3D Gesture Controller for Advanced User Interfaces-2014/4/3

Agenda

- Introduction
- MGC3130 Release V1.0
- Design-in Step
- MGC3130 Integration
- Colibri Parameterization
- Application Examples

The User Interface Challenge

Ease of Use?

Moisture , Water?

Performance?

Gloves?

Energy Consumption?

Noise?

Distraction?

2D Touch Experience

2D Touch until today

- 2D Touch enabled more room for content
- 2D Touch replaced keyboards
- 2D Touch created smartphones and tablets
- 2D Touch made the Internet mobile

3D Gesture Experience

Time for 3D

More possibilities – easier

Clean – no fingerprints

Hygienic – no germs

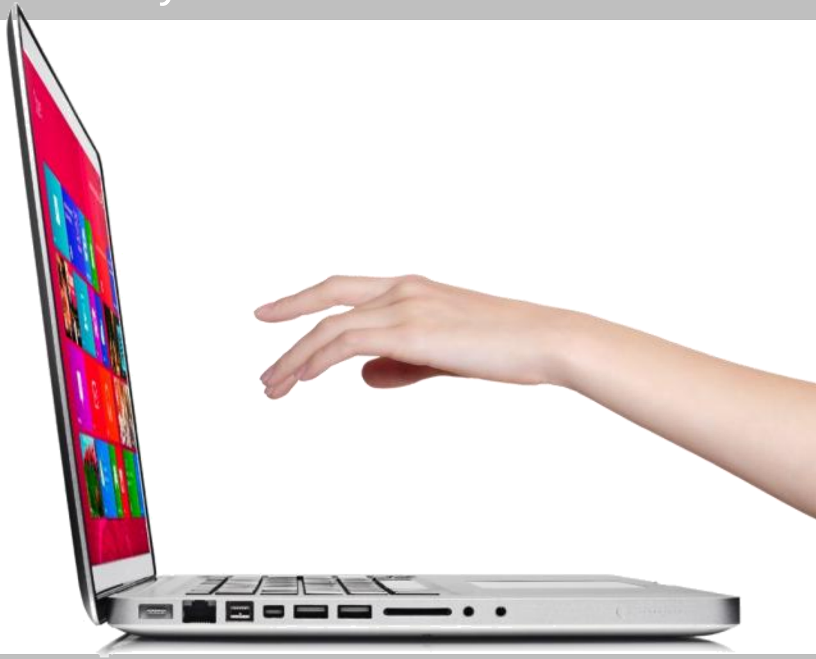
Less disruptive – better concentration

Converge with 2D Touch

How it works

Direct output of gestures, Approach & x/y/z.

Short development cycles. **Short TTM**.



Electrodes
sense user's action

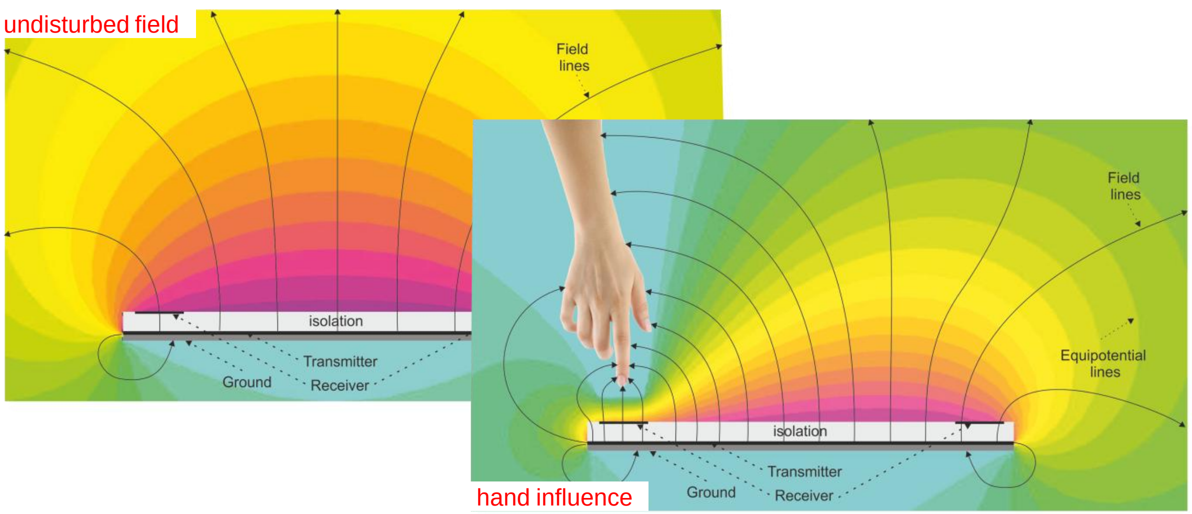
MGC3130
processes signals

host receives pre-processed **gestures** and **x/y/z** positional data

Technology Basics

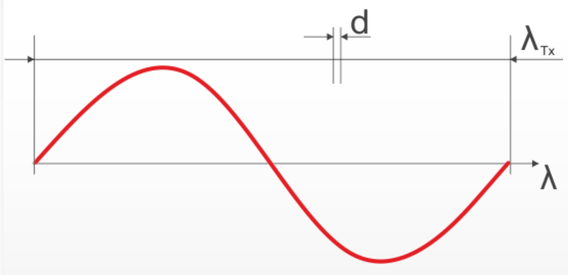
GestIC® Technology utilizes Electrical Near-Field (E-field) sensing for advanced proximity sensing

- E-Fields are generated by electrical charges
  - Field distortions inflicted by a user are translated into 3D hand tracking and gestures
    - Very low power consumption, since nearly no energy is transported



E-field Operation

GestIC Technology Wavelength

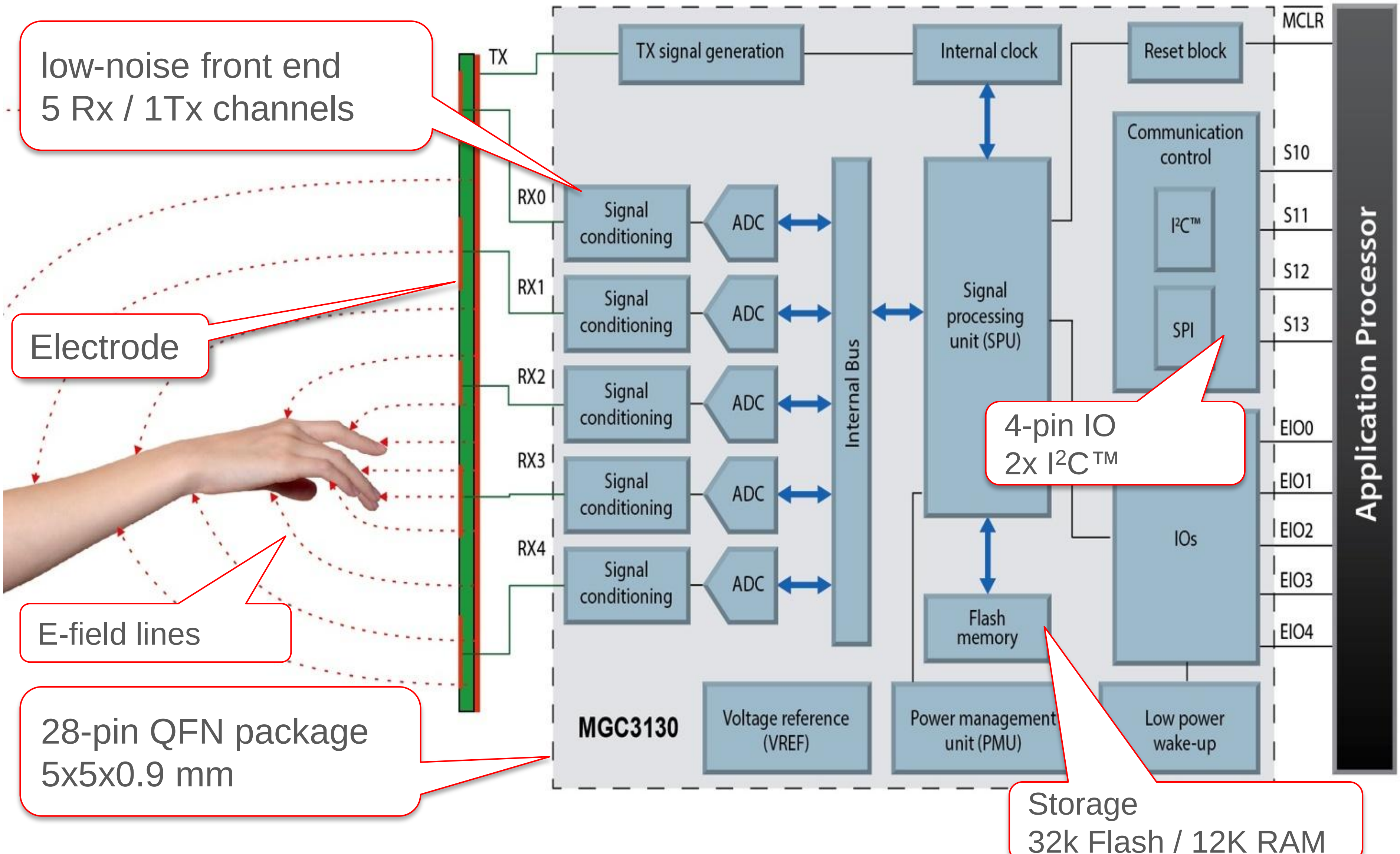


$$\lambda_{Tx} = \frac{c}{f} = 3\text{km (at 100kHz)}$$

electrode dimensions << λ

quasi-static E-field

MGC3130 –Block Diagram



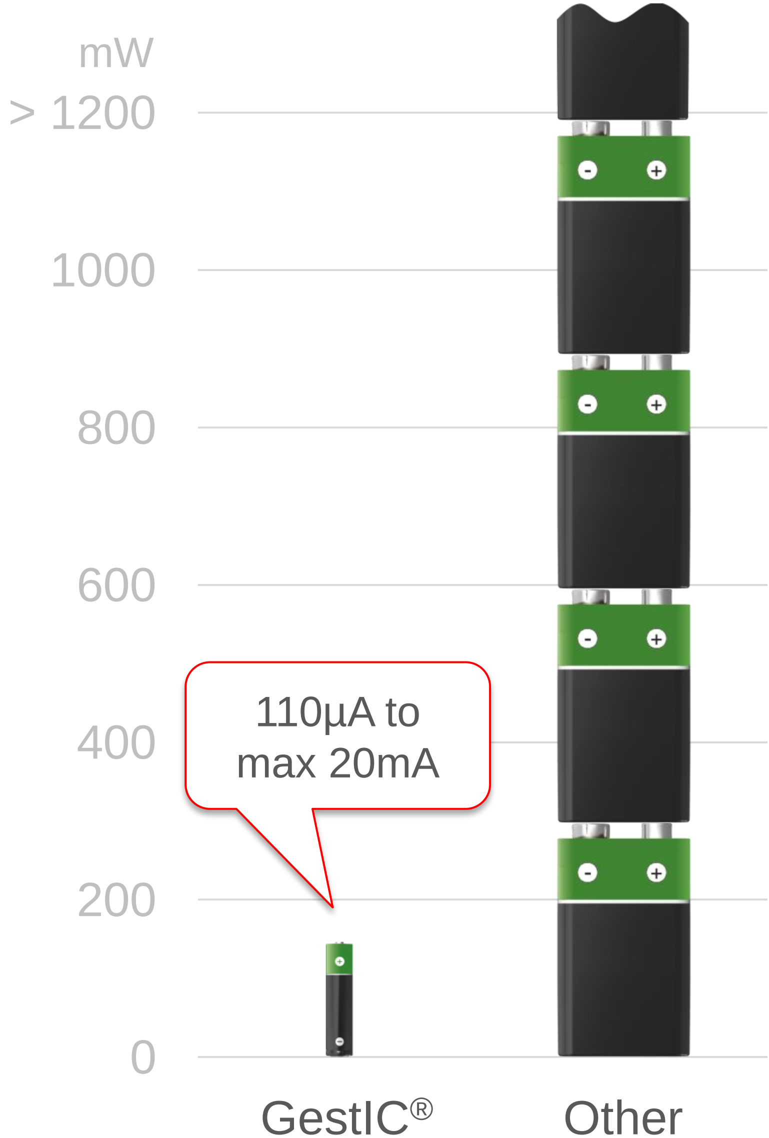
Invisible

sensing electrodes invisible

hidden below device surface

enable appealing industrial designs

Battery Efficiency

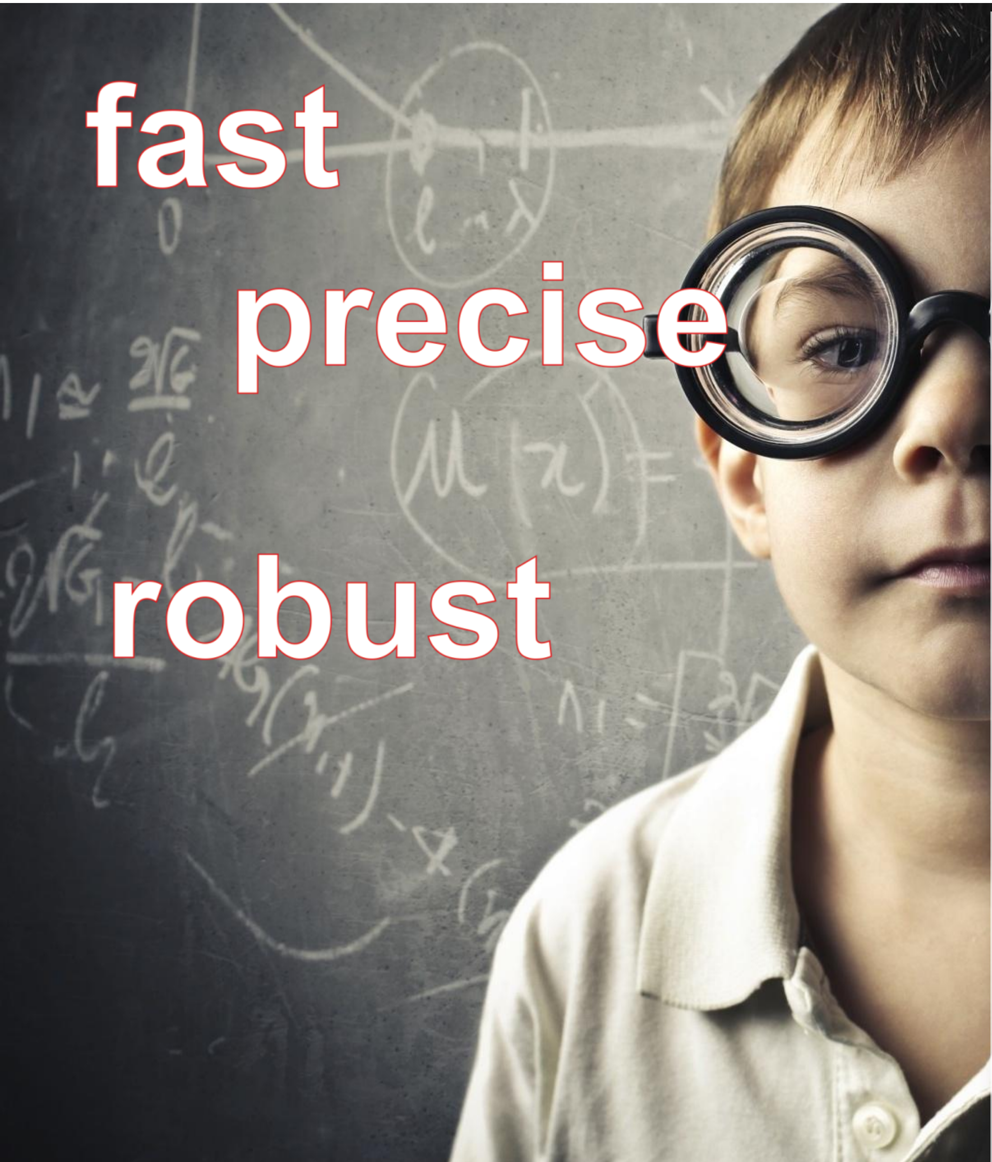


lowest power free-space of any 3D sensing technology

more than 90% lower than camera systems

always-on gesture sensing even for mobile devices

Smart Features



- fast data sampling at 200Hz
- 32-bit signal processing unit
- super low noise analog front end
- mouse-like resolution of 150dpi
- self calibration
- 44 - 115 kHz range - no RF interference
- frequency hopping against noise
- no environmental influences
- self wake-up at 110µA, deep sleep at 9µA
- field upgradable
- I²C and direct port interfaces
- Colibri Gesture Suite on-chip

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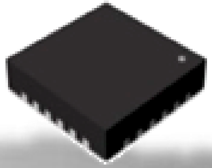
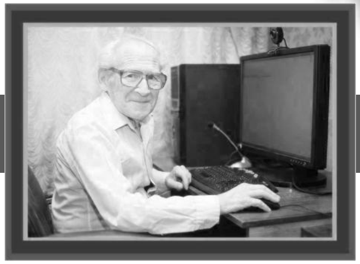
User-Interface Revolutions

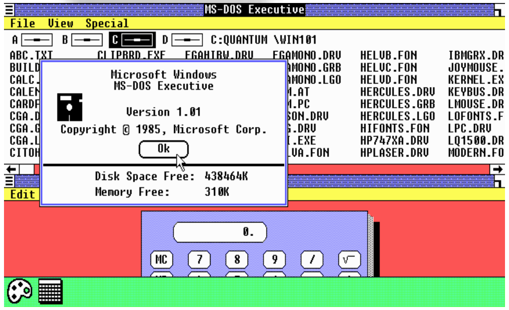
2013
3D GestIC®
by Microchip



1968
Douglas Engelbart
invented the mouse



1970 1990 2010



1985
Microsoft launched
Windows 1.0

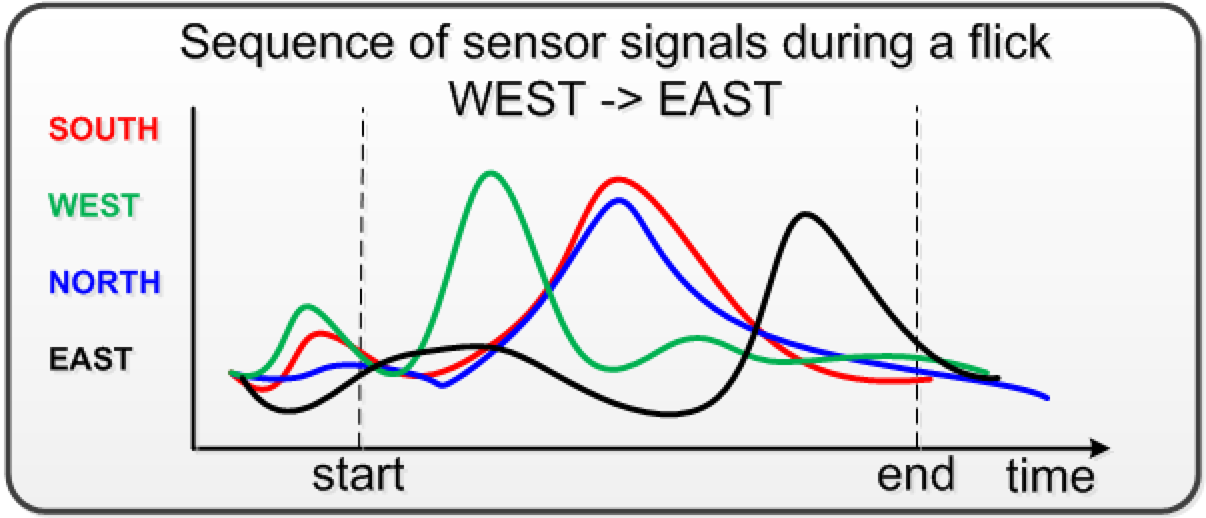
2007
Apple made the
Internet mobile
with 2D touch

V1.0 Software Updates

NEW 5 Sensor Touch
NEW Gesture Airwheel
NEW Gesture Port
NEW Full parameterization/customization via Aurea GUI

2013

Core Feature: Gesture Recognition



Highest gesture recognition rate

Statistical classification based on Hidden Markov Models (HMM)

free-space **gestures**

Gesture Recognition model to detect and classify hand movement patterns performed inside the sensing space

