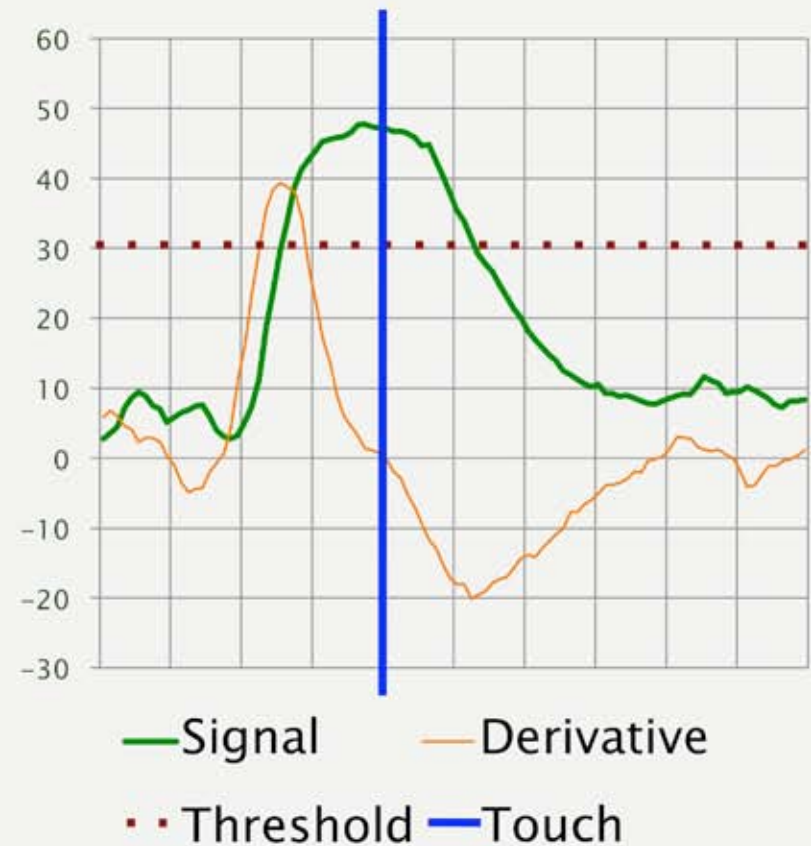




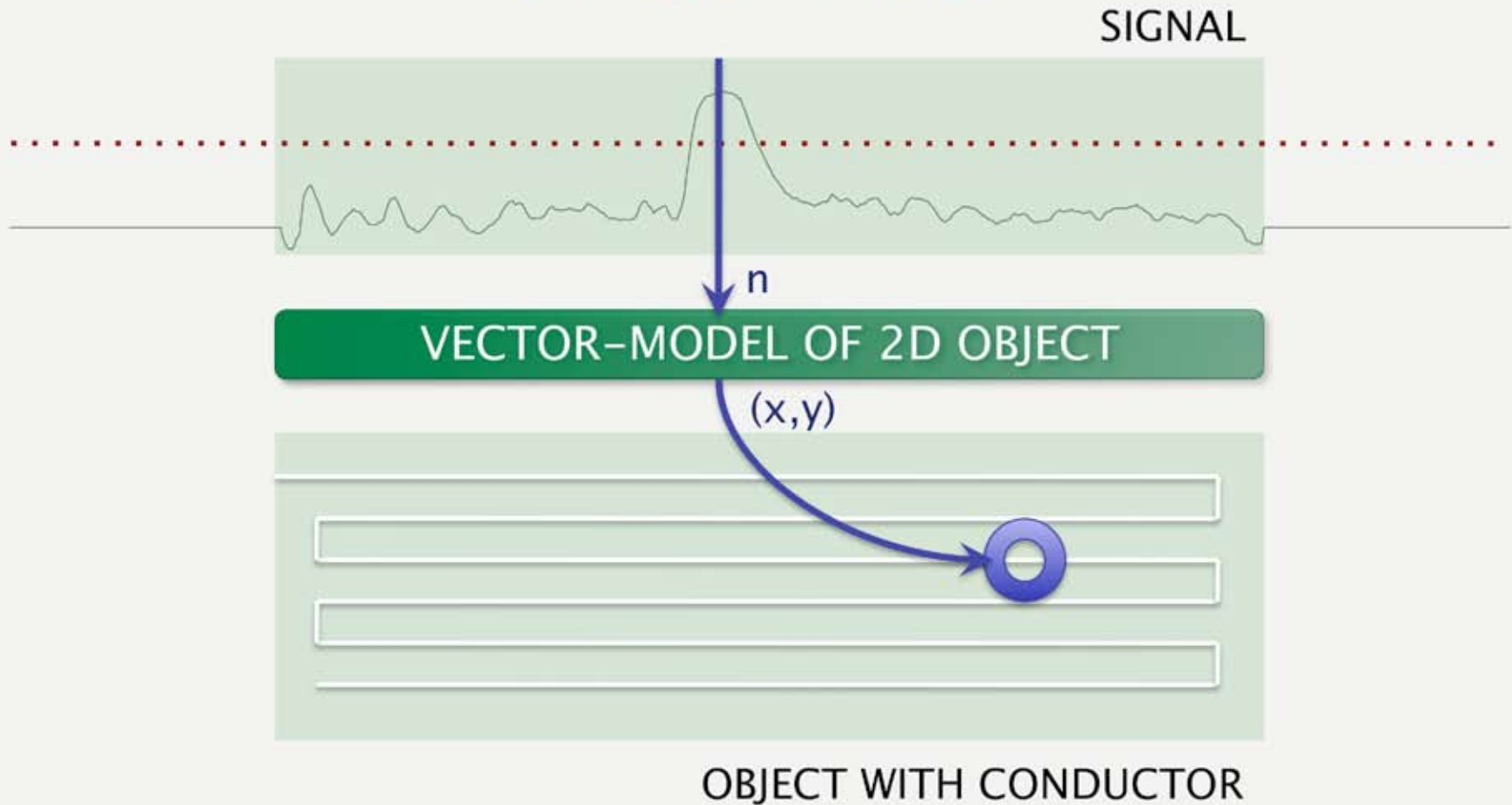
5. DETECTION

CONDITIONS:

