Latest developments at SENIS

Dr. Dragana Popovic Renella, COO

IMMW21
International Magnetic Measurement Workshop
24th – 28th June 2019

SENIS
magnetic & current measurement

OUR PRODUCTS....

SENIS
magnetic & current measurement

3D Magnetic Field Measurement
at single spot

Compact and thin
1-, 2-, 3- Axis Hall Probes

High accuracy and resolution
Analog Transducers and
Digital Teslameter

Handheld USB 3D Teslameter

Fast, high resolution mapping
of magnetic field (Bx/By/Bz)
around permanent magnets,
electromagnets and
electronic circuit PCBs

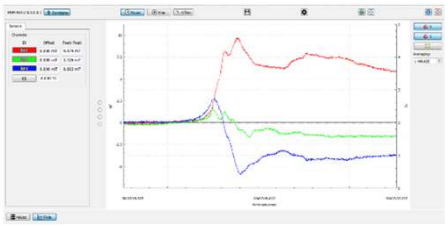
Bus Bar current sensor modules
(f-bandwidth of DC to 200kHz)
Clamp-on Closed-Loop and
Open-Loop
(highest accuracy and resolution)

3D Hall sensor
Fast magnetic angle sensor
Any Axis Hall sensor

DIGITAL TESLAMETERS

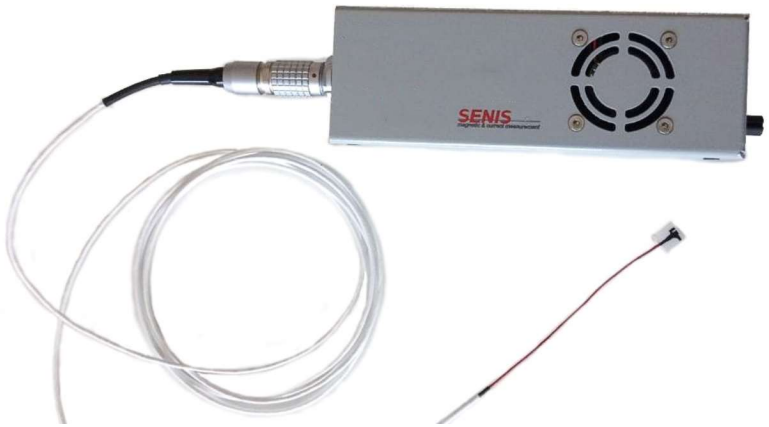
SENIS
magnetic & current measuremen

Handheld USB 3D Teslameter **3MTS**



- 3-axis Hall
- 2uT to 20T
- Accuracy 1%
- MFSV 150x150µm
- 2uT to 20T
- DC to 500Hz