Core Feature: Gesture Recognition

3D gesture recognition

based on Hidden Markov Models

plus 3D hand tracking

Approach

power saving self wake-up

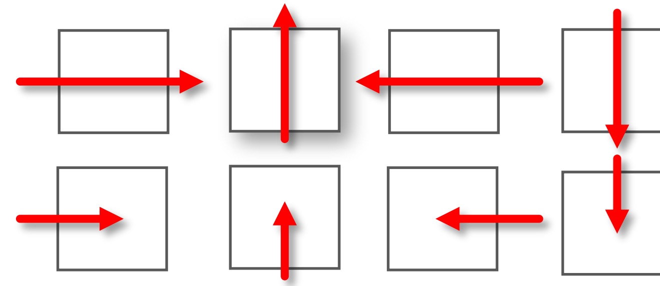
Position Tracking

hand tracking in 3D

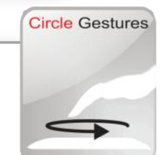
Sensor Touch

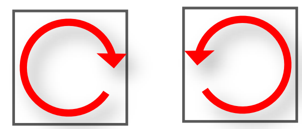
touch, multitouch, tap, double tap

Flick Gestures

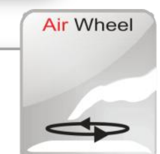


Circle Gestures



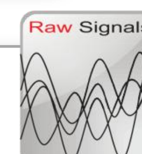


AirWheel



real time rotational control

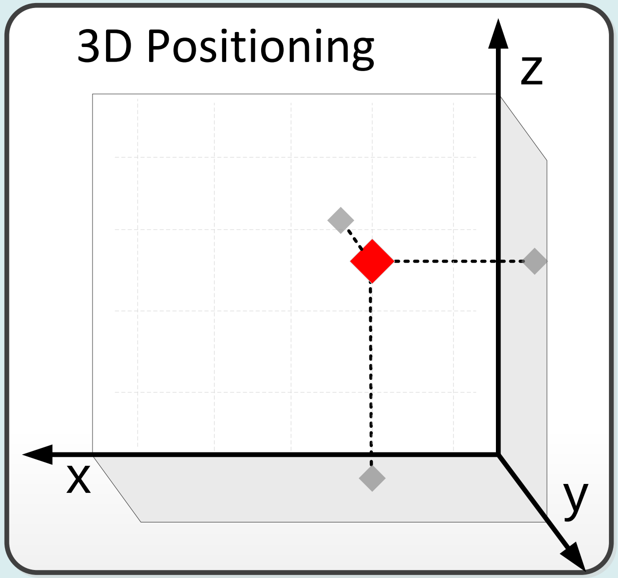
Raw Sensor Signals



Core Feature: Position Tracking

x/y/z hand position on chip

- 3D hand position over time and area
- Absolutely to the defined origin of the Cartesian coordinate system (x, y, z)
- Continuously acquired in parallel to Gesture Recognition



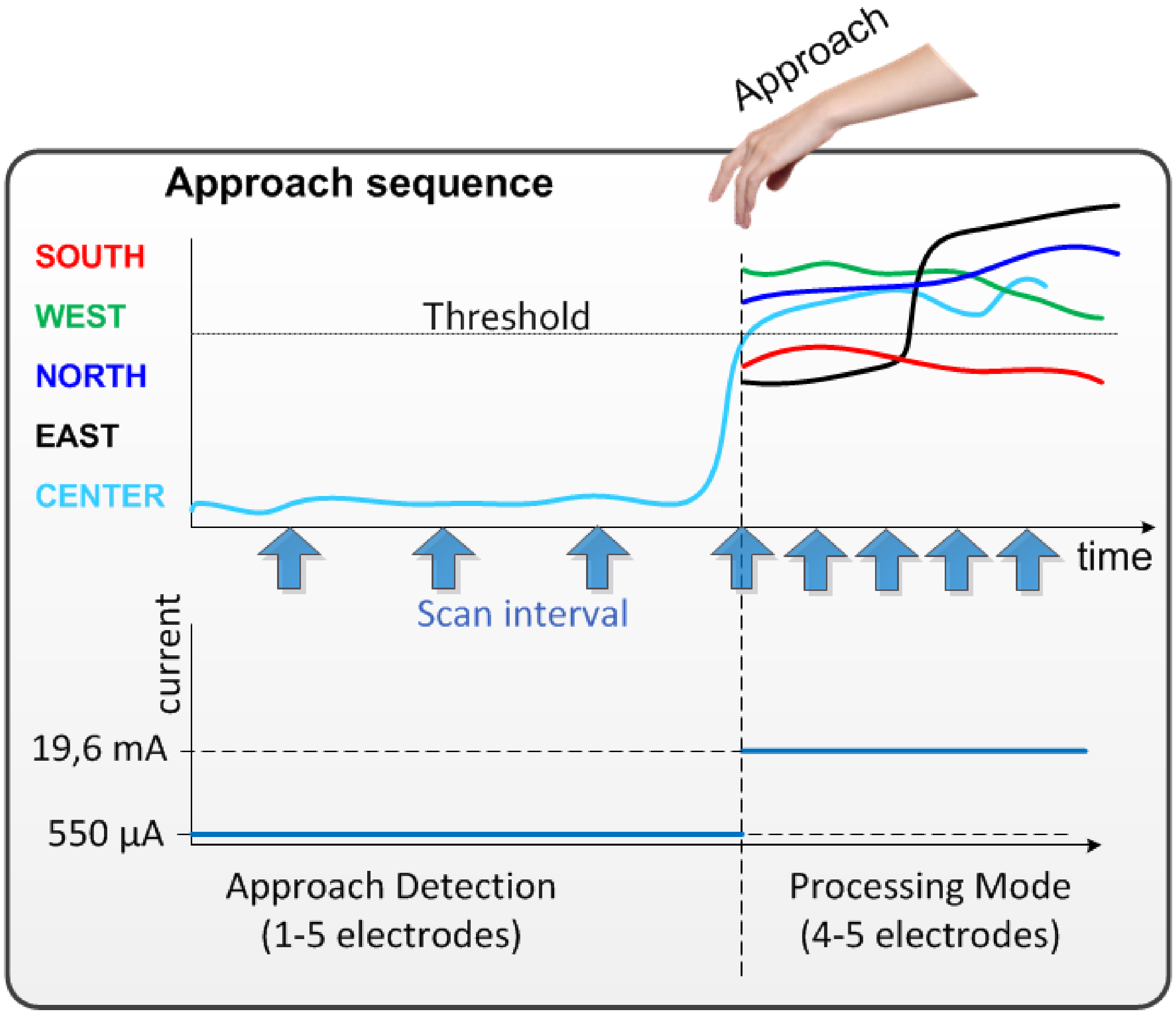
Performance:

- Position rate: 200 positions/sec
- Spatial resolution: up to 150 dpi

Parameterization:

- Adjustable to customized electrodes (Hillstar)

Core Feature: Approach Detection



Performance:

- 550 µA low current consumption (typ.)
- 20 ms fast reaction time (typ.)

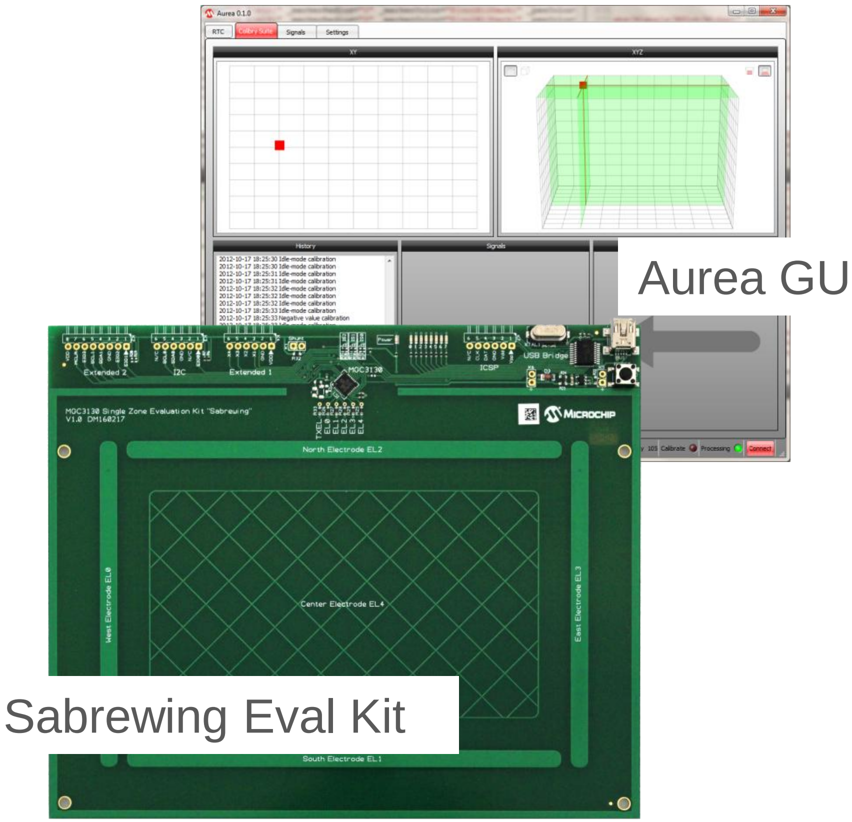
Parameterization:

- Active electrodes
- Sensitivity
- Scan interval

Sabrewing
MGC3130 Single Zone Evaluation Kit

Evaluation Kit with preset 140x90mm PCB Electrode

- USB / I²C™ connection
- Windows® 7 OS
- Microchip Aurea GUI
  - Colibri Suite
  - Real-time control function



MICROCHIP DIRECT

PART NUMBER: DM160217

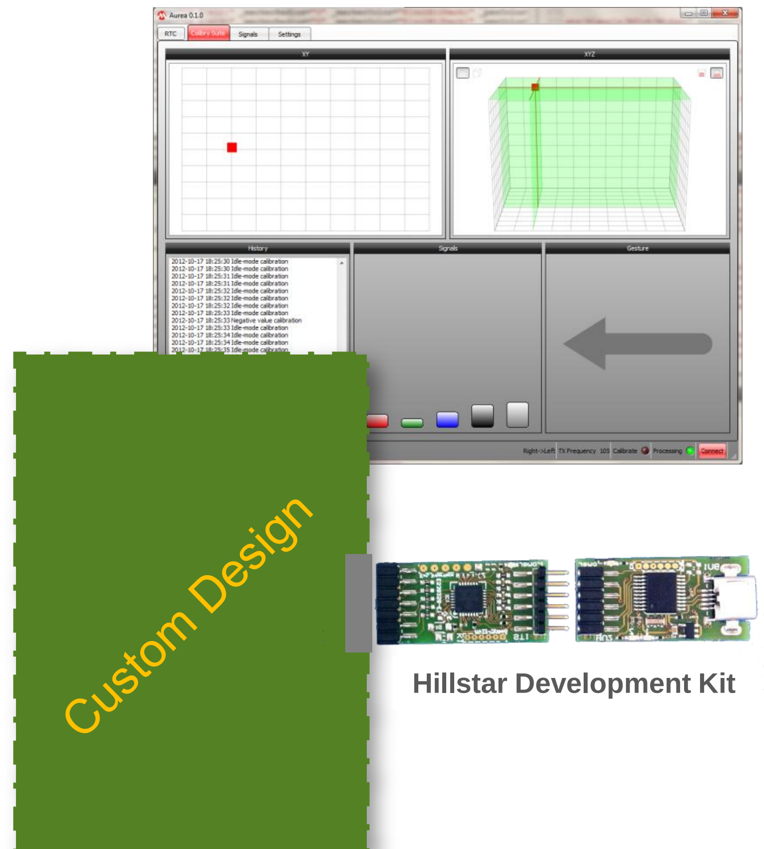
Development Kit for Custom Design

- USB and **I²C** connection
- Microchip **Aurea GUI** on Windows® 7/8
  - Colibri Gesture Suite
    - Real-time control
    - **Design-In** parameterization wizard
- Reference Electrodes **from 1.6” to 7”** and aspect ratios from 1:1 to 1:2
- Electrode **Design-Guide**

MICROCHIP DIRECT

PART NUMBER: DM160218

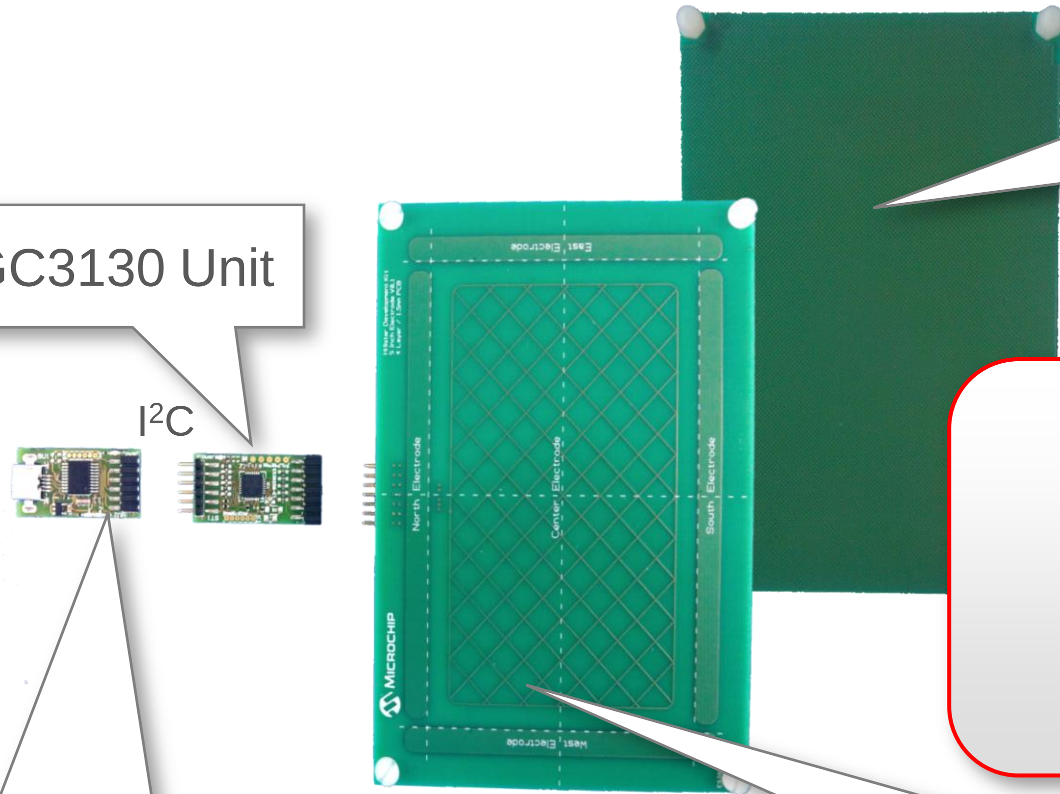
AUREA GUI



Hillstar Development Kit

Hillstar

MGC3130 Single Zone Development Kit



95x60mm Reference Electrode
Backside view
(no components)

MGC3130 Unit

I²C

Each Hillstar Kit contains

1 physical 95x60mm Reference Electrode and

design / gerber files for

6 additional Reference Electrodes

I²C™ to USB Bridge
Connection to PC / Aurea GUI / MGC3130 / System Paramterization

95x60mm Reference Electrode
Frontside view

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Five Design-In Steps

five step

design-in

Use Case
- Hand / finger use, posture
- Detection area, range
- Movement tracking, gesture recognition

Electrode
- Stack up
- Hatching
- Feeding lines

AFE
- Electrode assignment
- Automatic signal matching

DSP
- E-Field linearization
- Tracking filter
- Scan time and power saving

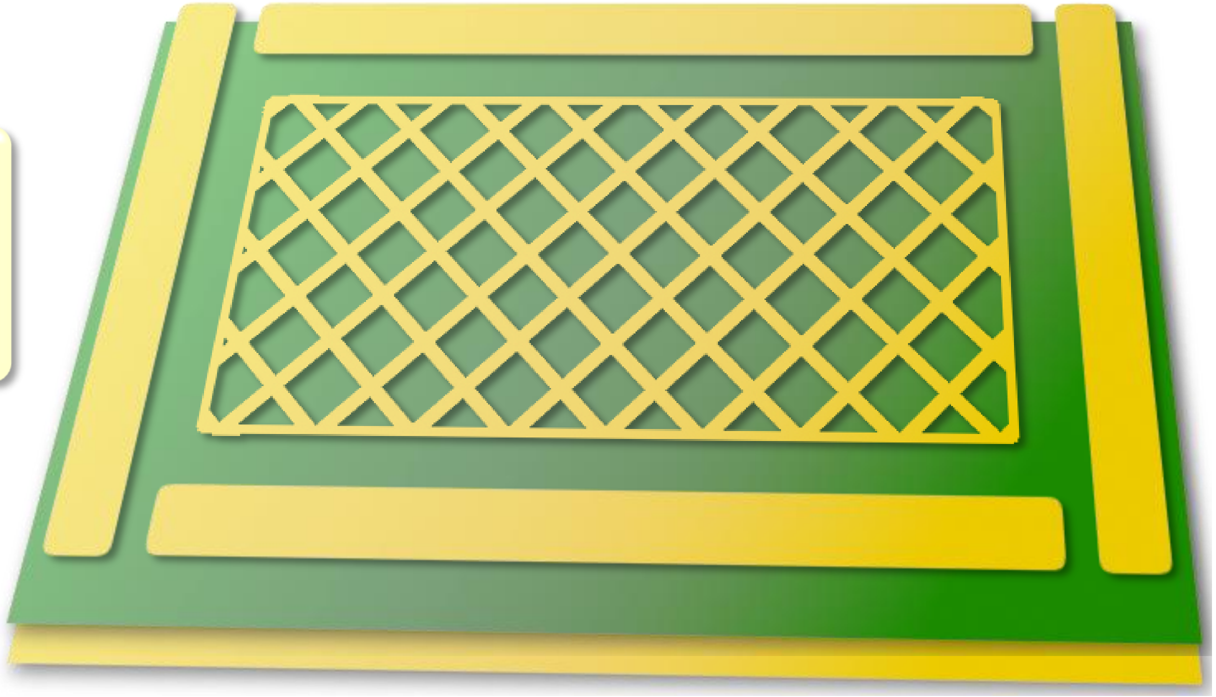
HMM
- Gesture customization
- Rejection and other threshold adaptation

GestIC Sensor

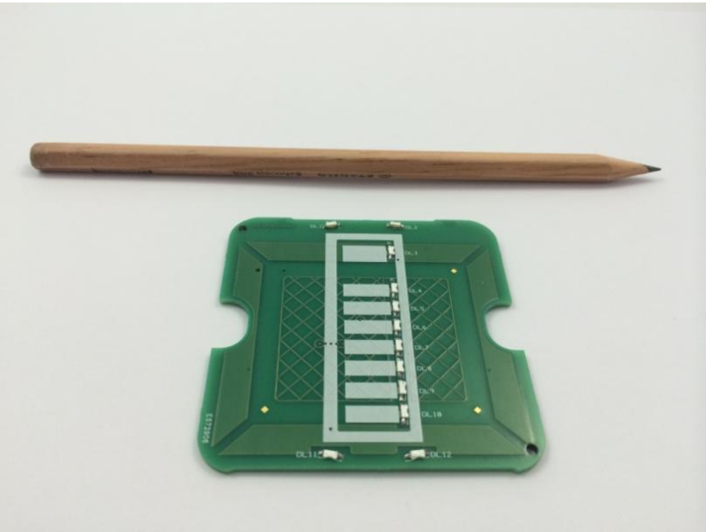
- 2 Layers
- 1 TX Electrode (bottom)
- 4 RX Frame Electrodes (top)
- Optional RX Center Electrode (top)

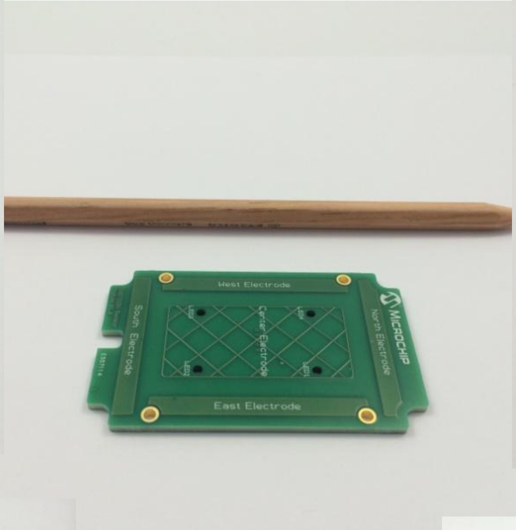
Material:

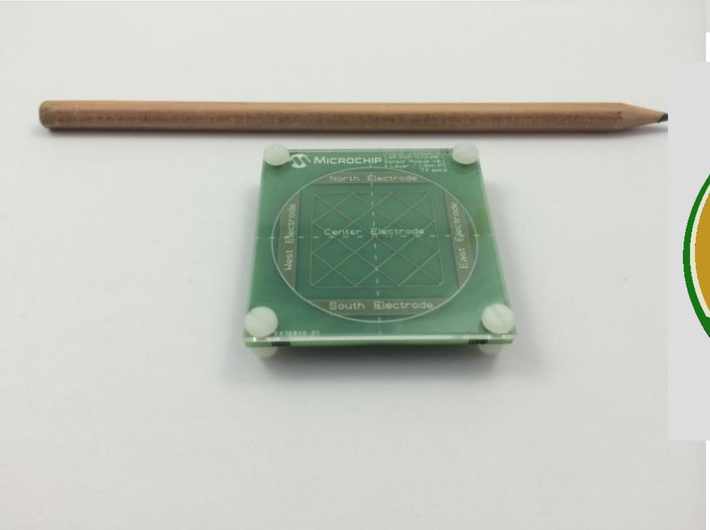
PCB, Plastic, Glass, etc.