1. Signal $>$ Threshold
2. Derivative = 0



6. MAPPING





»NICE. BUT: HOW DOES IT FEEL?«

APPLICATIONS

»WIRE«

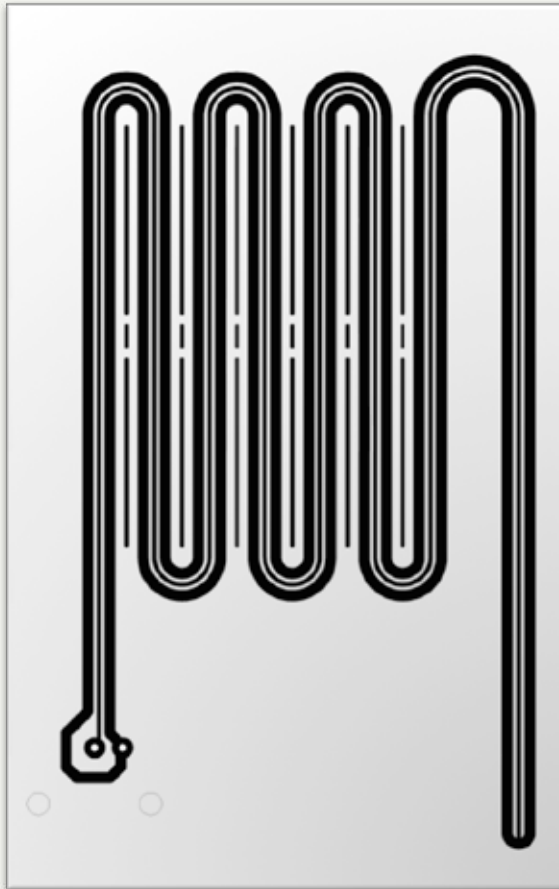


- Unshielded **two-core wire**
- **Short-circuit termination** performs best