Miniaturized 3D Low-Noise Digital Transducer **MLNT-3D**



- 3-axis Hall
- 0.8uT to 2T
- Accuracy 0.01%
- DC to 500Hz
- Mini Box

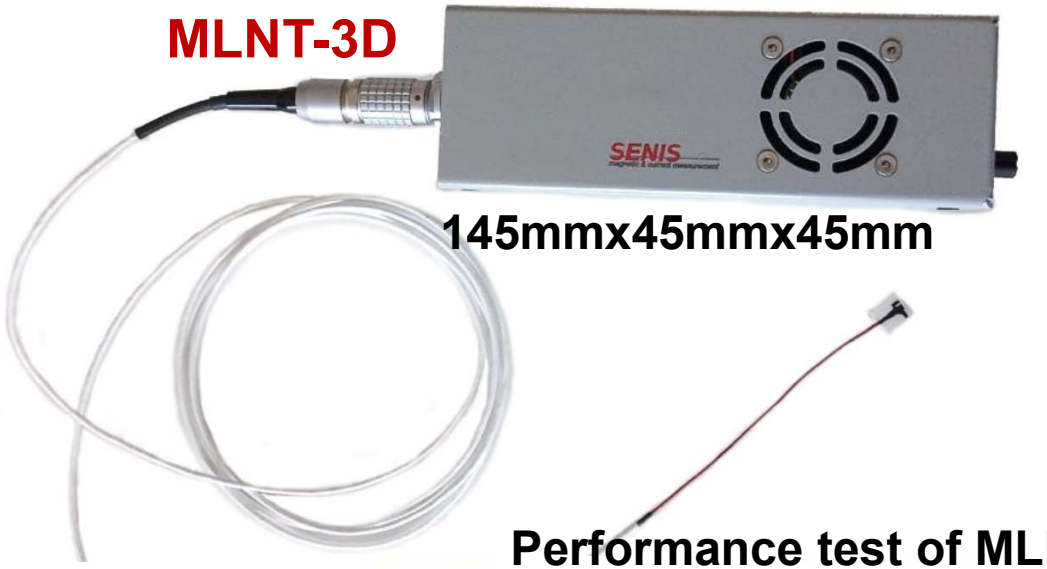
High-precision 3D Teslameter **3MH6**

- 3-axis Hall
- Single Si-chip
- 100x10x100µm
- Resolution 1ppm
- Accuracy 0.005%
- DC to 2.5kHz

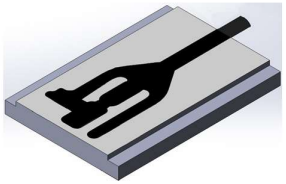
MINIATURIZED 3D LOW-NOISE DIGITAL TRANSDUCER