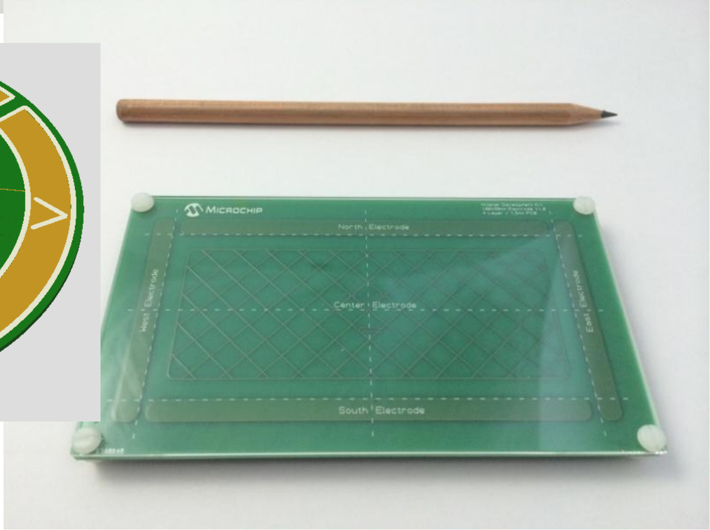


Electrode Design - Examples



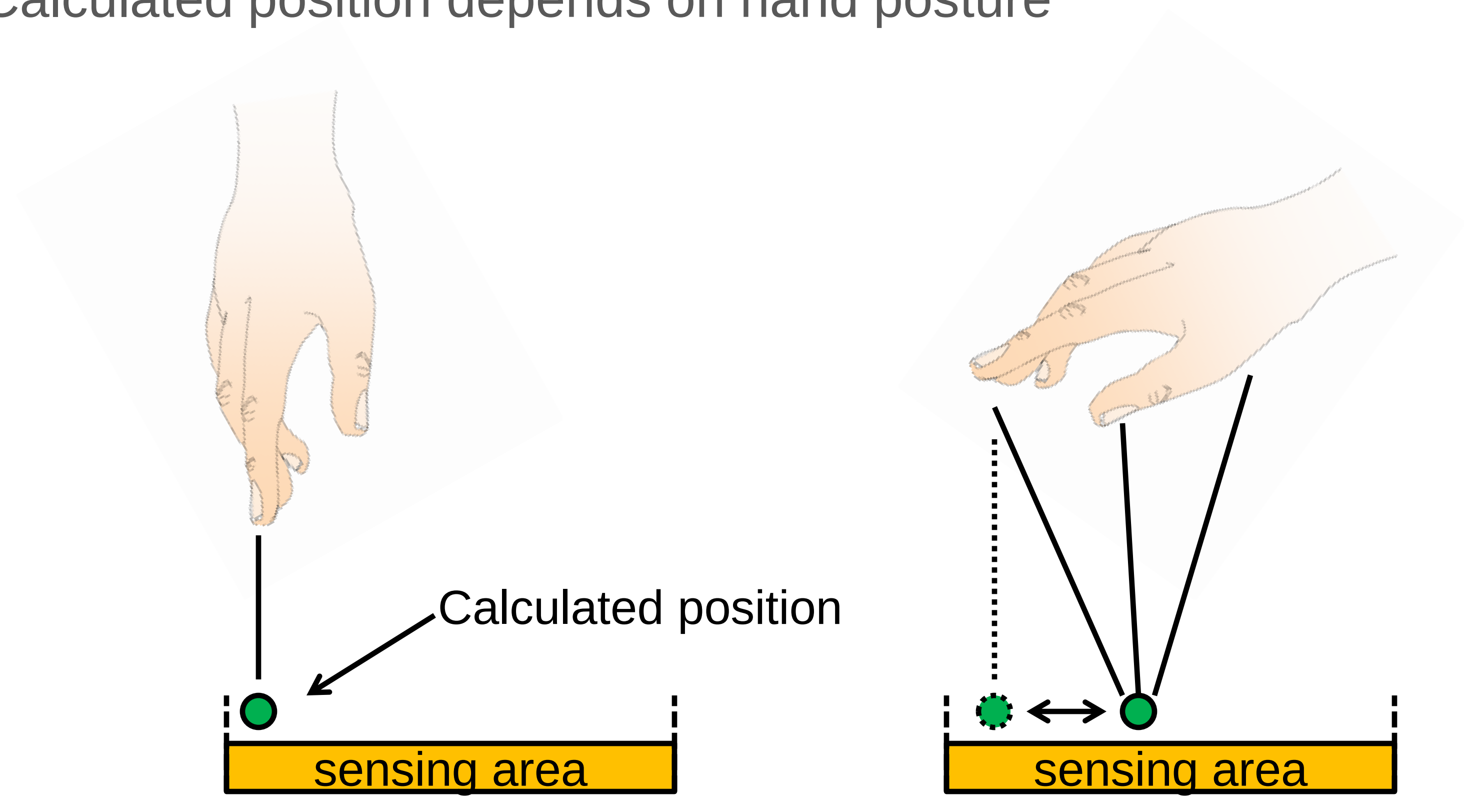






Center of Gravity

- The **whole hand** has an impact on the e-field distortion
- Calculated position depends on hand posture



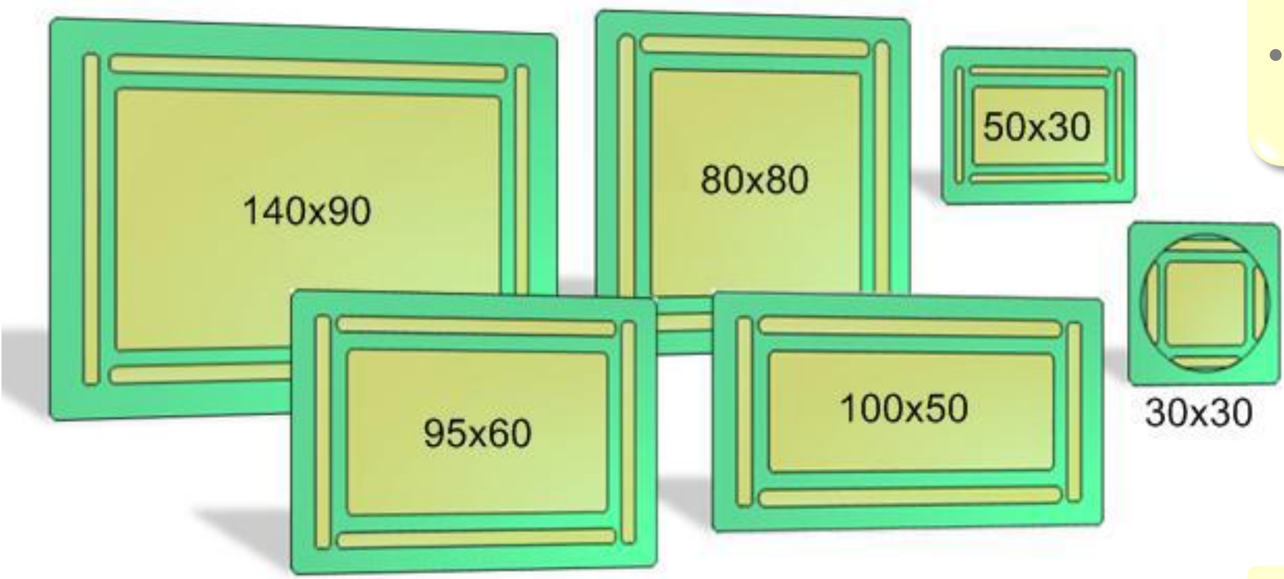
Electrode Design - References

Are there References available?

Can references be scaled?

Hillstar Hardware References

MGC3130 – Hillstar Hardware Reference Package V1.0.5



Reference Electrodes
- 2 Layer
- 4 Layer

Sensor Modules
- MGC3130 backside assembly

Parameter files

Electrode design according to recommendations

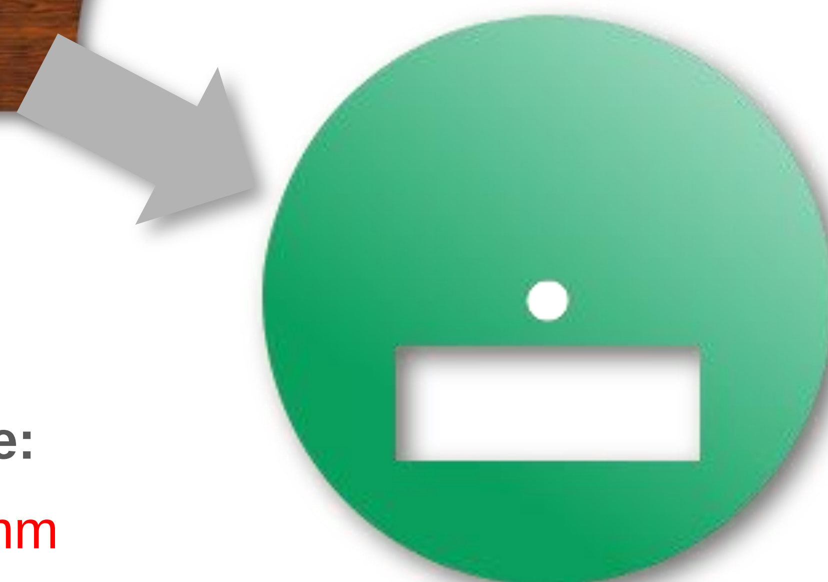
If no reference design available, follow the next 5 steps to design your electrodes:

- Step 1: Sensor Outline
- Step 2: Rx / Tx Electrodes
- Step 3: Chip connection / placement
- Step 4: Layer Stack
- Step 5: Feeding Lines

STEP1: Sensor Outline

Available Space:

- Circle 15cm diameter
- Display to be integrated (hole)



Maximum Size:

- 140mmx140mm

Minimum Size:

- 25mmx25mm

STEP2: Rx/Tx Electrodes

Rx electrodes:

- At the edges of the Sensitive Area
- Ratio: 1:1, 1:2
- Length: as long as possible, < 14cm
- Width: 3,5 … 7% from length
- Center electrode should be cross hatched (5-10% hatching)

Tx electrodes:

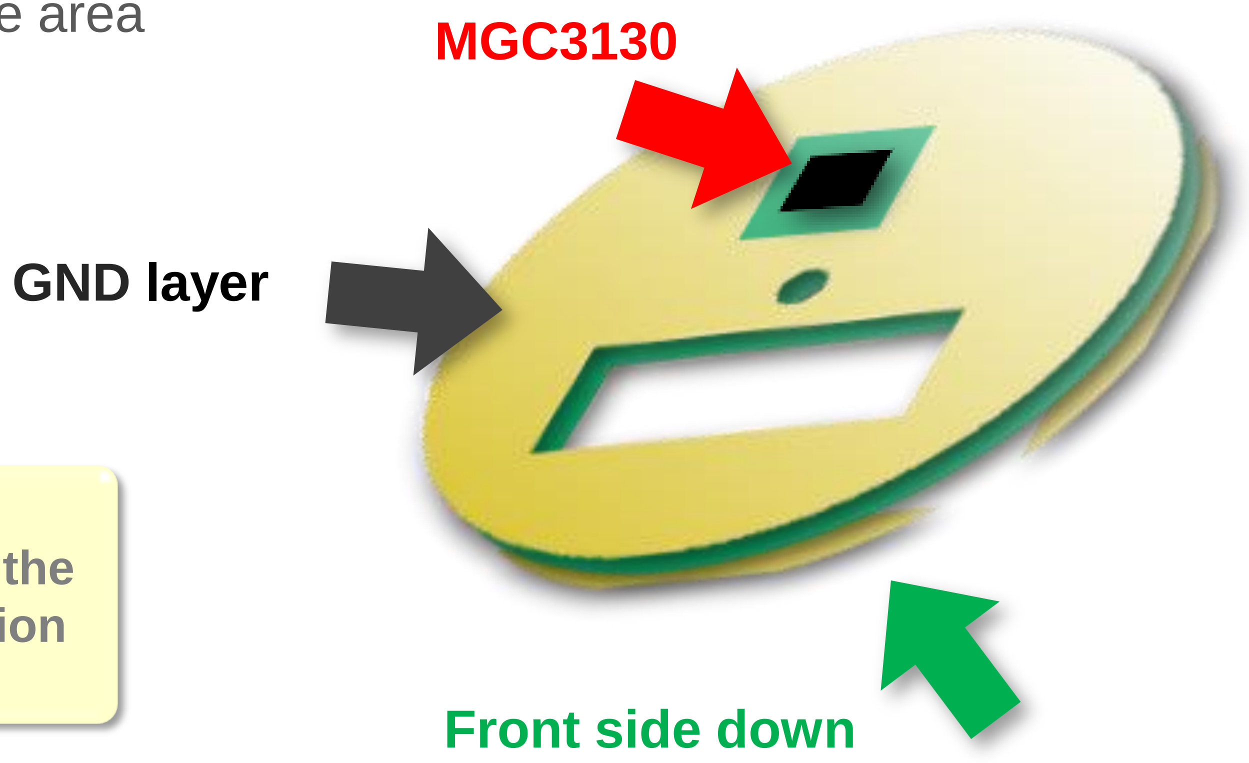
- Covers complete area below Rx electrodes
- Decrease capacitance to GND by hatching

Double-check with Capacitance Design Goals

STEP3: Chip Connection / Placement

MGC3130 backside placement:

- On the sensor backside, embedded in GND (backside assembly)
- Far from sensitive area



Make sure that the circuitry is away from the usual approach direction of the sensor

STEP4: Layer Stack

In general only 2 Layers are ok, but

Backside assembly? → add GND layer

Shielding necessary? → add GND layer

Recommended distances:

- Rx-Tx: 0,5..2,5mm
- Tx-GND: > 0,3mm

C_{TxGND} < 1nF

Double-check with Capacitance Design Goals

Consider hatching of Tx and GND

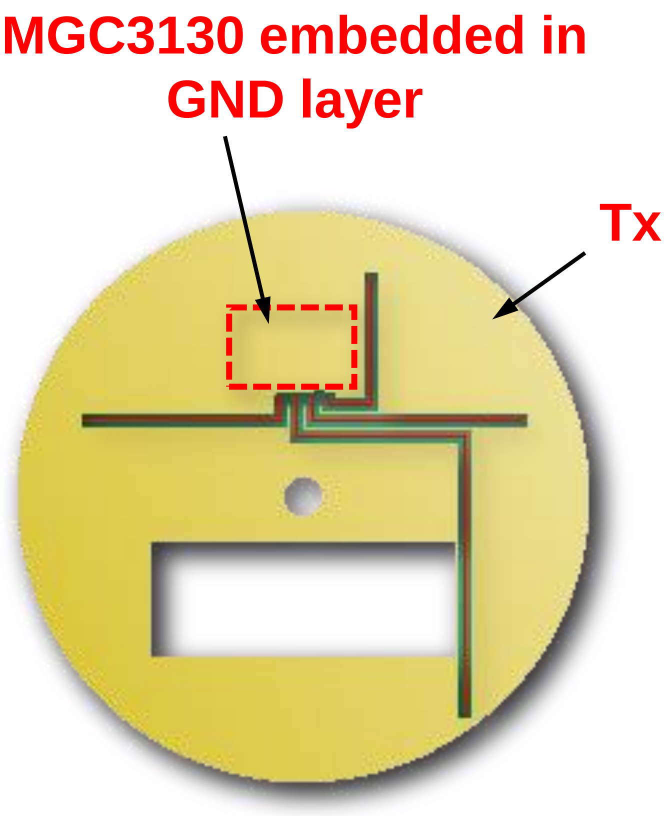
STEP5: Feeding Lines

→ Rx feeding lines are sensitive

→ Rx feeding lines add capacitance

Rules for the Rx feeding line

- Keep Rx feeding lines thin and short (width 0,1mm)
- Do not expose to the hand
- Keep away from other analog and digital sources
- Keep away from ground
- Keep area underneath the Rx electrodes clear of feeding line traces
- Keep away from Tx
- Achieve most symmetrical layout

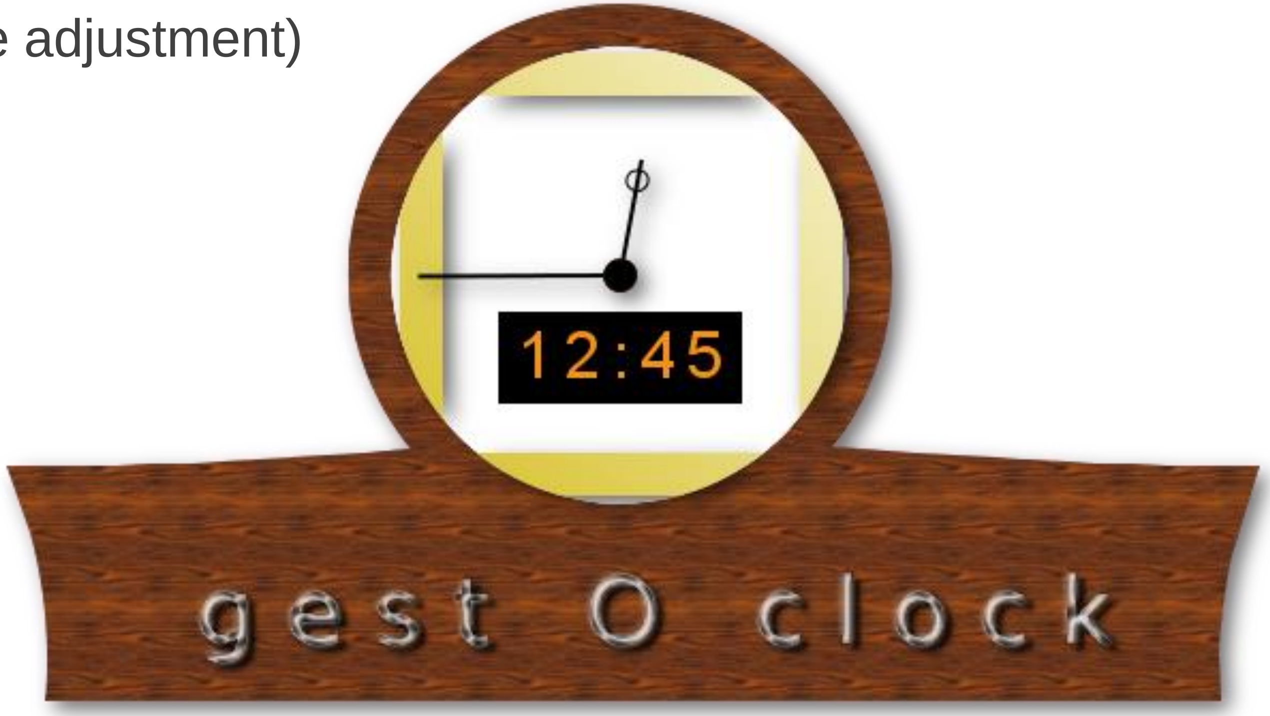


Ready for Prototyping!

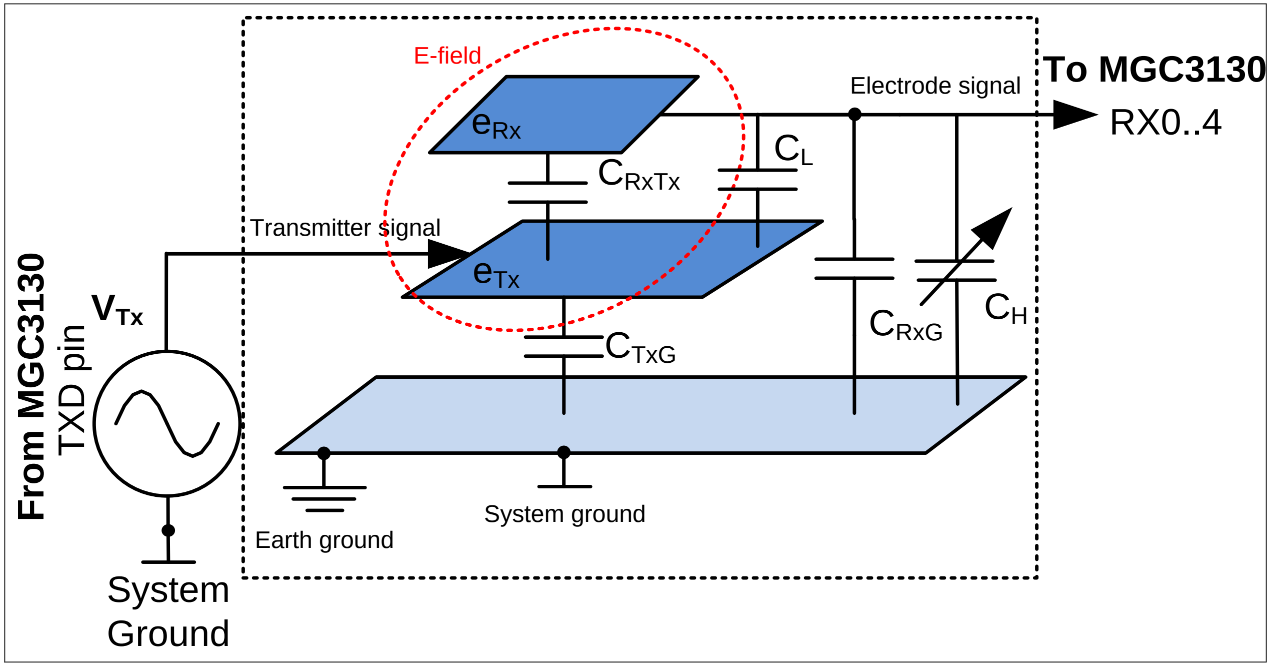
Sensor Touch (Setup)

3D Flicks (Time Zone)

3D AirWheel (Time adjustment)