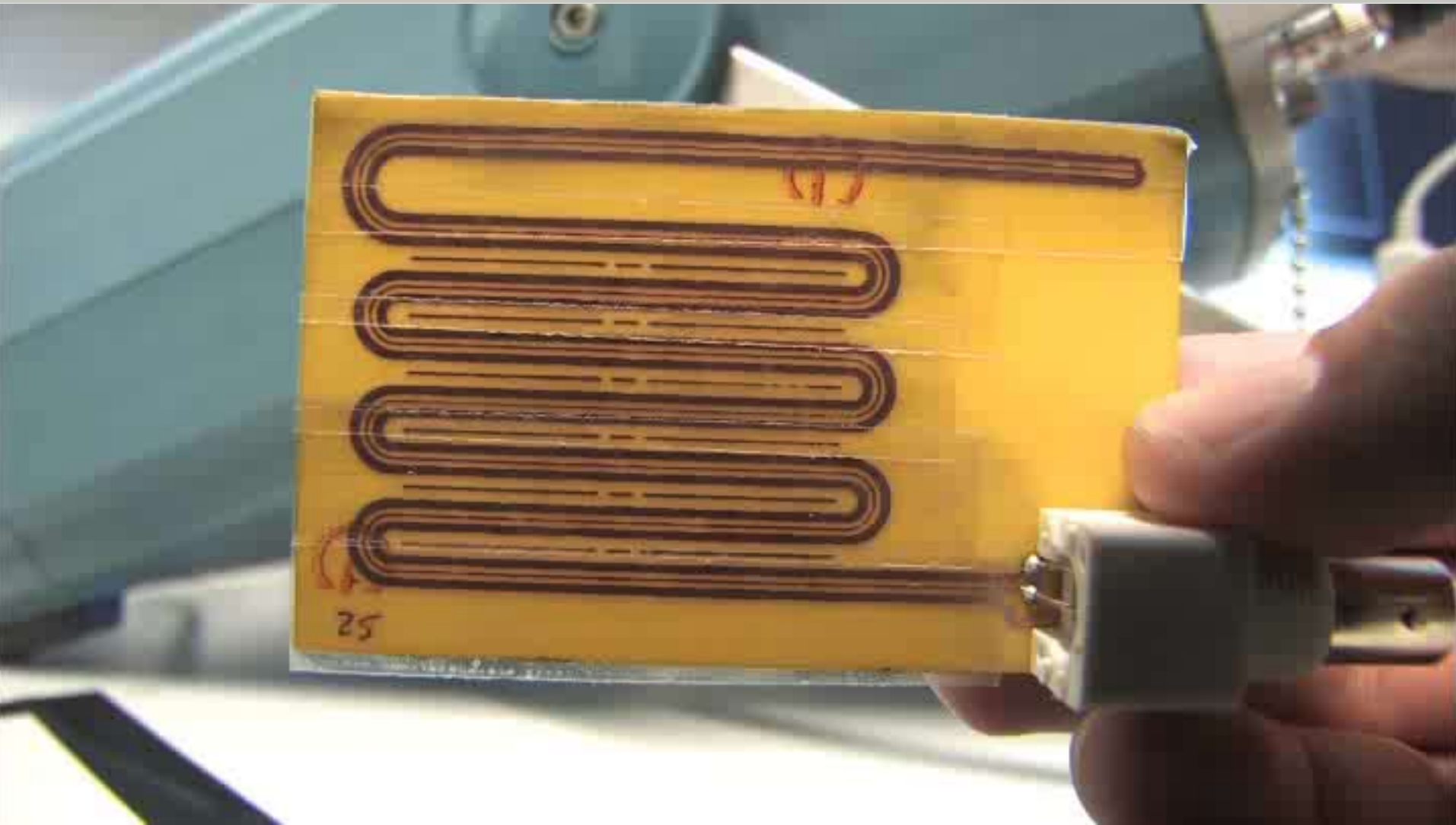


»SNAKE«

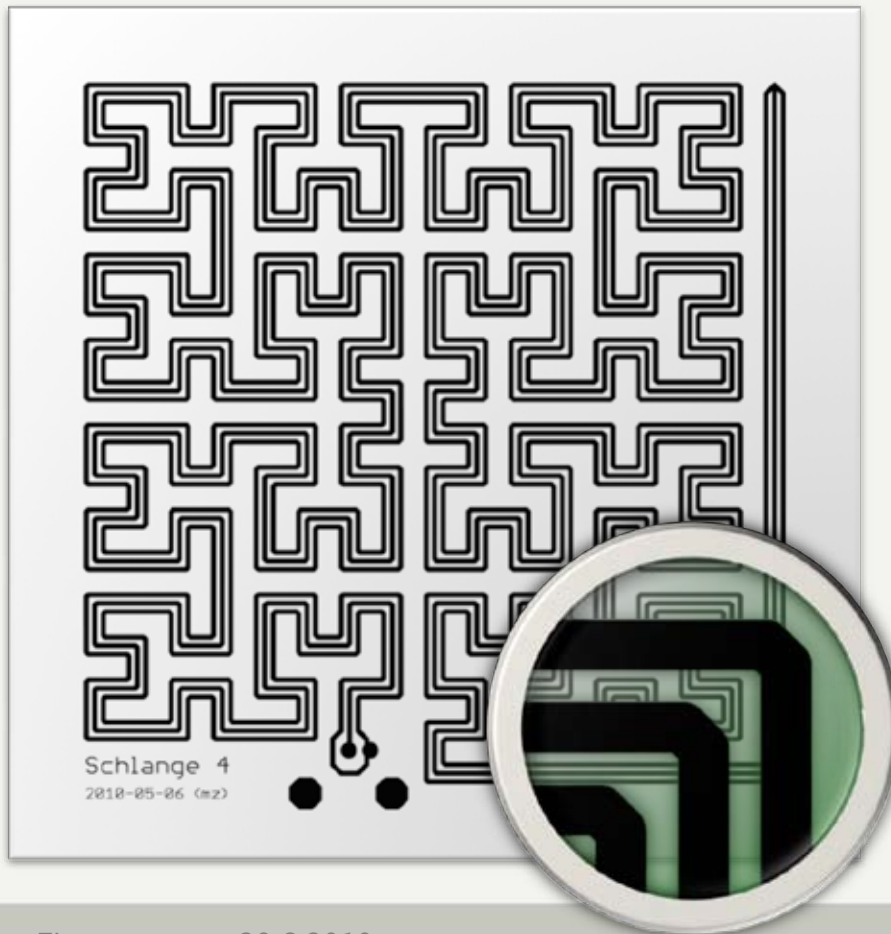


FIRST PCB DESIGN

- coplanar waveguide
- Behavior test
Material
Insulation
Curves
- Raw with big gaps
- *Chi-Fang Huang*
(Huang2009)