SENIS
magnetic & current measurement

MLNT-3D

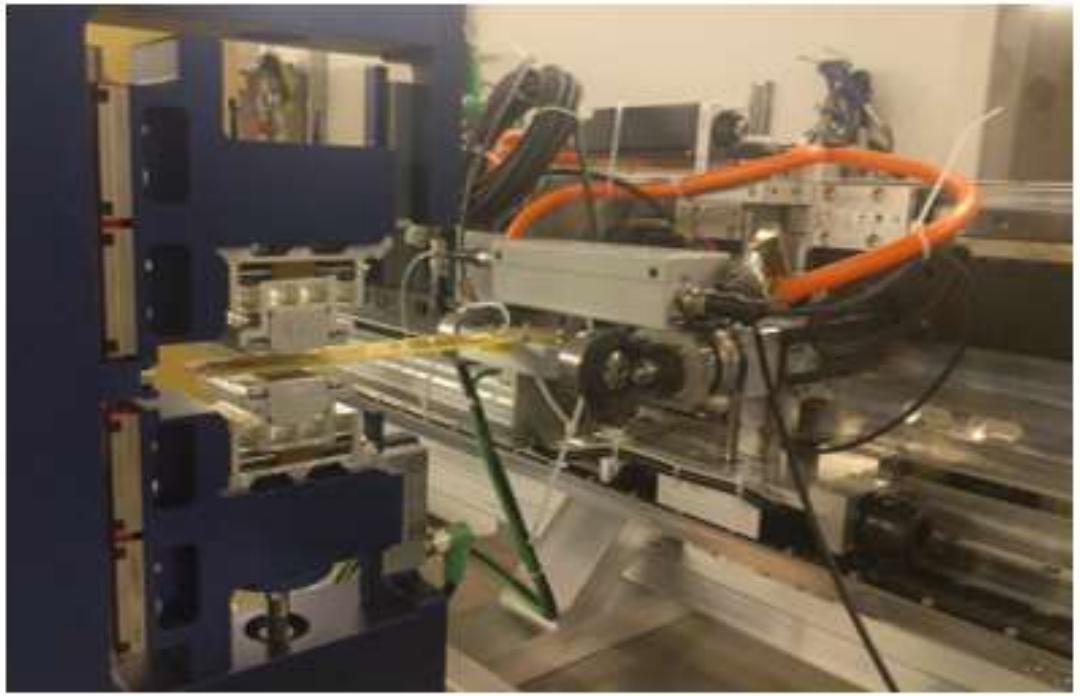


145mmx45mmx45mm

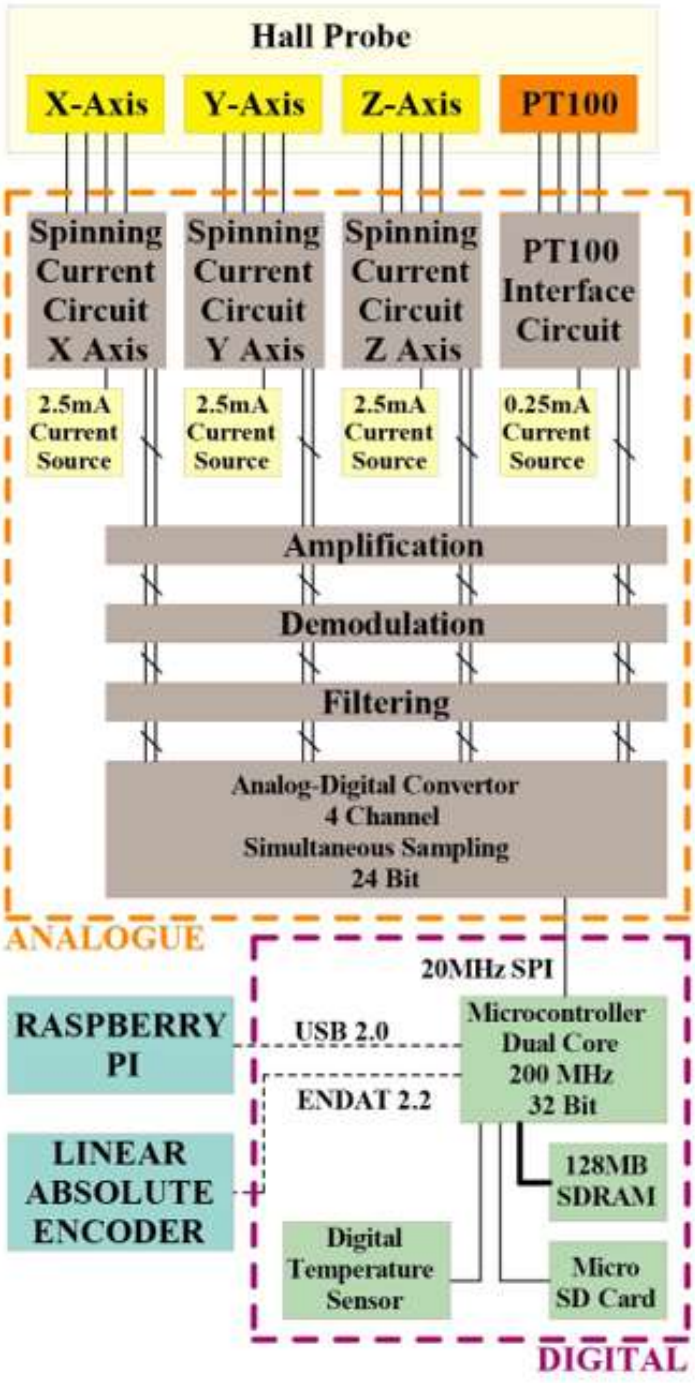


- 3-axis Hall
- Hybrid probe
- 0.8uT to 2T
- Accuracy 0.01%
- DC to 500Hz
- Mini Box