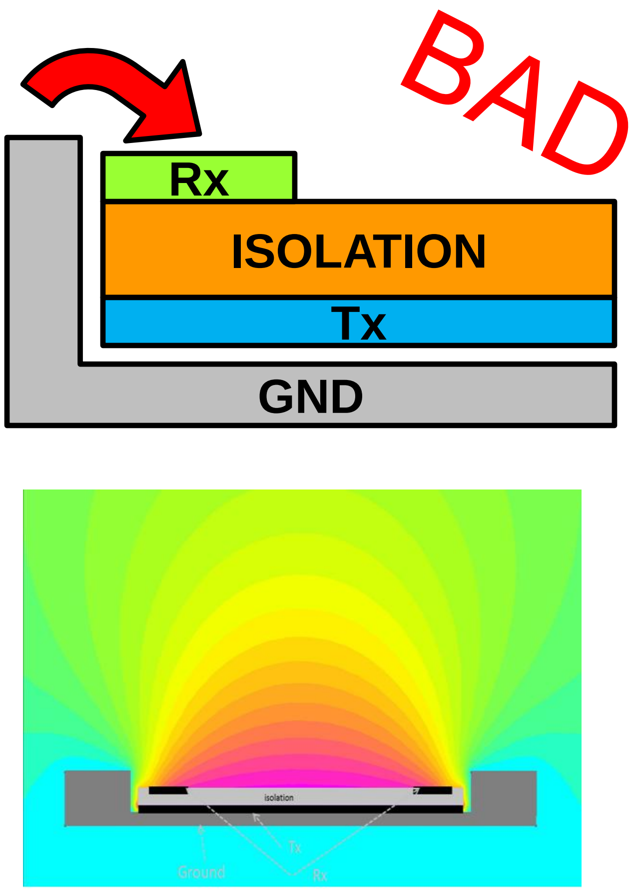
GESTIC EQUIVALENT CIRCUIT

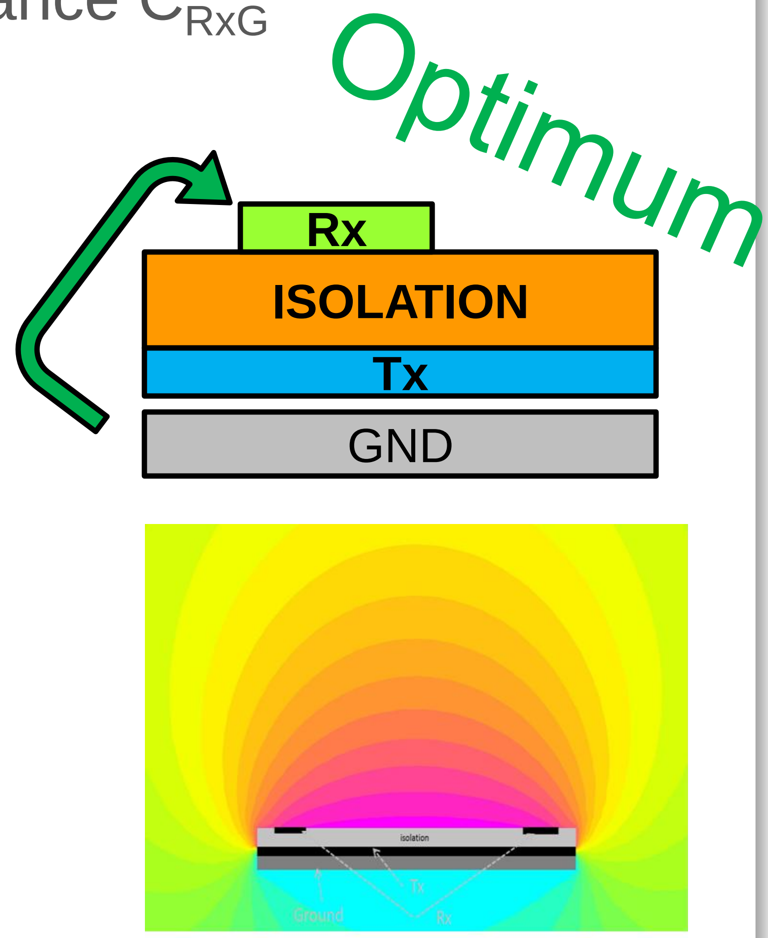


- V_{Tx}: Tx electrode voltage
- V_{RxBuf}: MGC3130 Rx buffer input voltage
- C_H: Capacitance between receive electrode and Hand (Earth ground)
- C_{RxTx} : Capacitance between receive and transmit electrodes
- C_{RxG}: Capacitance of Receive (Rx) to system ground + input capacitance of receiver circuit
- C_{TxG}: Capacitance of Transmit (Tx) to system ground

Rx Electrode and System Ground

- Low Rx-ground capacitance C_{RxG}

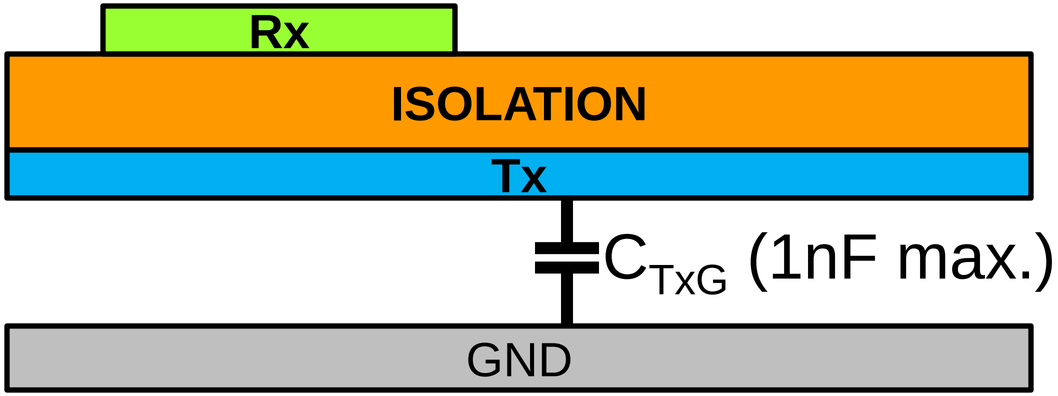




Tx Electrode and Ground

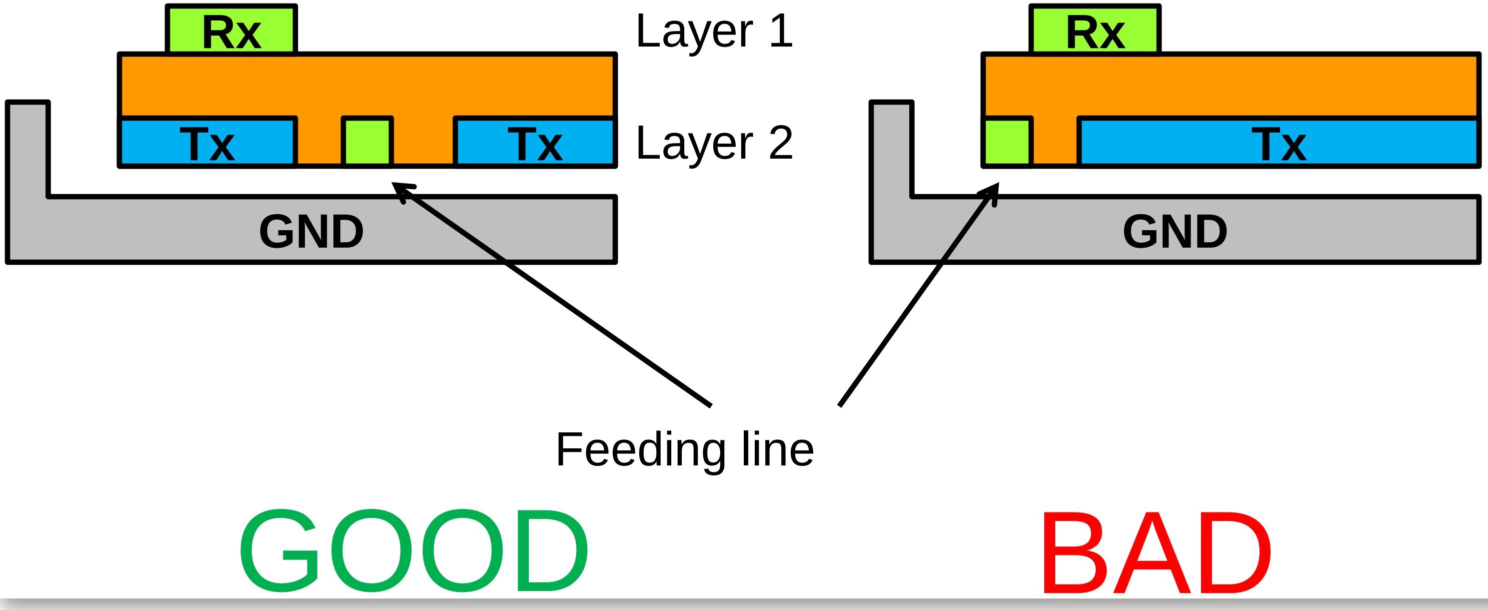
- MGC3130 can drive up to 1 nF with 800 Ω output impedance
- Large Systems with a low distance between ground and Tx may exceed this values

  → It is recommended to use an external boost amplifier for higher capacitances



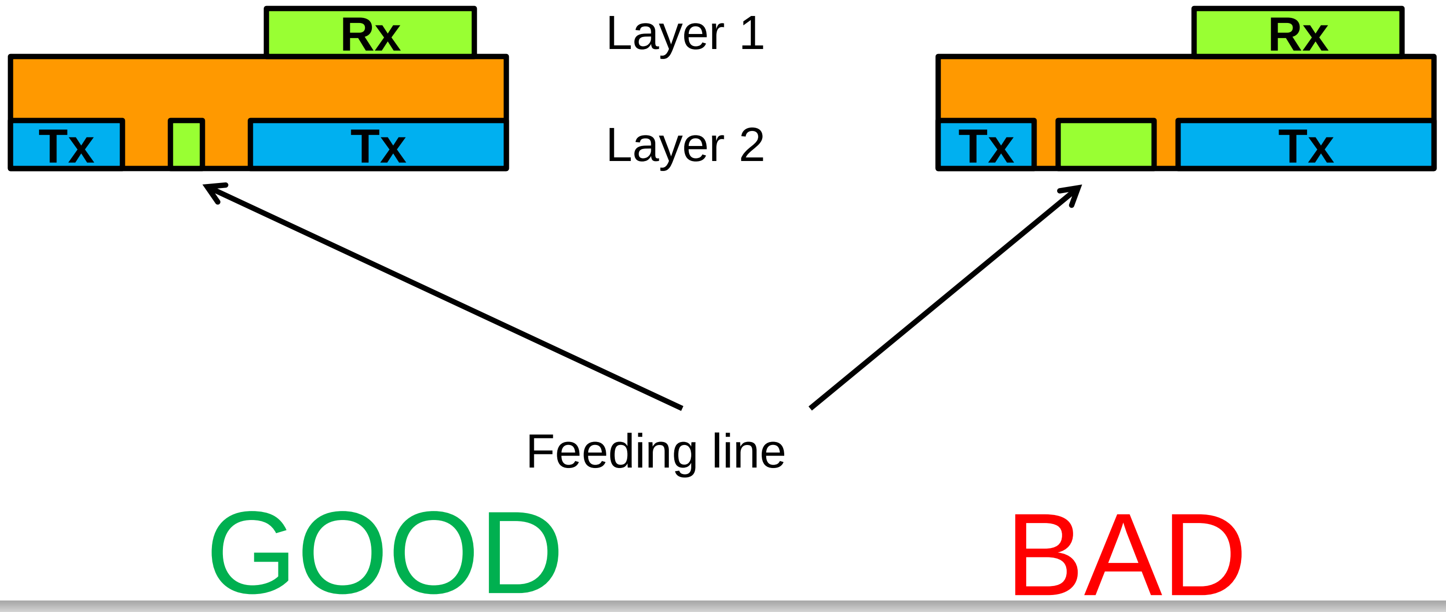
Feeding lines

- Keep line away from ground and communication traces to avoid crosstalk



Feeding lines

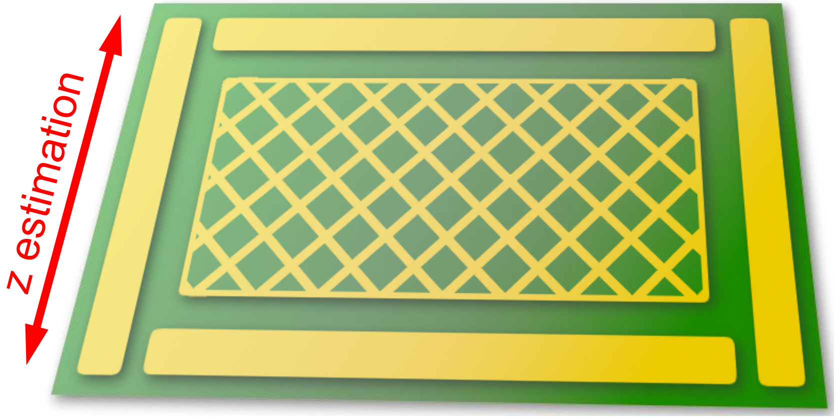
- Reduce feeding line coupling to the hand
  →**Traces should be as thin as possible**



Optimization of Sensitivity

Rule of the thumb:

The expected z distance is equal
to the length of the shorter electrode.



Performance optimization

- Increase sensitive area
- Improve Electrodes design → capacitances design rules
- Make sure Tx driver strength is ok
- Avoid external noise conditions
- Place electrodes away from GND / add distance to GND layer

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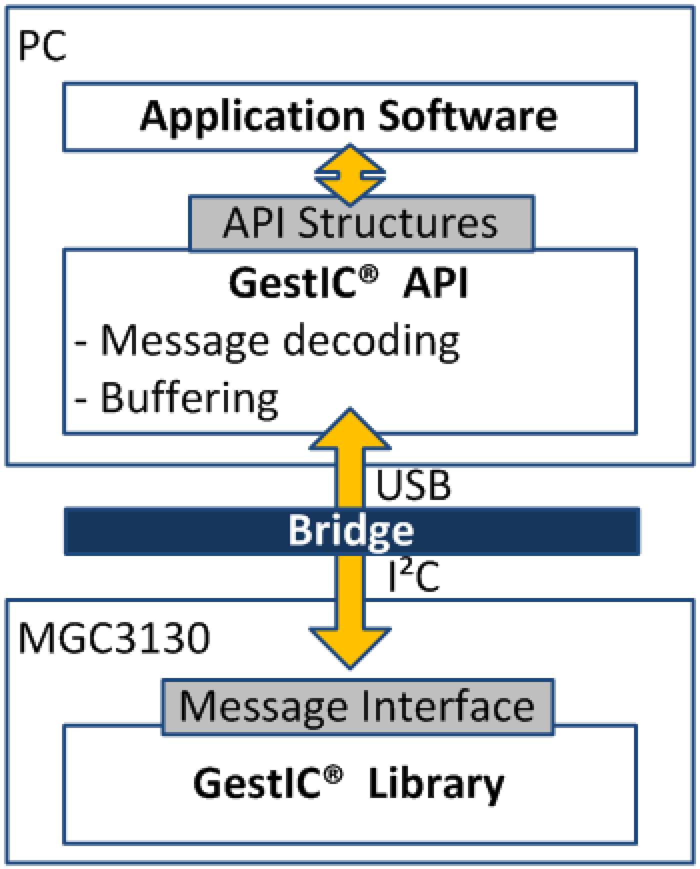
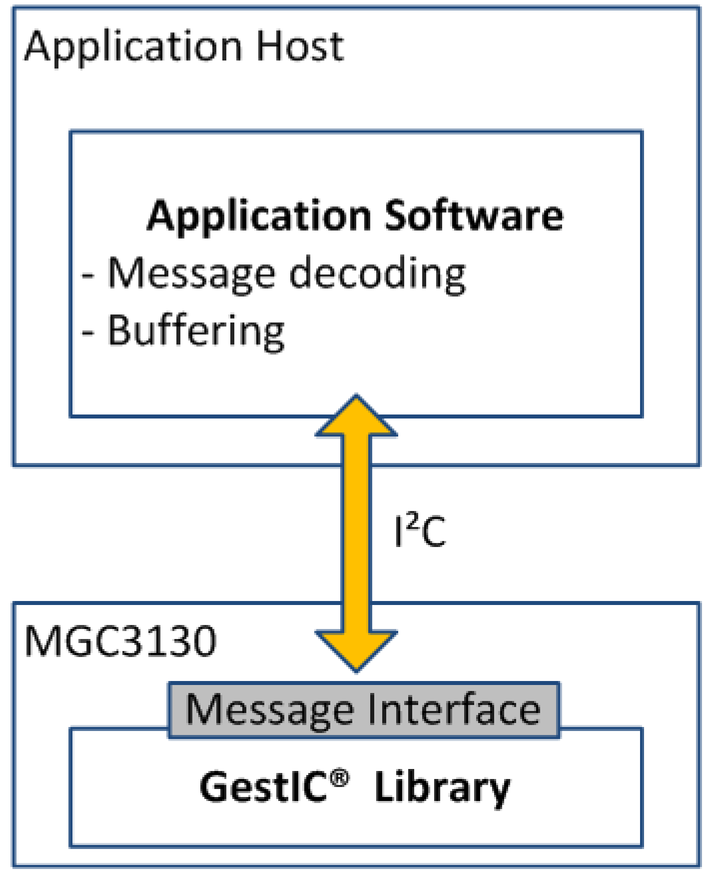
GestIC Firmware Library

ADMINISTERED INTERFACE

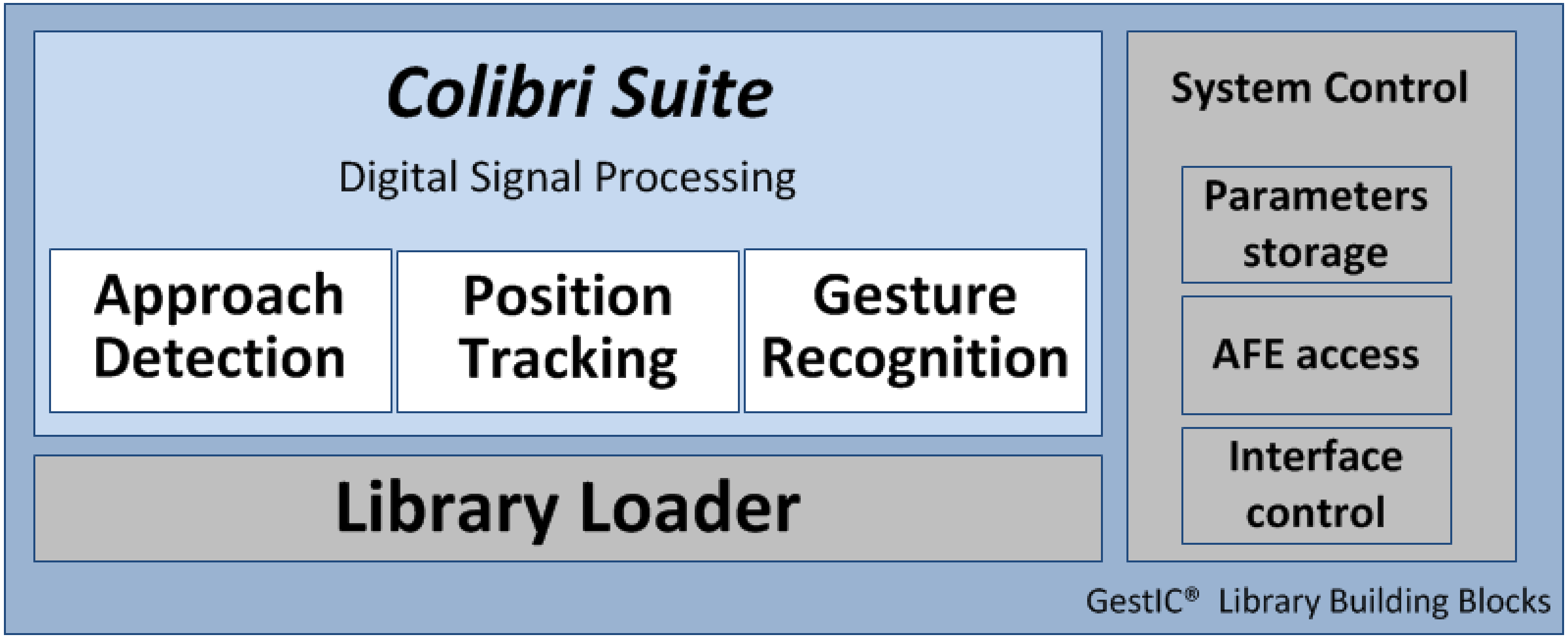


DIRECT INTERFACE



GestIC Firmware Library

- Operational code for MGC3130 SPU
- Encrypted binary preprogrammed in the chip's flash memory
- Configurable, updatable