»HILBERT«

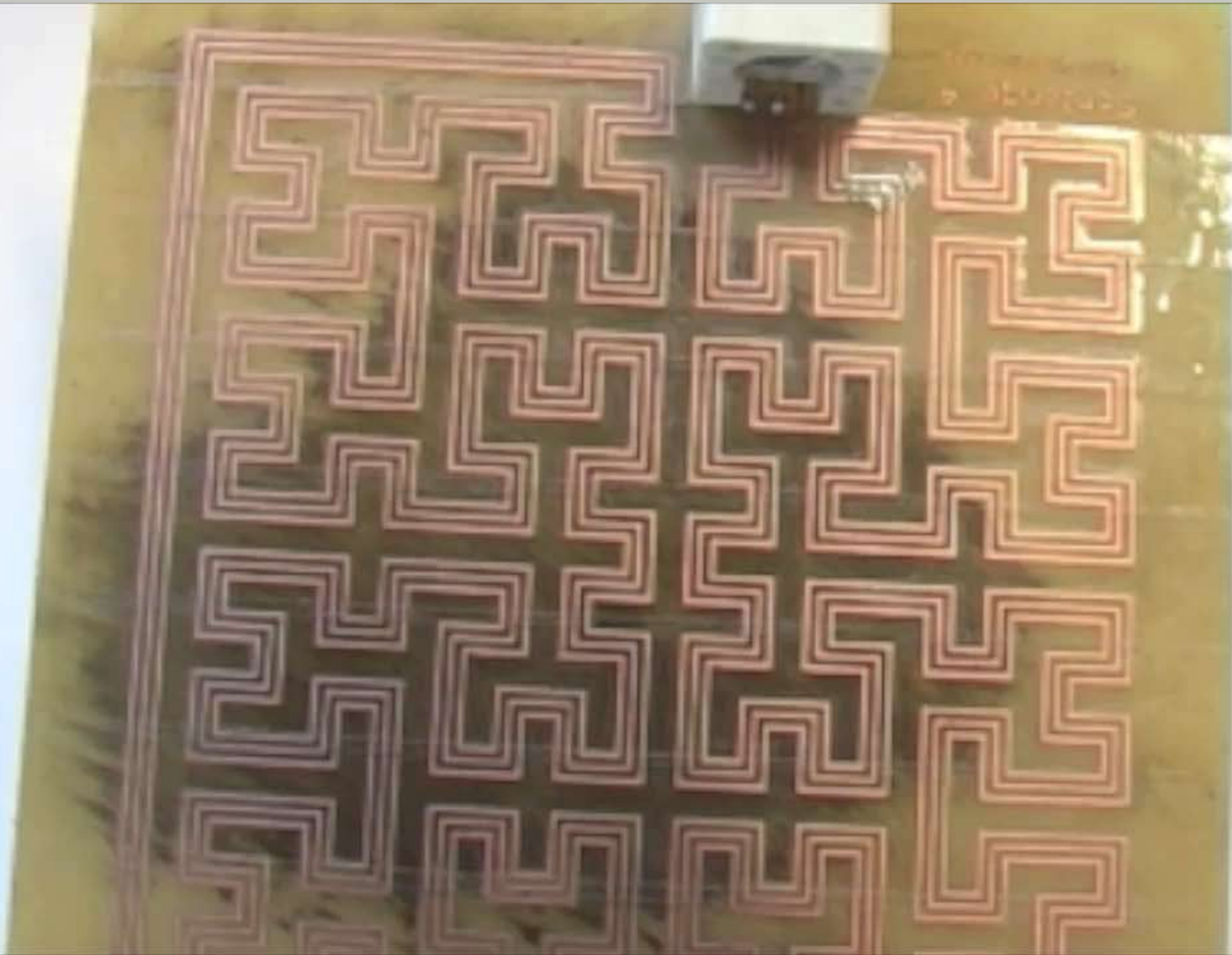


SPACE-FILLING CURVE

- Spatial resolution increased

MITRED BENDS

- Reflections reduced





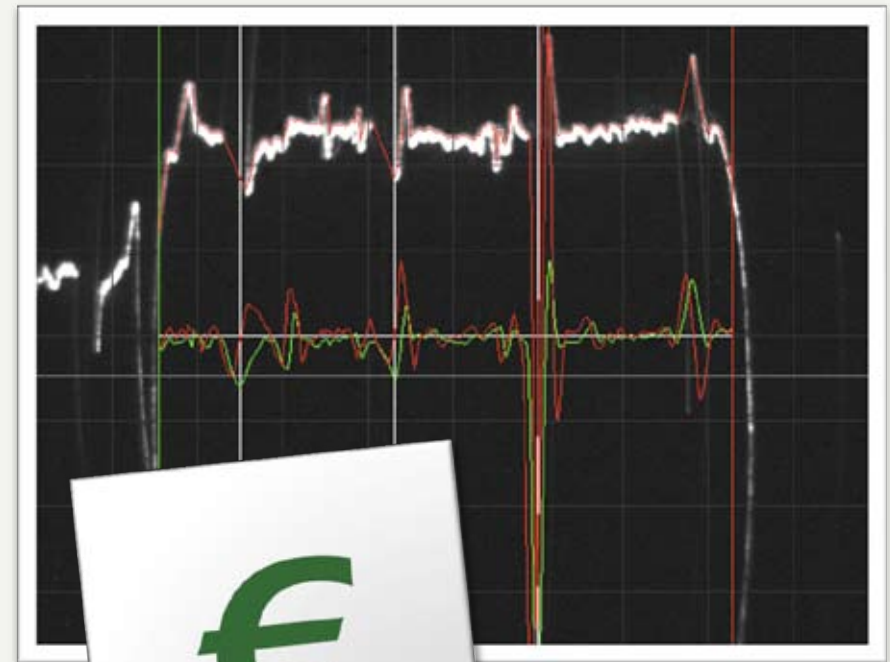
USE CASES: OUTLOOK

- **Wiring 3D Objects**
- **Transparent:** ITO coating
- **Wearable:** conductive twine
- **Gaming:** guitar
- **Guidance:** user tracing

DISCUSSION

PROTOTYPING TECHNIQUE

- Noise
- HF interferences
- Limited resolution:
Affordable
- **Good resolution:
Expensive**



GSM/EDGE



REFERENCES & SOURCES

- **Huang2006:** Huang C, Hung Y. P-53: Precise Location of Touch Panel by Employing the Time-Domain Reflectometry. *SID Symposium Digest of Technical Papers*. 2009.
 - **Rako2007:** Rako P. TDR: taking the pulse of signal integrity. *Electronics Design, Strategy, News*. 2007.
 - **Agilent2006:** Agilent. *Time Domain Reflectometry Theory*. Agilent; 2006.
 - **Cole1977:** Cole RH. Time domain reflectometry. *Annual review of physical chemistry*. 1977;28(1):283-300.
 - **Schmitt1999:** Schmitt R. Analyze transmission lines with (almost) no math. *EDN*. 1999;44(6):143-150.
 - **Tektronix2008:** Tektronix. *TDR Impedance Measurements : A Foundation for Signal Integrity*. Tektronix; 2008.
1. http://de.wikipedia.org/w/index.php?title=Datei:Partial_transmittance.gif
 2. [Tektronix2008]
 3. <http://www.photocase.com/de/photodetail.asp?i=59811>
 4. http://images.businessweek.com/ss/06/08/wow_bridges/source/2.htm
 5. <http://www.photocase.com/de/photodetail.asp?i=183023>