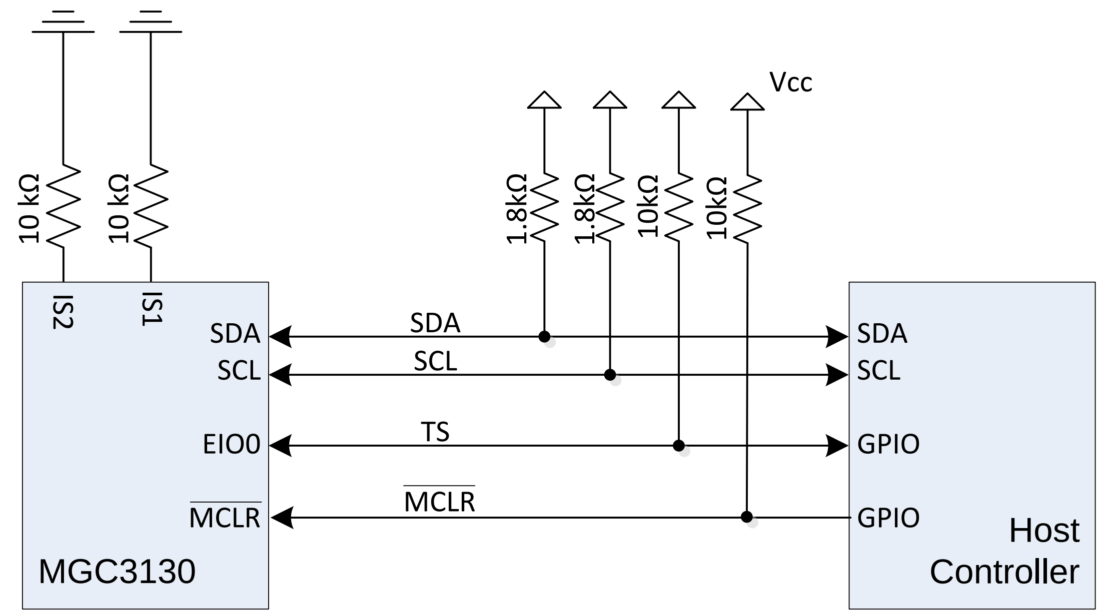
Communication With Host Application

MGC3130 uses I²C™:

- SDA, SCL

Additional signals:

- TS (Transfer status)
- MCLR (RESET)



IS2 PIN	IS1 PIN	Slave Device Adress	DEVICE WRITE ID	DEVICE READ ID
GND	GND	0x42	0x84	0x85
VCC	GND	0x43	0x86	0x87

Transfer Status (TS) line

MGC3130 (I^2C slave) :

- Informs the host controller that there are data available which can be transferred

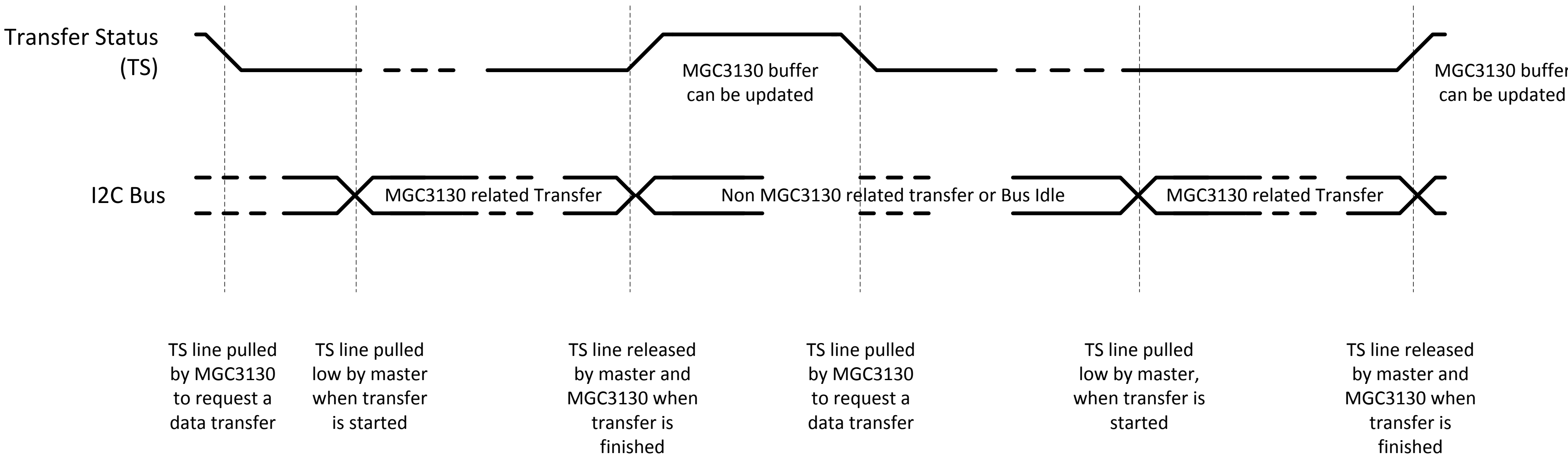
Host controller (I^2C master):

- Indicates that data are being transferred and prevents MGC3130 from updating its data buffer

Note:

- Transfer Status is only needed for data transfer from MGC3130 to the host controller. Writing to MGC3130 does not require the additional TS signal.

Communication With Host Application



- I²C stop condition is generated by the host controller (I²C master) after the data transfer is completed.
- It’s mandatory to check the amount of bytes to be read in the message header

Communication With Host Application

Code implementation in Host Controller:

```
I²C read loop:
Read TS
If TS == 0:
         Assert TS
         Do I²C transfer
         Release TS
   Wait  20µs  (to  assure  that  MGC3130
released TS line, too)
```

GestIC Firmware Library Message Interface

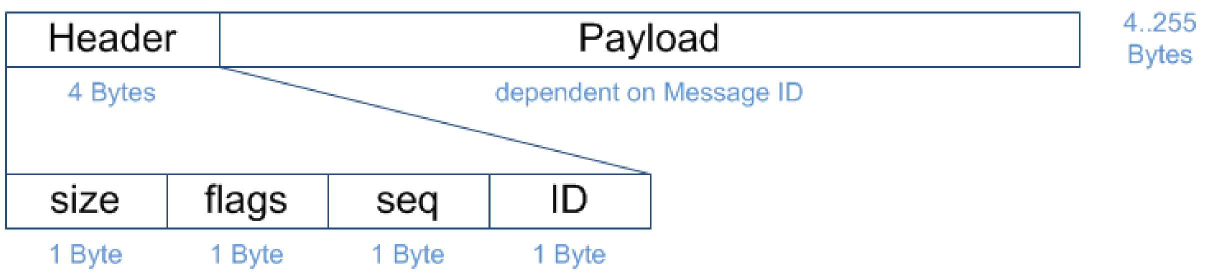
- GestIC FW Library provides a message based interface to the application host
- Messages consist of a fix header and a variable payload
- Message max. length is aligned with I^{2}C frame size

MGC3130 MESSAGE EMBEDDED IN THE I^{2}C FRAME

START	Device Address	R/W	MGC3130 Message	STOP
1 Bit	7 Bit	1 Bit	4..255 Bytes	1 Bit

GestIC Library Message Interface

- GestIC Library provides a message based interface to the application host
- Messages consist of a fix header and a variable payload
- Message max. length is aligned with I²C frame size



Header Parameter	Definition
Size	Size of the message in Bytes including the header.
Flags	8 bit field containing configuration and error bits.
Seq	Sequence number, increased for each message sent out by MGC3130.
ID	ID of the message

Messages Overview

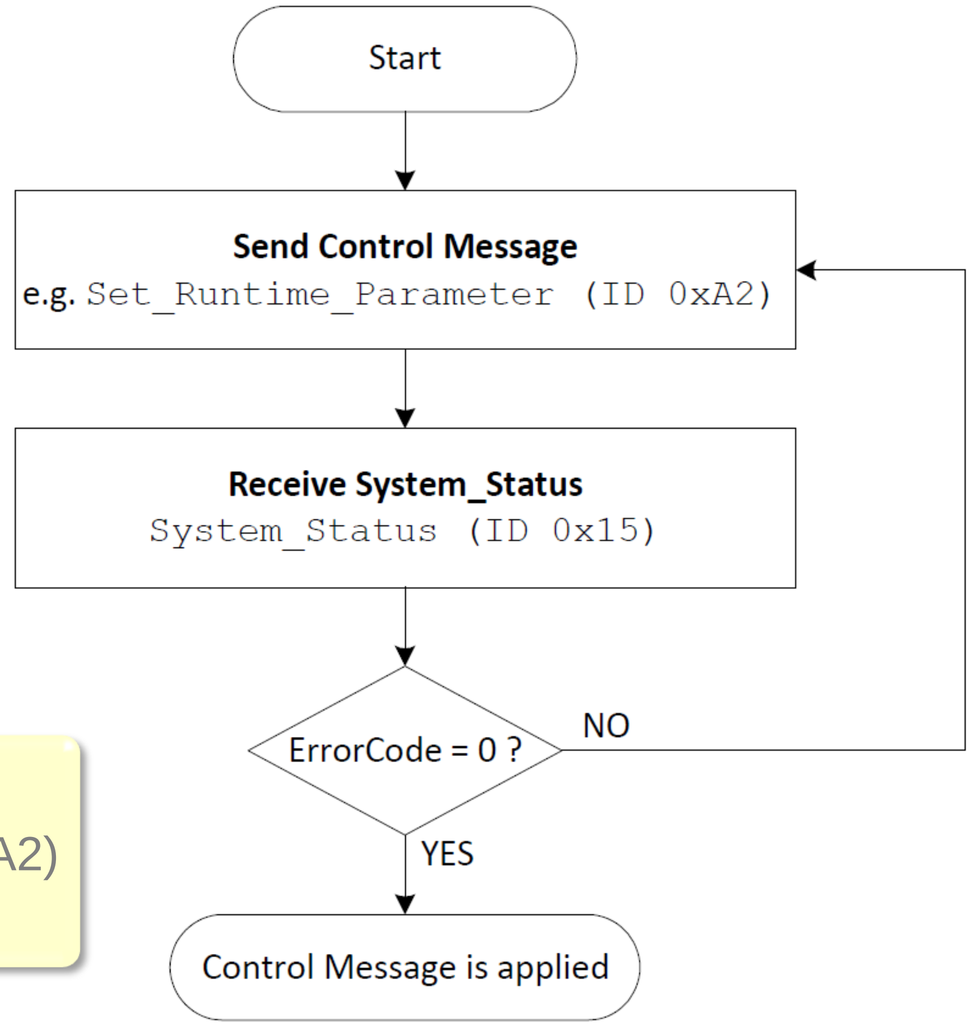
MESSAGES FOR SYSTEM CONTROL

Message ID	Name
0x15	System_Status
0x83	FW_Version_Info
0xA2	Set_Runtime_Parameter
0xA5	Trigger_Action
0x6	Request_Message

MESSAGES FOR DATA OUTPUT

Message ID	Name
0x91	Sensor_Data_Output

System Control



Messages

- Set_Runtime_Parameter (ID 0xA2)
- Request_Message (ID 0x06)

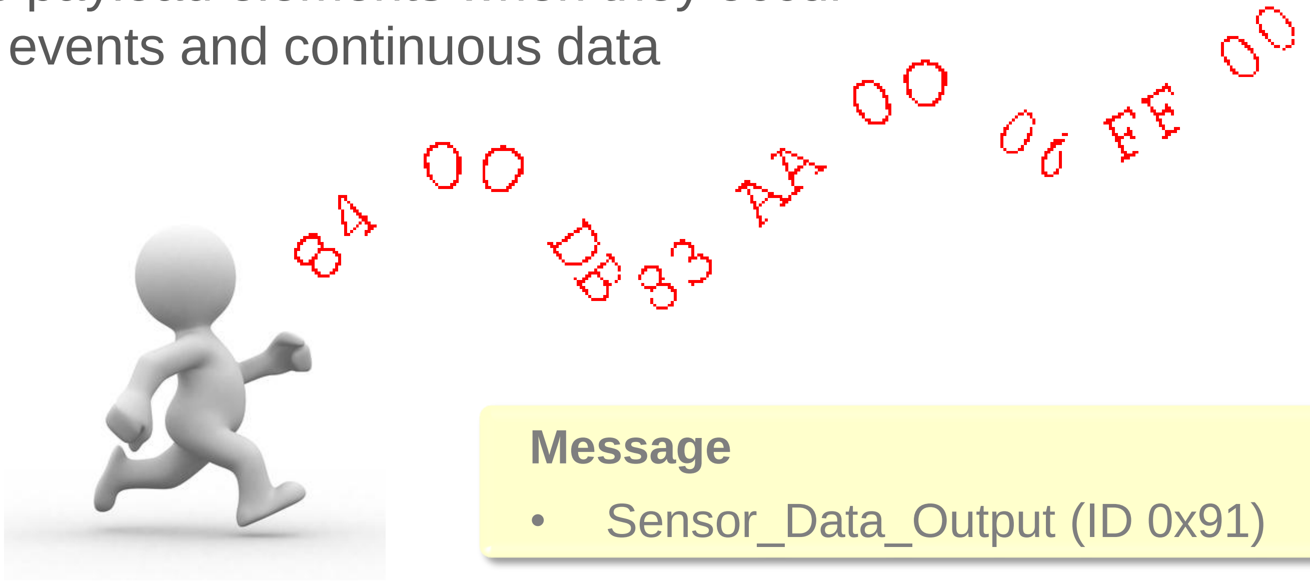
Sensor Data Output

Combines all data which are generated in MGC3130

- Events (gestures, DSP status)
- Continuous Data (position or raw sensor data)

Flexible

- Variable length
- Data output configurable (Off, Static or Dynamic)
- Data added as payload elements when they occur
- 2 Priorities for events and continuous data



Message

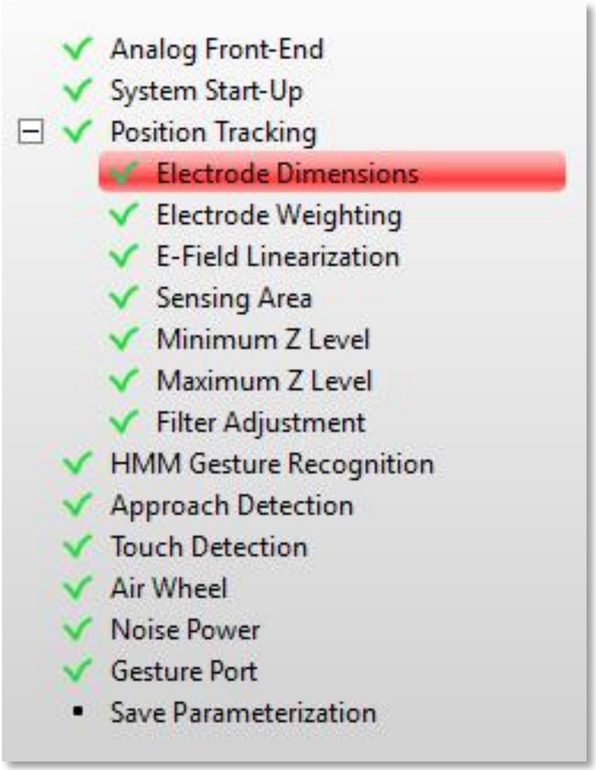
- Sensor_Data_Output (ID 0x91)

Agenda

- Introduction
- New features V1.0
- GestIC Electrode Design
- MGC3130 Integration
- Colibri Parameterization
- Application Examples

Colibri Parameterization

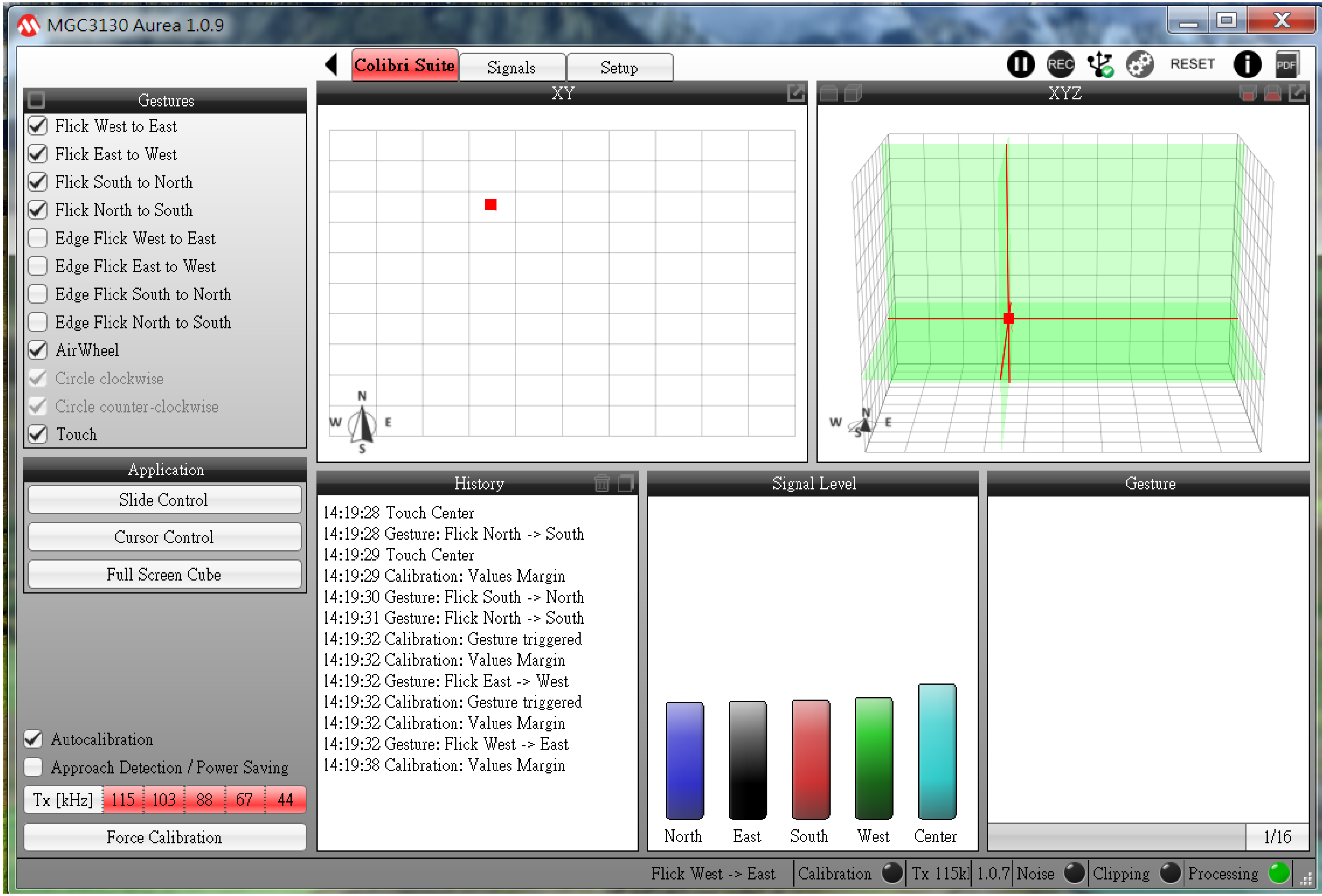
- Analog Frontend, Position
- HMM Gestures
- MGC3130 startup
- Gesture port



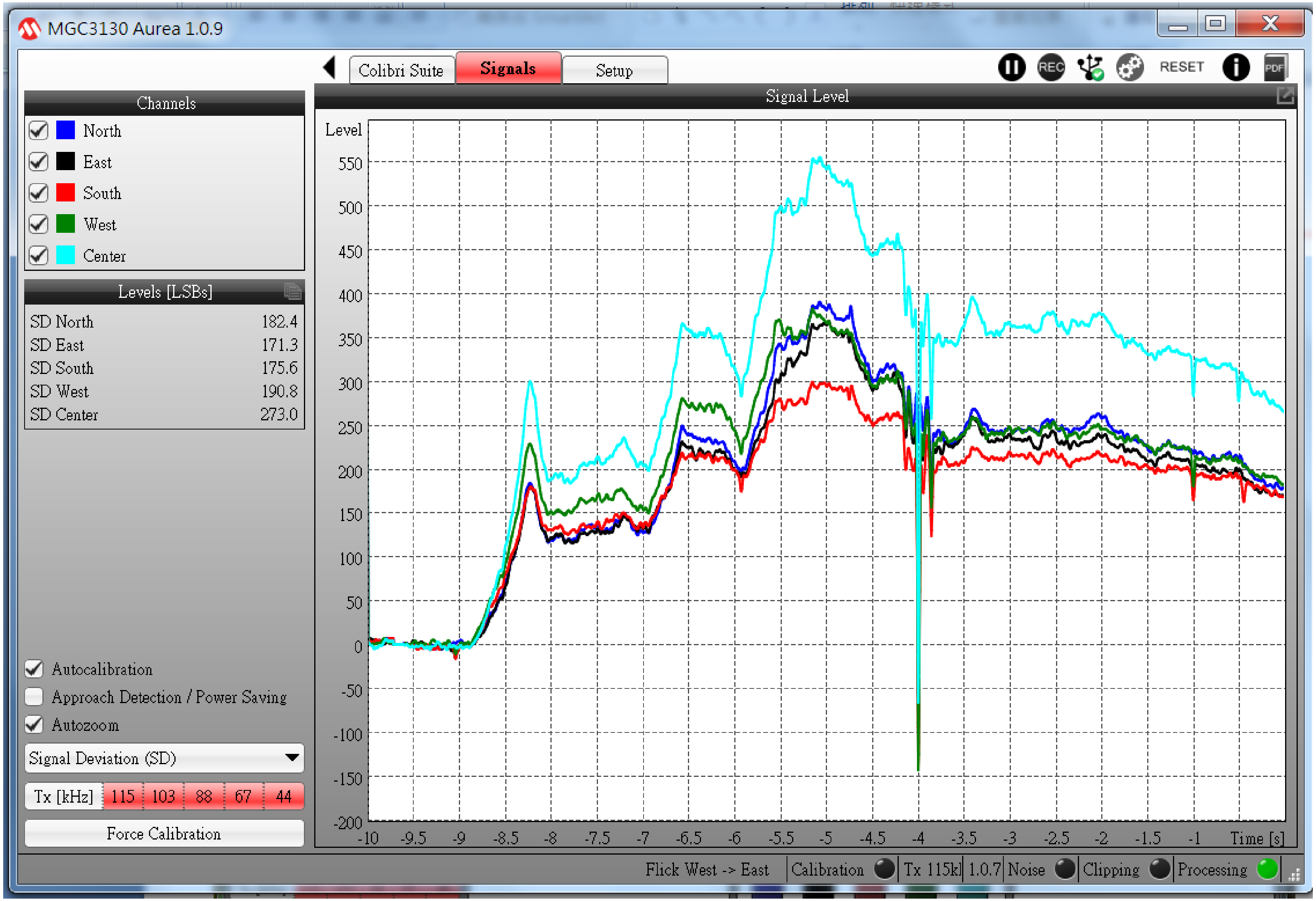
Resources:

- Aurea Manual
- Aurea Help
- Videos

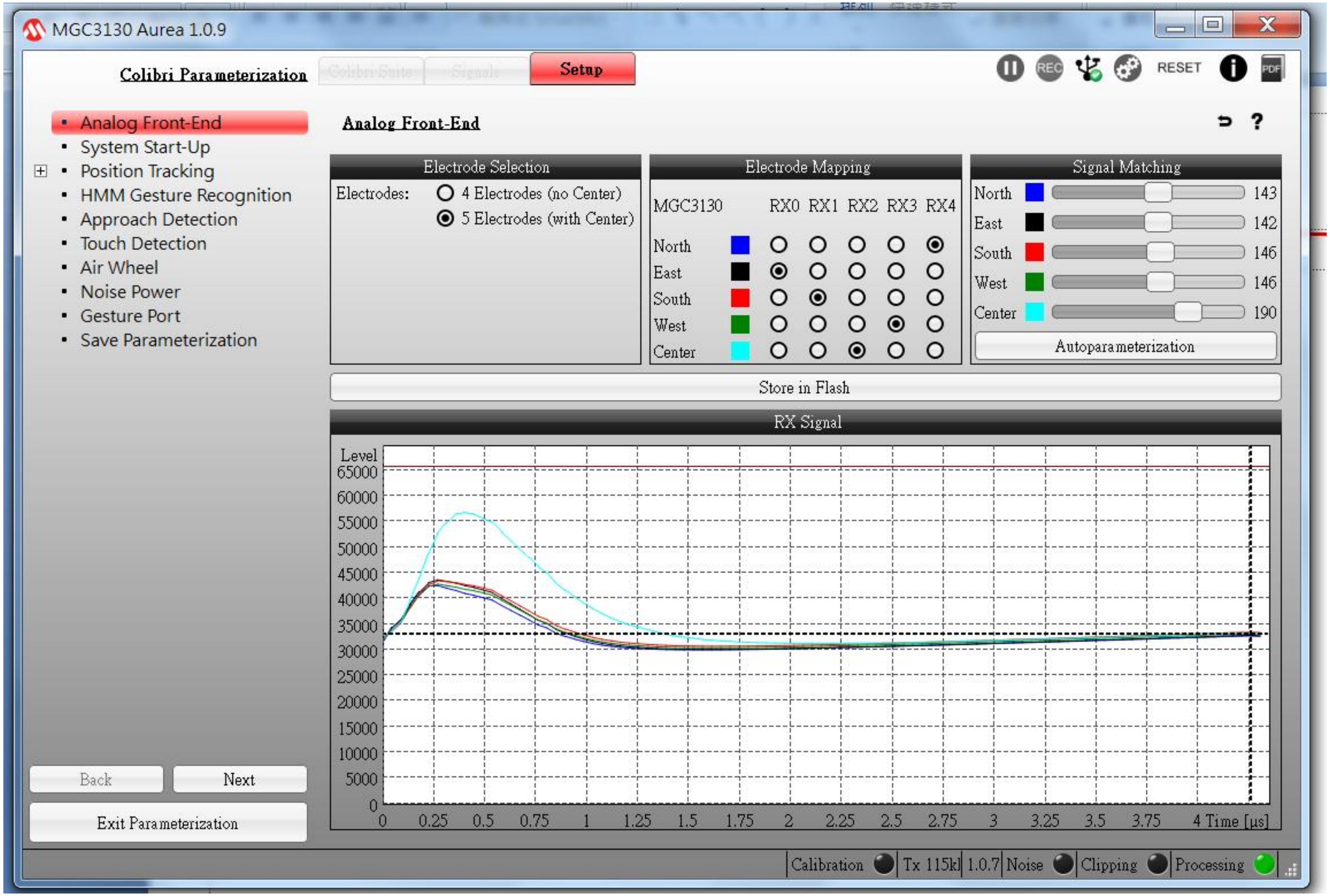
MGC3130 Aurea – Colibri Suite



MGC3130 Aurea - Signals



MGC3130 Aurea - Parameterization



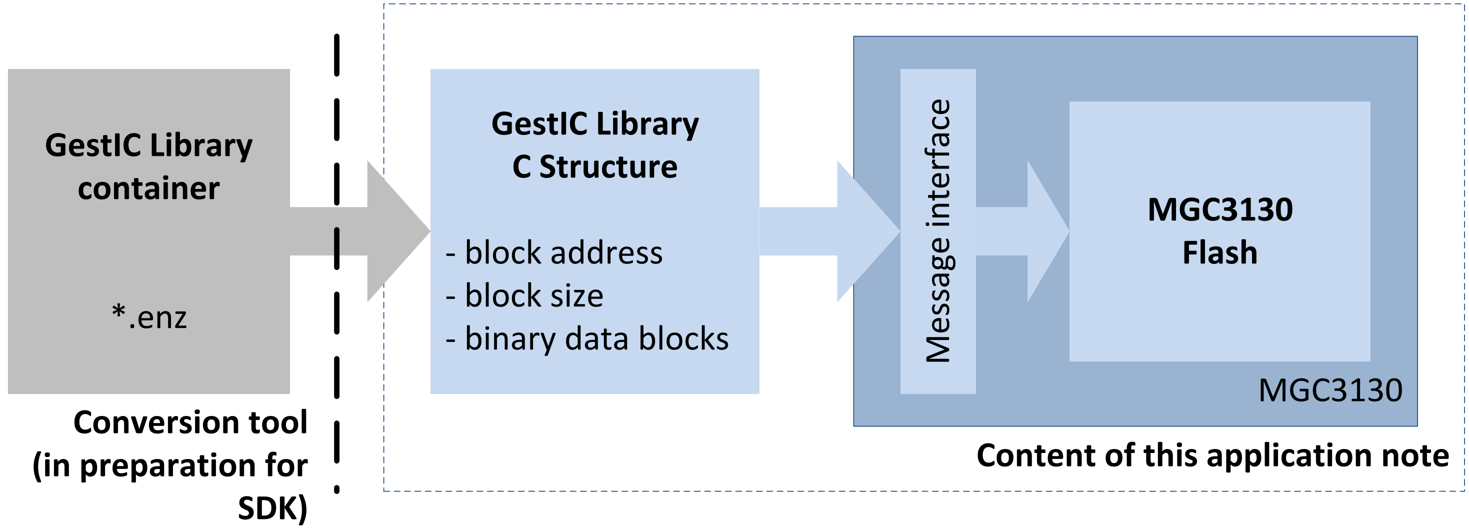
GestIC Firmware Library download via I²C interface

Update of

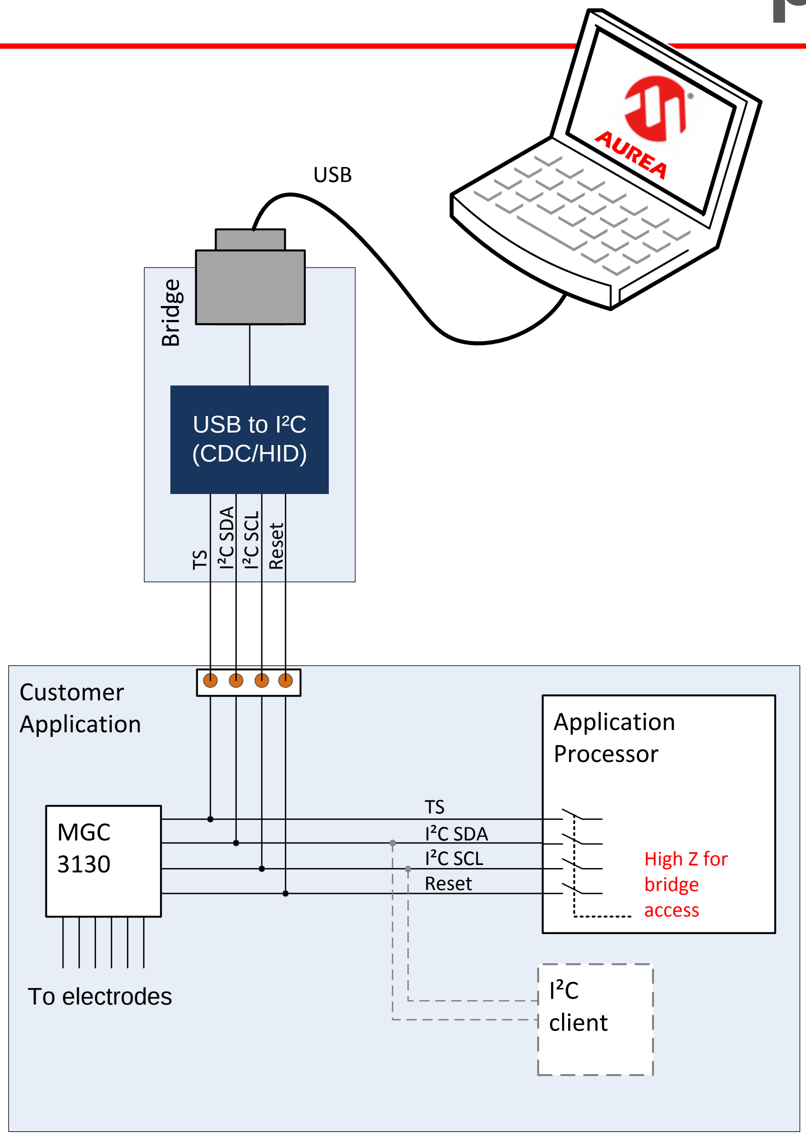
- GestIC FW Library
- Library Boot Loader
- Parameter File

Upcoming MGC3130 documentation:

- **GestIC FW Library delivered as C Structure**
- **Appnote to explain the update process**



In-Circuit debugging and programming I



Application processor sets I²C interface to high Z for AUREA parameterization and debugging

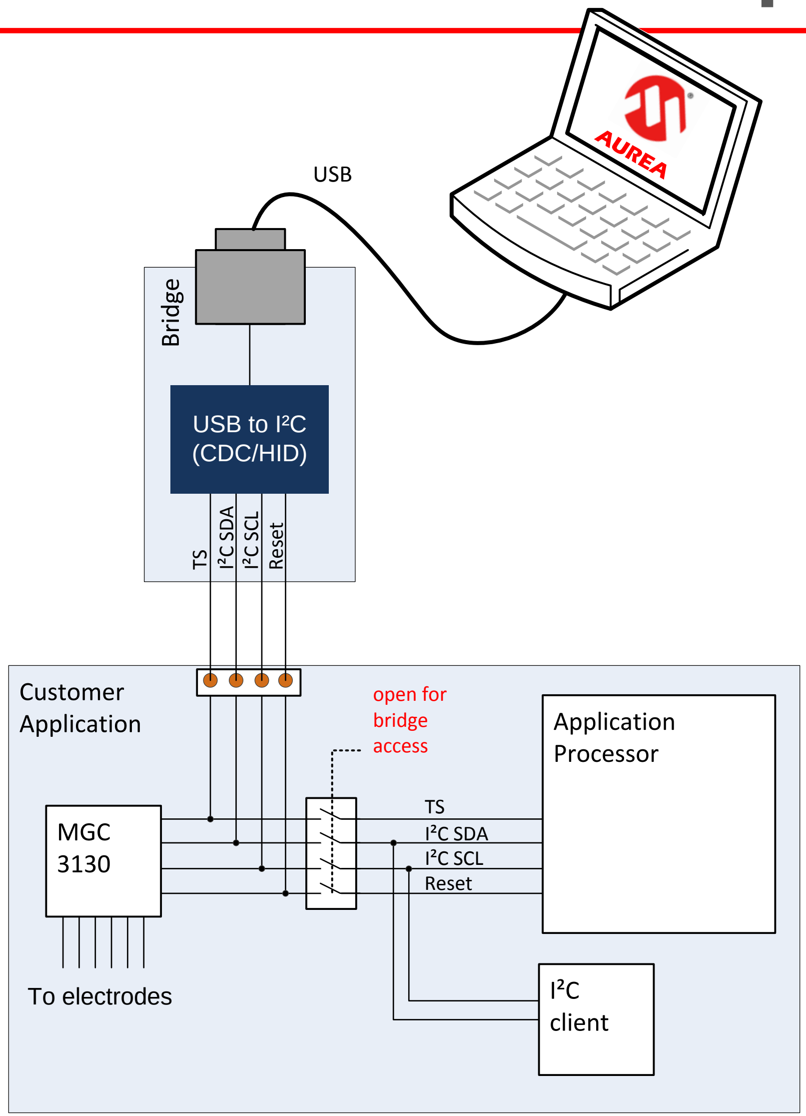
PRO

- Easy approach
- Low hardware efforts

CON

- Processor pins need to be switchable to high Z
- No other clients can be controlled during Aurea access

In-Circuit debugging and programming II



Physical I²C connection disconnected for AUREA parameterization and debugging

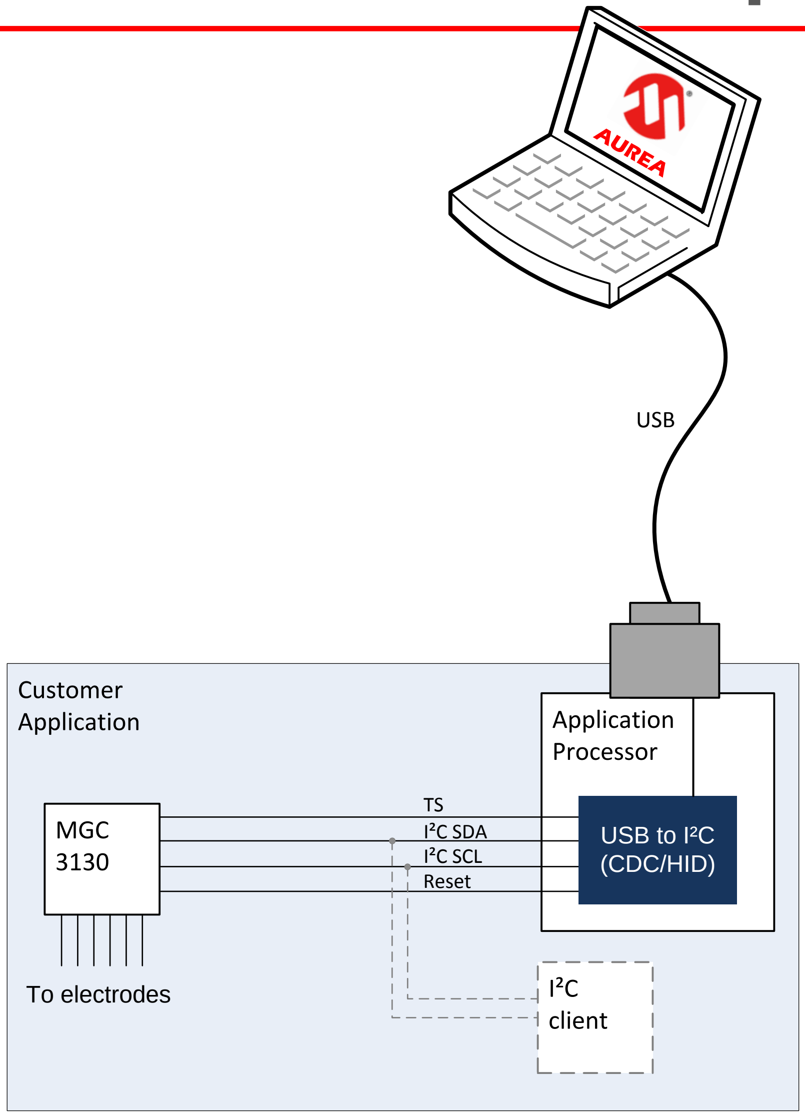
PRO

- Communication to other I²C clients not interrupted

CON

- Additional hardware switch

In-Circuit debugging and programming III



USB bridge integrated in Application processor

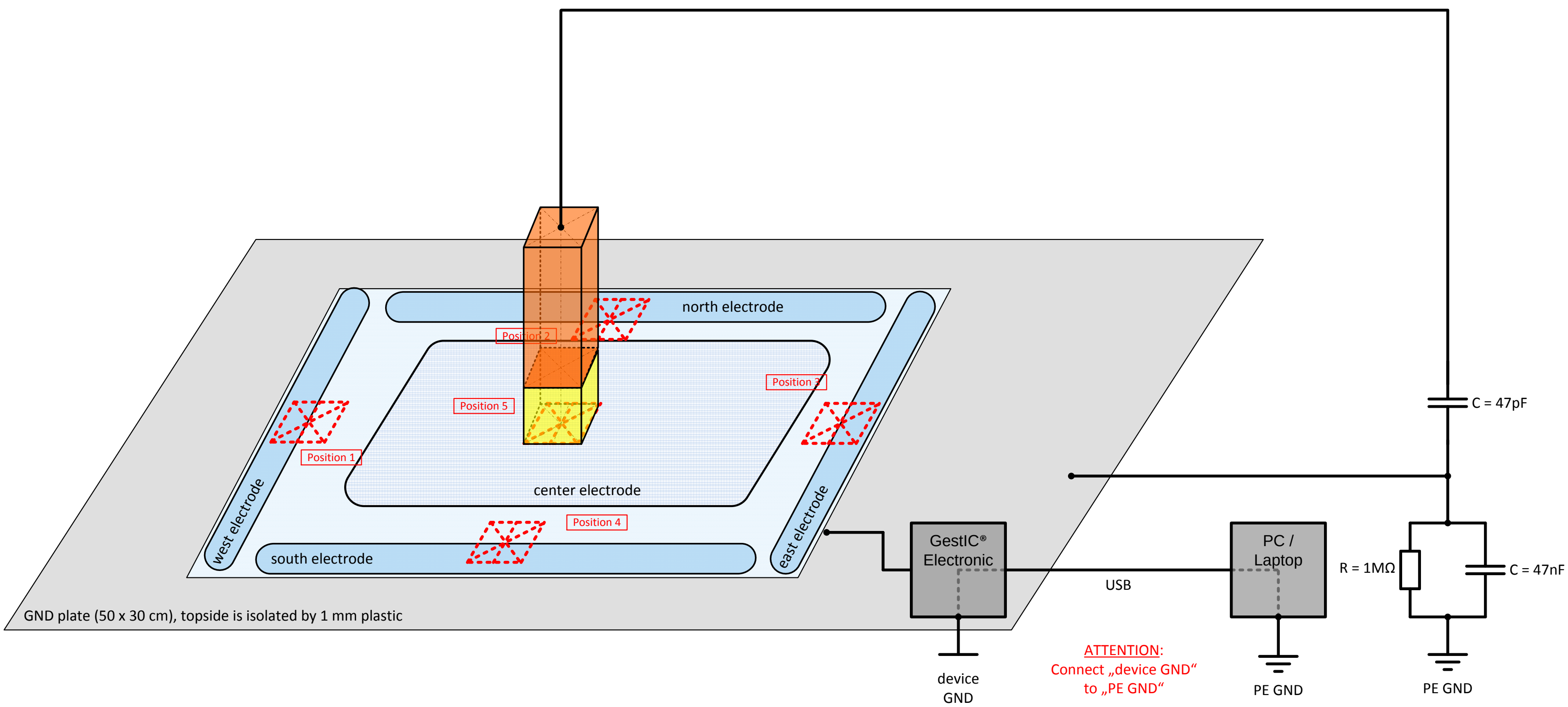
PRO

- No hardware efforts
- Works if other I²C clients connected to the bus

CON

- Additional software efforts

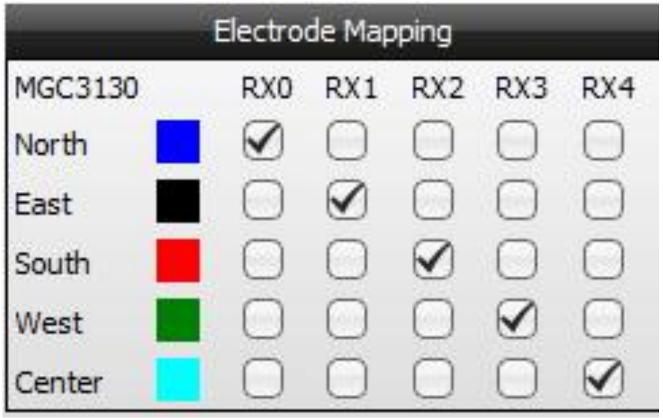
STANDARD TEST SETUP



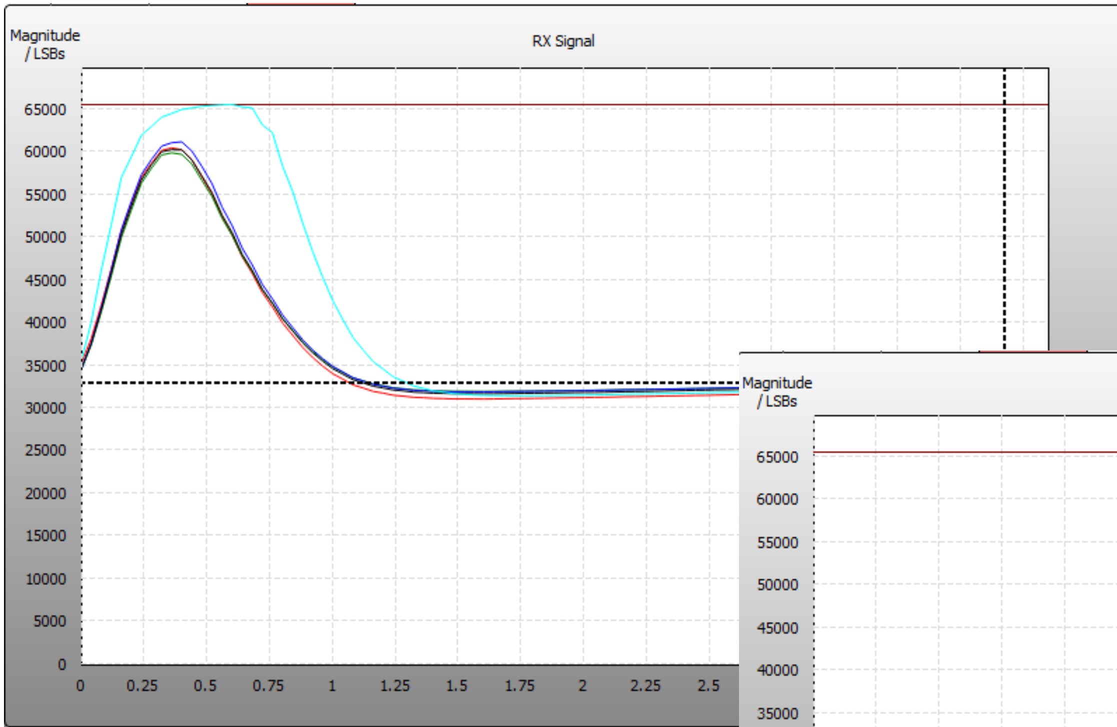
STANDARD TEST SETUP

ELECTRODES MAPPING

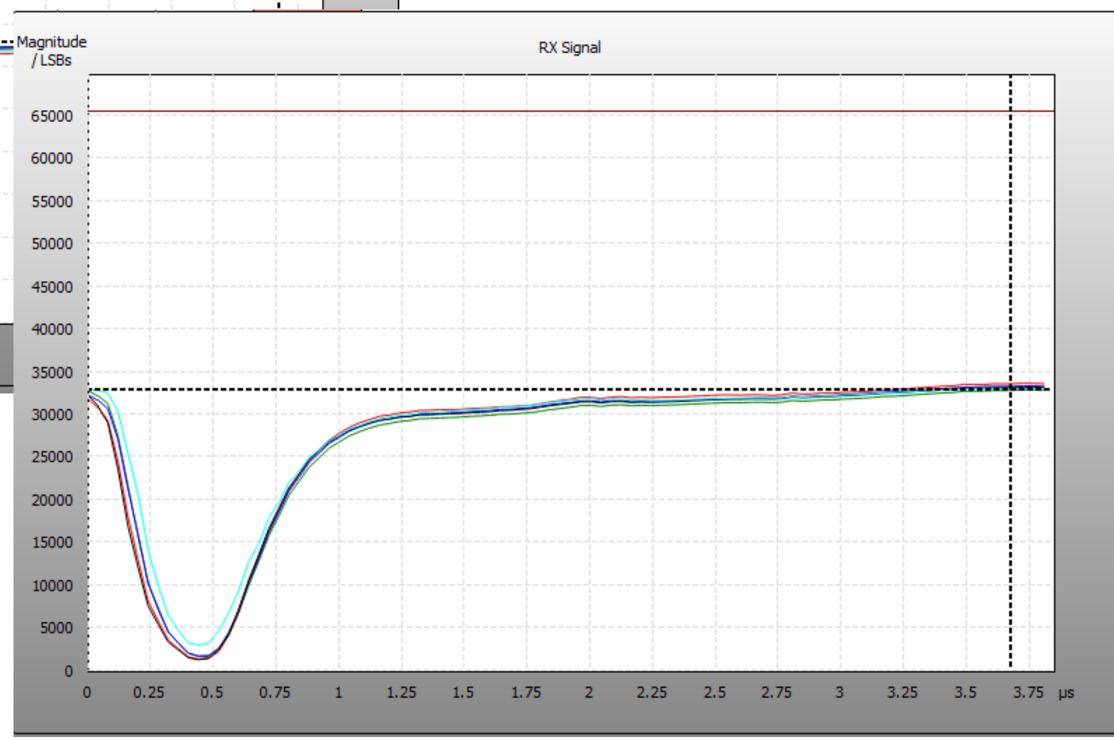
- Frame electrodes are named according to their cardinal directions - north, east, south and west
- Electrodes can be assigned to each Rx pin without any preferences
- Electrodes mapping can be updated by the user using GestIC Library messages runtime control or Aurea PC Software



GOOD SIGNAL MATCHING

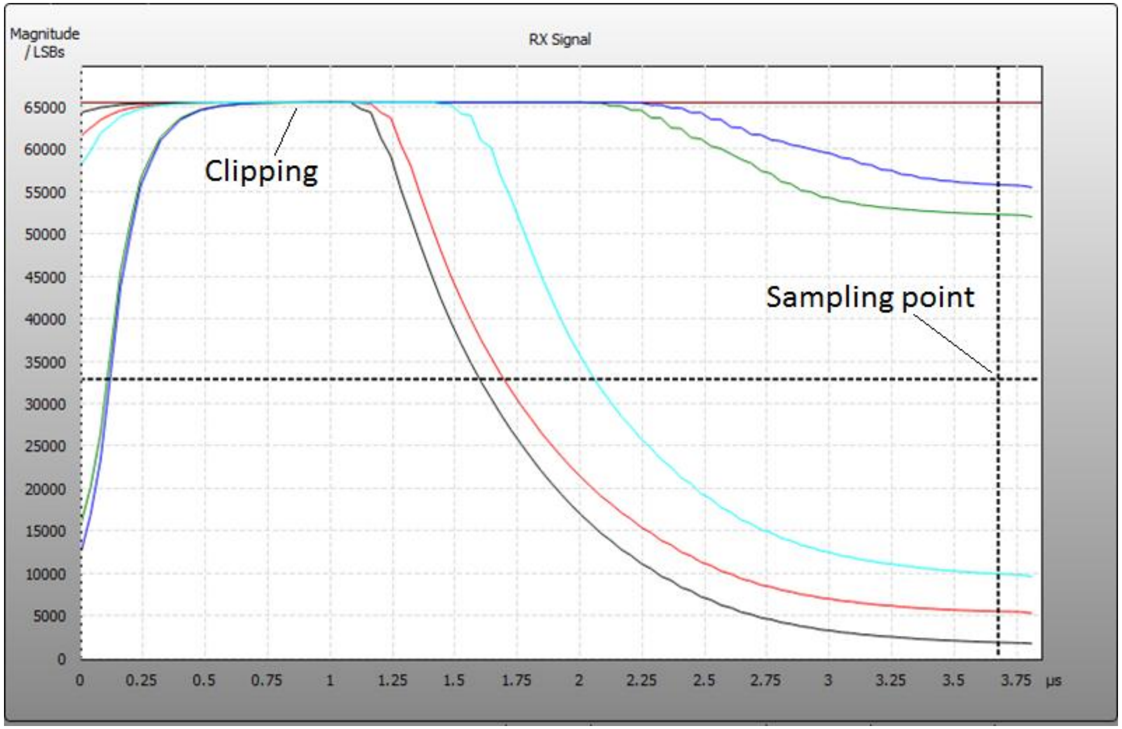


Depending on electrode capacitances, the input signal can have an over swing or an under swing.

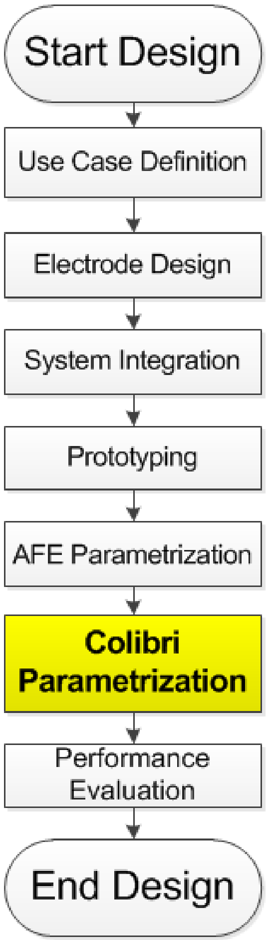


BAD SIGNAL MATCHING

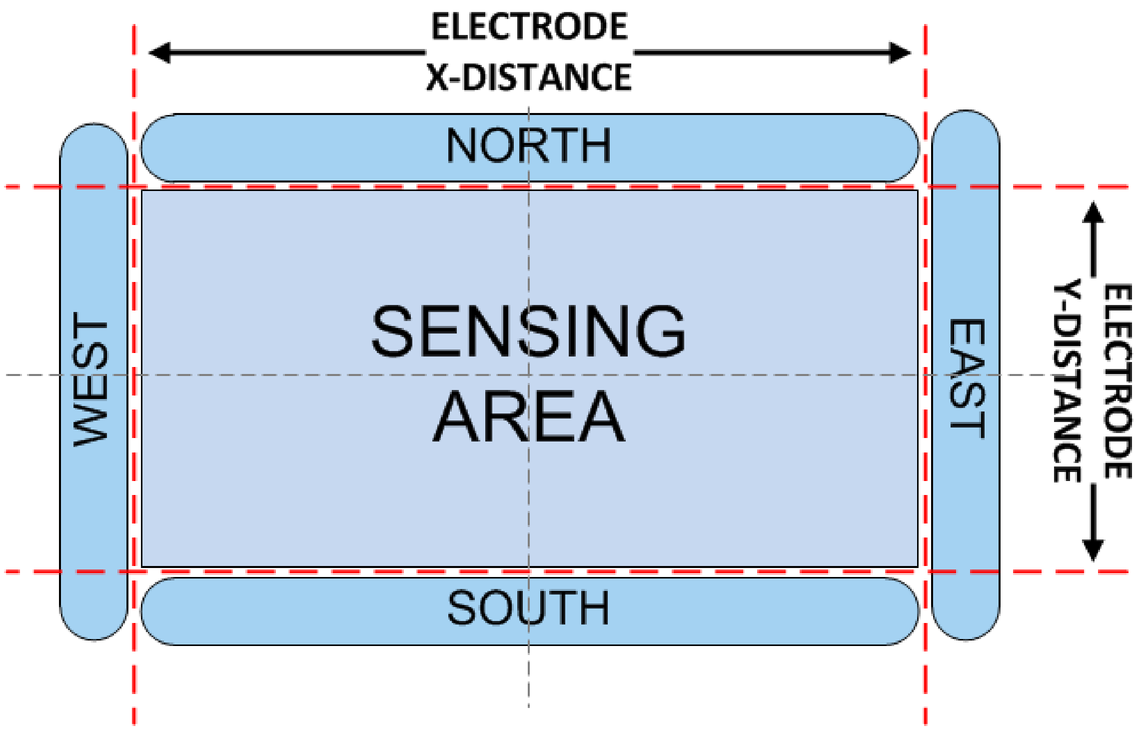
- Signals do not meet sampling point
- Clipping



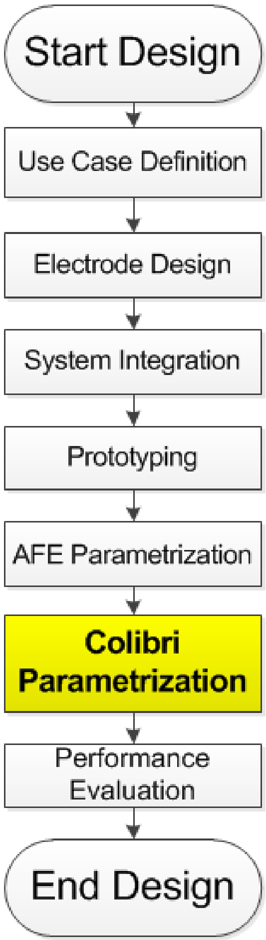
Electrode Dimensions



- Uncalibrated sensing space
- Required information for further parameterization steps

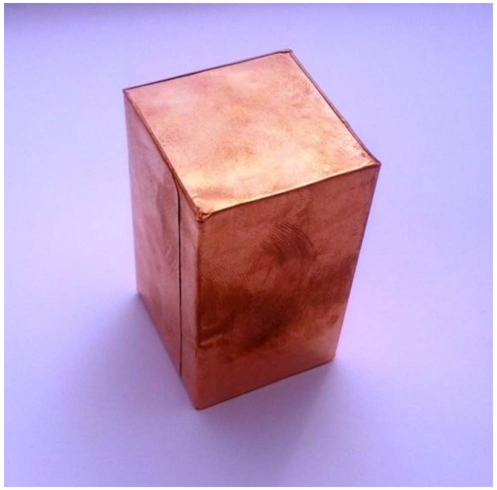


Measurement Equipment



Artifical hand ‚Hand - Brick‘

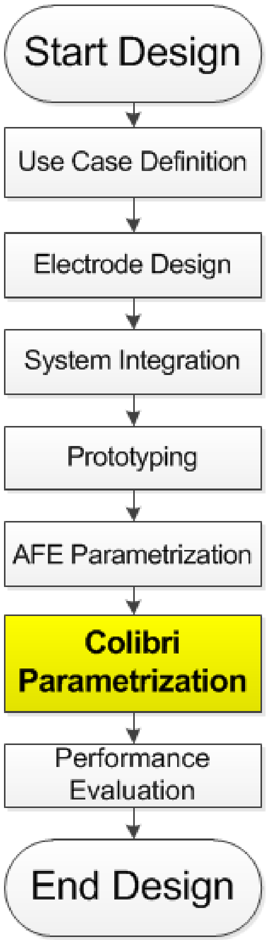
- Styrofoam block
- Covered by conductive copper foil
- Size 70mm x 40mm x 40mm

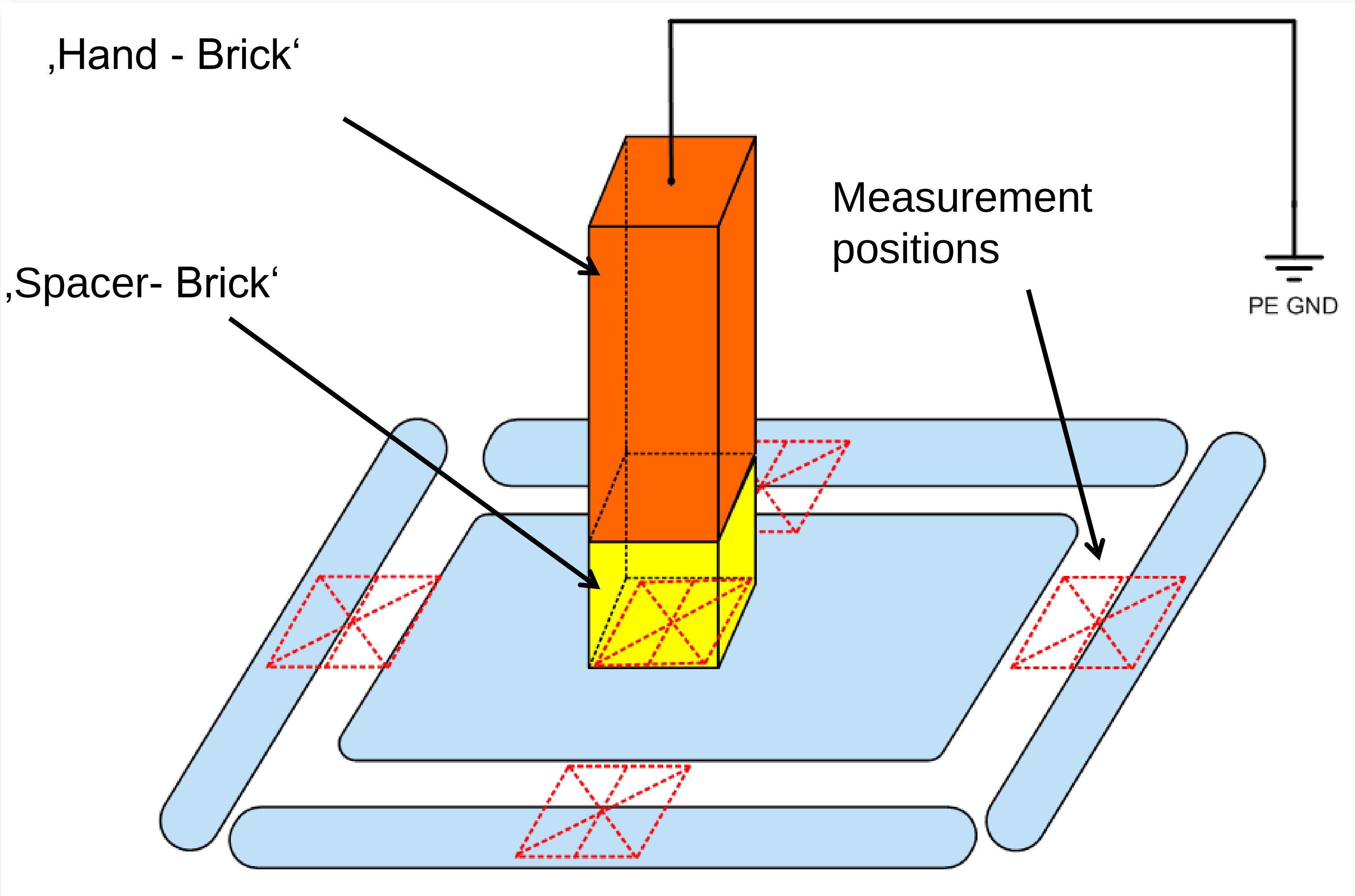


Spacer ‚Spacer - Brick‘

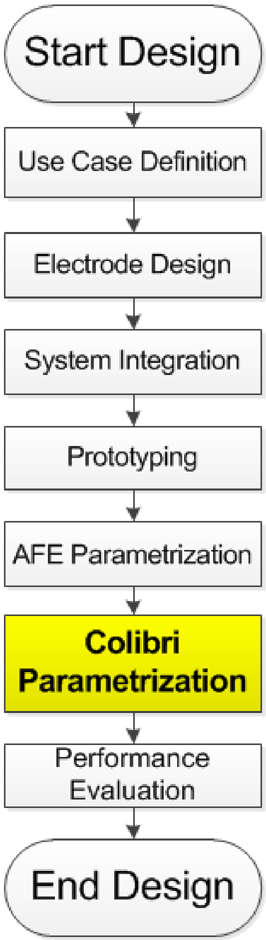
- Styrofoam block
- Set of 10mm, 30mm and 50mm blocks

Brick Measurement Setup

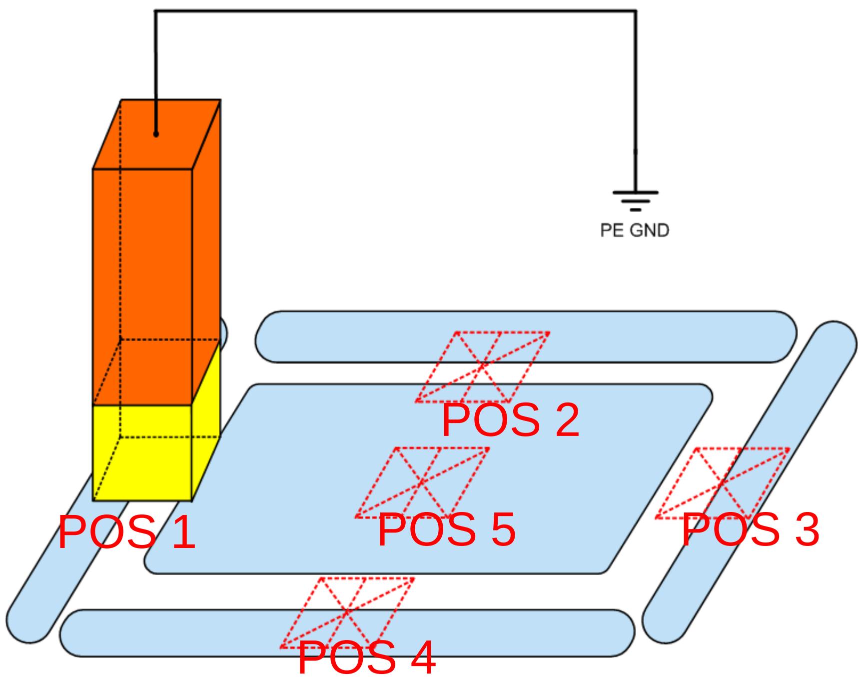




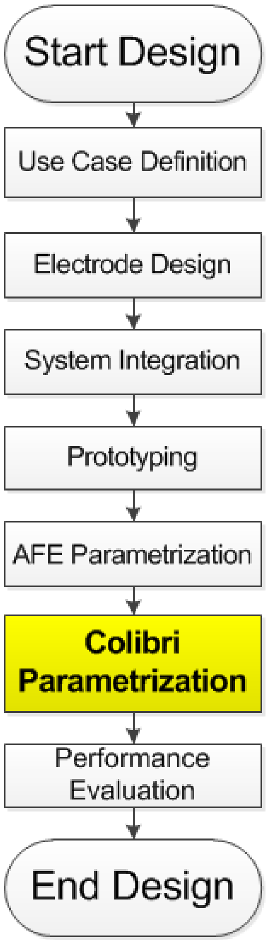
Electrode Weighting – Brick Measurement



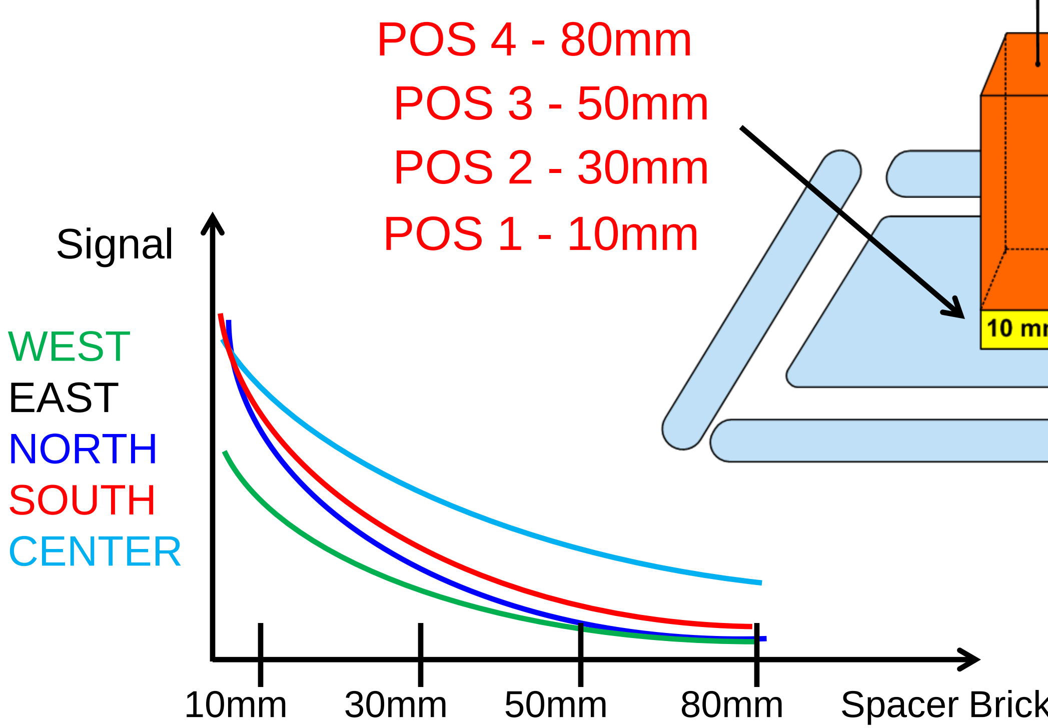
- Compensate electrode sensitivity differences for Z-Position calculation
- 5 semi-automatic brick measurements at a constant Z-level

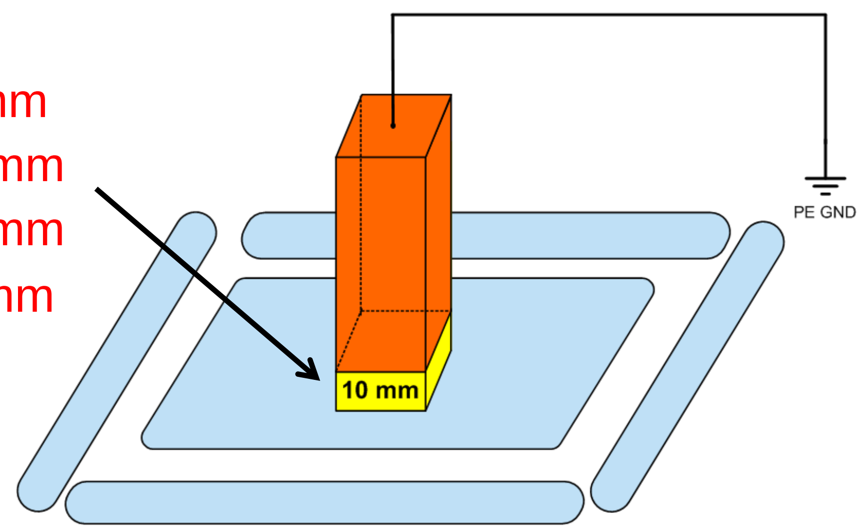


E-Field Linearization – Brick Measurement

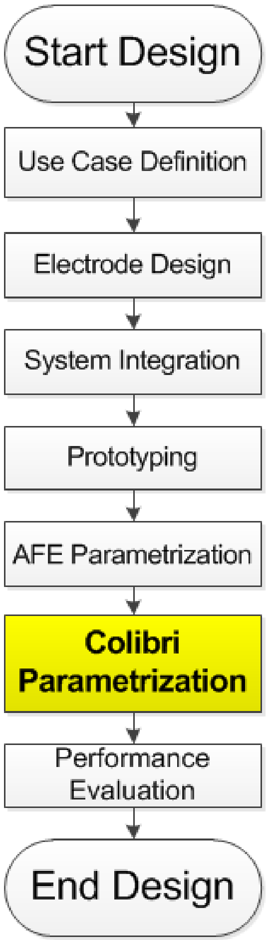


- Compensate non linear E-field distribution
- 4 semi-automatic vertical brick measurements
- Auto-curve fitting

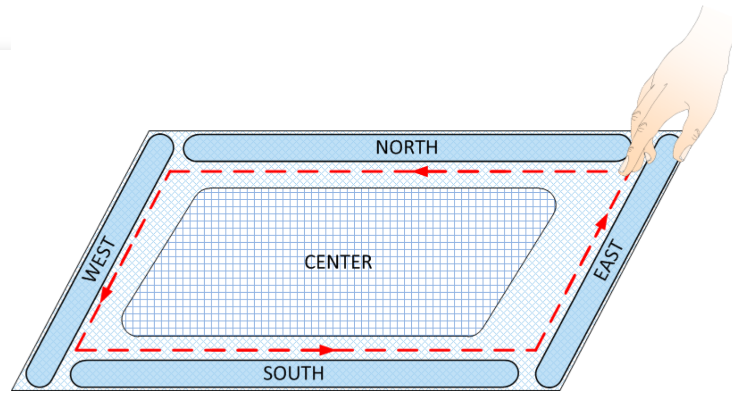




Sensing Area



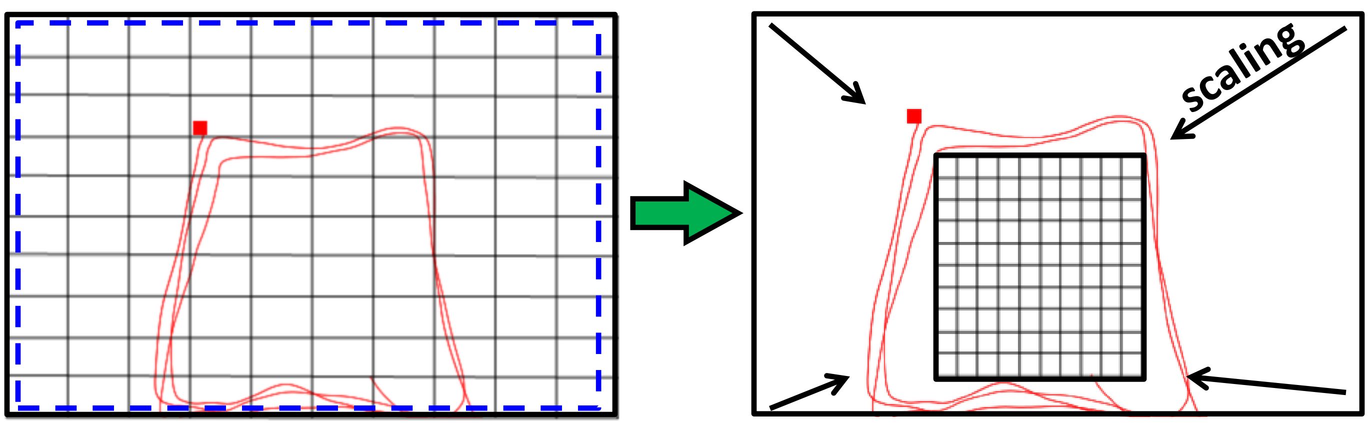
- Feeding line
- Hand posture
- Low electrode sensitivity



Hand movement

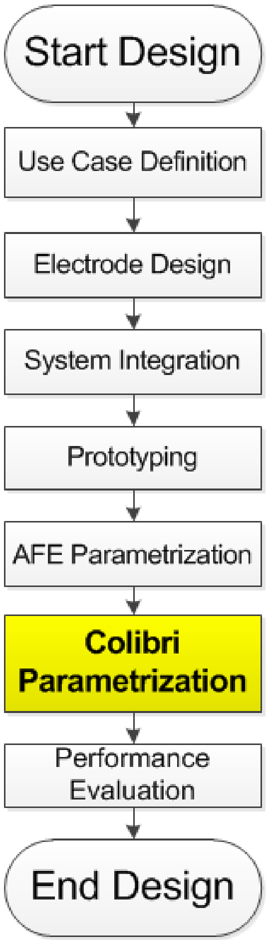
- - Real **Position**

— Calculated Position



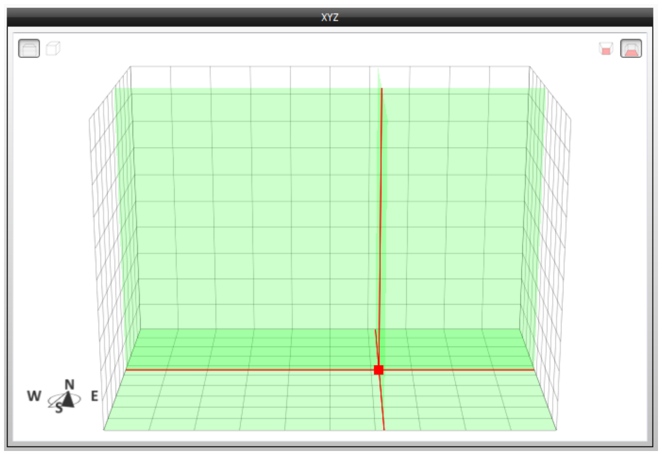
Uncalibrated sensing area **Calibrated sensing area**

Z-Positioning

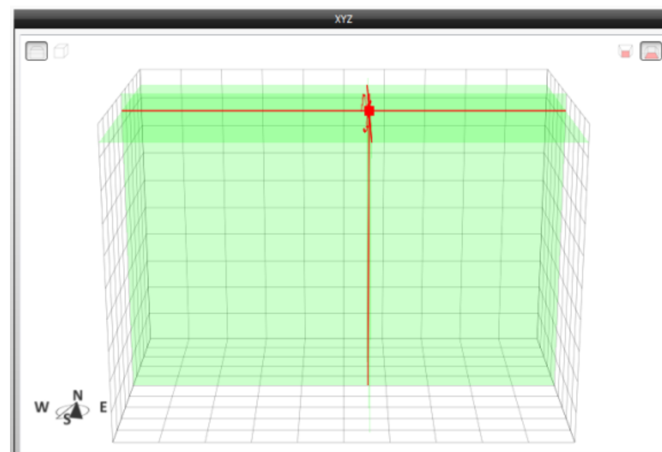


- Offset adjustment ‚0 mm distance'
- Readjust System entrance

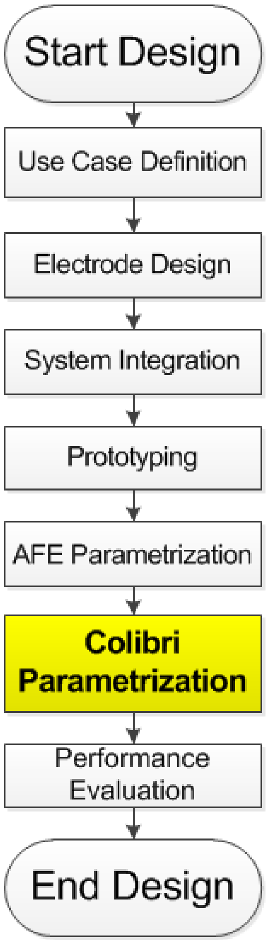
‚0 mm' distance



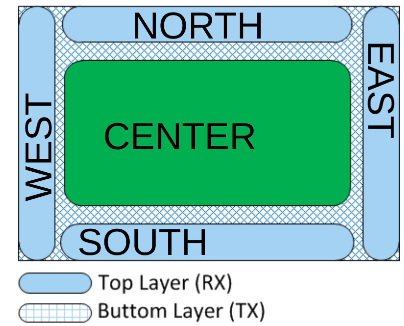
System entrance

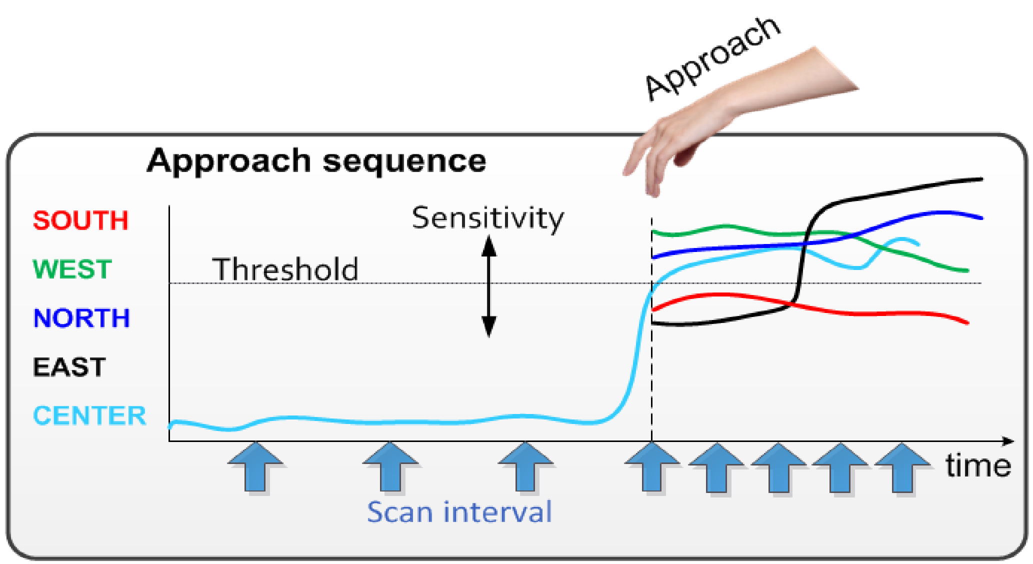


Approach Detection

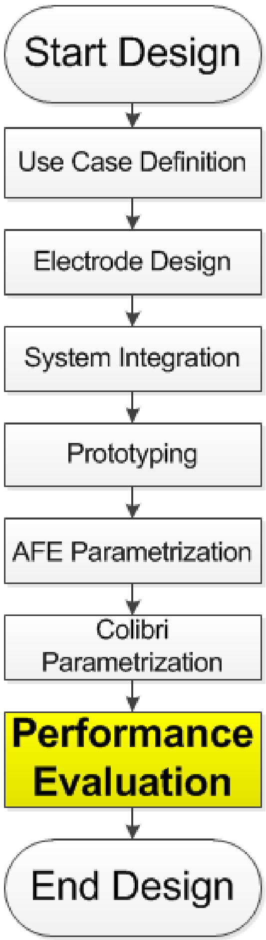


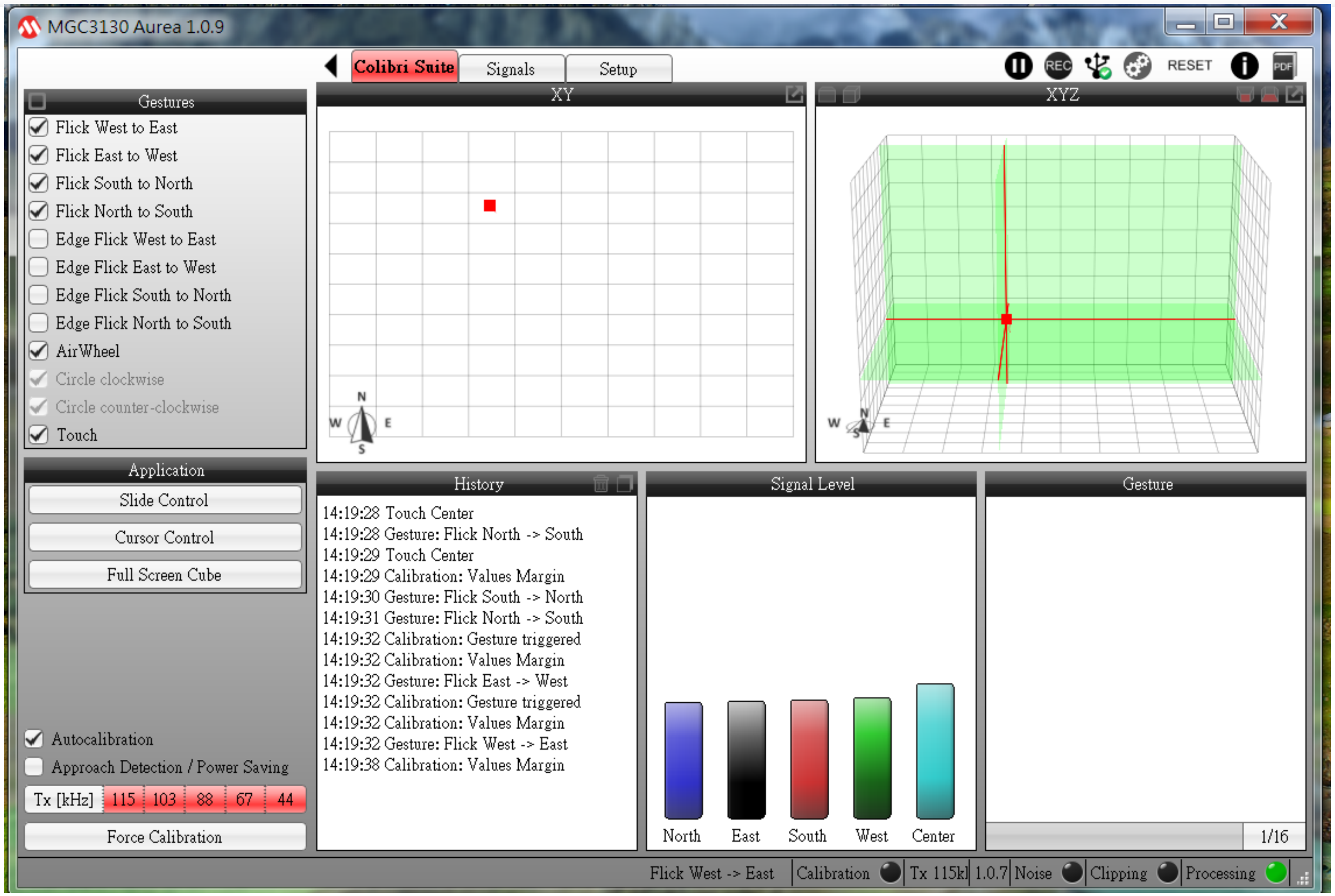
- Electrode selection
  - Define sensitive area for wake up
- Timing adjustment
  - Scan interval
  - Idle timeout
- Sensitivity adjustment





Performance Evaluation

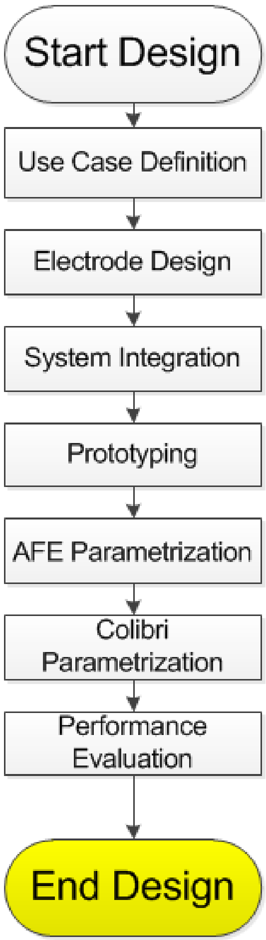




Performance not good enough?

→ Repeat the corresponding parameterization step

End of Design-In



Congratulations!

You have now a parameterized GestIC® system

Agenda

- Introduction
- New features V1.0
- Design-in Step
- MGC3130 Integration
- Colibri Parameterization
- Application Examples

Applications Overview

Home Automation

Lightswitch

Consumer products

Battery driven Devices

GestIC Applications

GestIC exclusive *3D only*	Light Switches and Dimmer Audio Docks Headphones Household Appliances
GestIC and Keys/Buttons *3D and 1D*	Notebooks Accessory Keyboards Household Appliances Car Cockpit
GestIC and pCAP *3D and 2D*	Computer Touch Pads Remote Controls Game Controller Automotive
GestIC Touch Display *3D and 2D display*	Tablets Mobile Phones Notebooks Industrial and Automotive

Resources

Getting started

- MGC3130 GestIC® Technology Quick Start Guide
- MGC3130 Single Zone 3D Gesture Controller Product Brief
- MGC3130 Single-Zone 3D Gesture Controller Data Sheet

GestIC DevKit Hillstar

- MGC3130 Single Zone Development Kit Hillstar
- MGC3130 Hillstar Development Kit User's Guide
- MGC3130 Software Package - Aurea GUI and GestIC Library
- MGC3130 – Aurea Graphical User Interface User's Guide

GestIC Electrode design / HW references

- MGC3130 GestIC® Design Guide
- MGC3130 Hillstar Hardware References

Interface, I2C, sample Code

- MGC3130 GestIC® Library Interface Description User Guide
- MGC3130 Software Development Kit (SDK)
- MGC3130 PIC18F14K50 Host Reference Code

Thank you!