Performance test of MLNT-3D at PSI

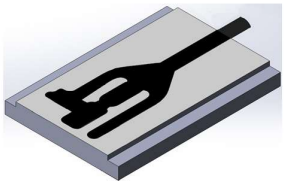


BLOCK DIAGRAM OF MLNT-3D

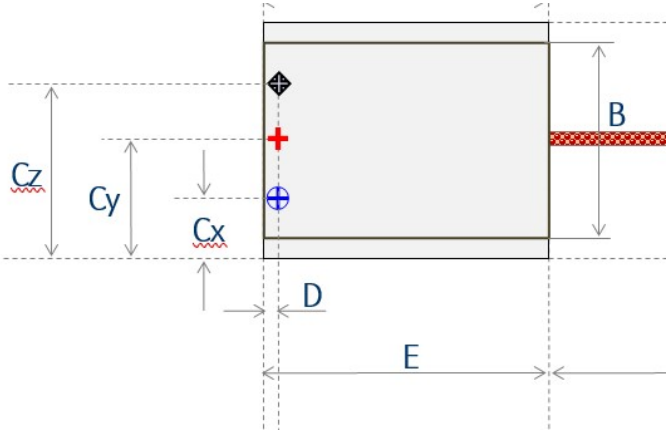


SENIS
magnetic & current measurement

3D HALL PROBES FOR MLNT-3D



Hybrid 3D Hall probe
10mm x 10mm



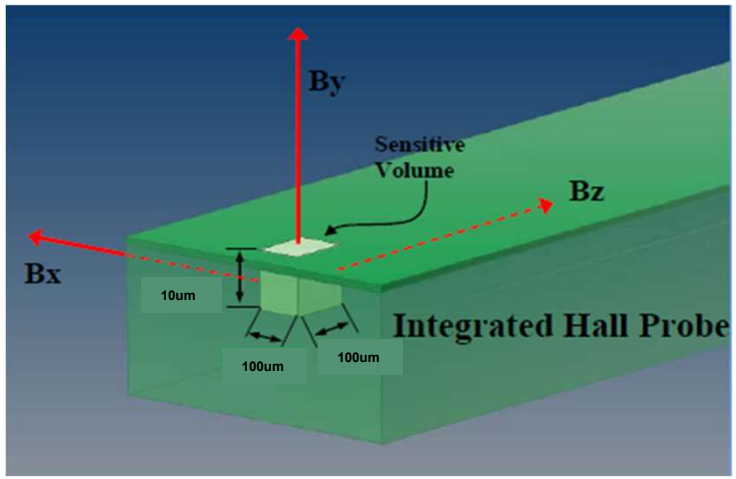
Integrated 3D Hall probe
8mm x 4mm
MFSV: 150µm x 150µm x 10µm -> 100µm x 100µm x 10µm

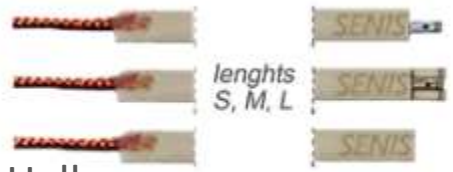
SENIS
magnetic & current measuremen

MLNT-3D

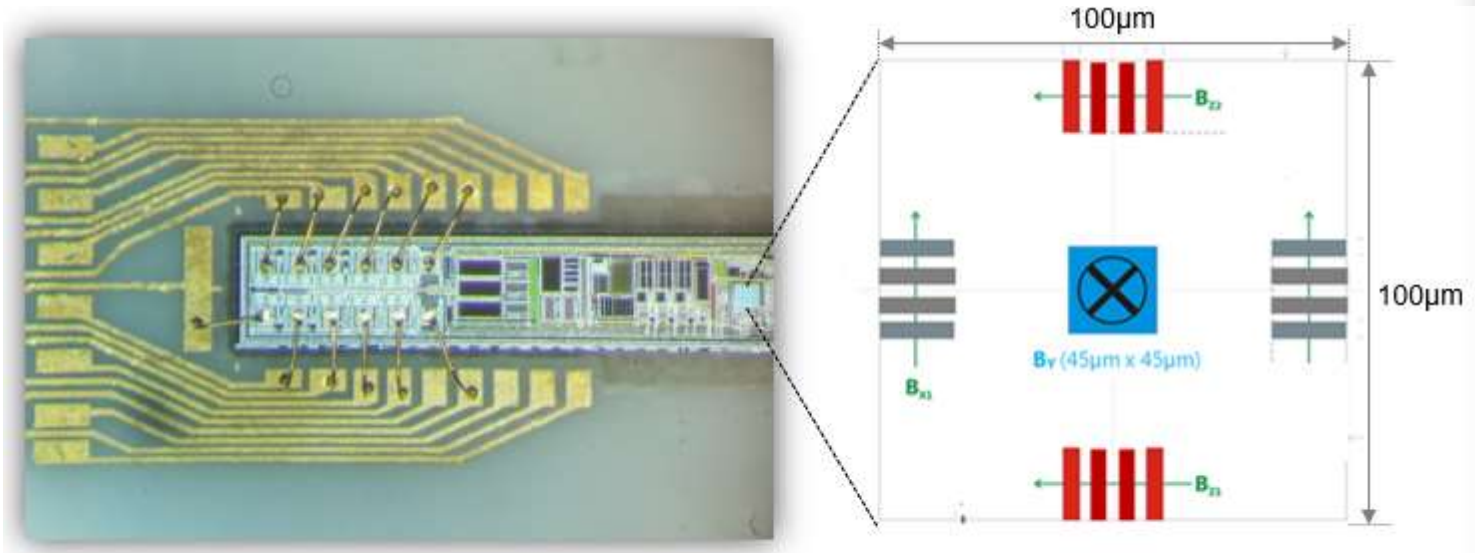
- 3-axis Hall
- Hybrid probe
- 0.8 uT to 2T
- Accuracy 0.01%
- DC to 500Hz
- Mini Box

3-AXIS HALL PROBE CHIP

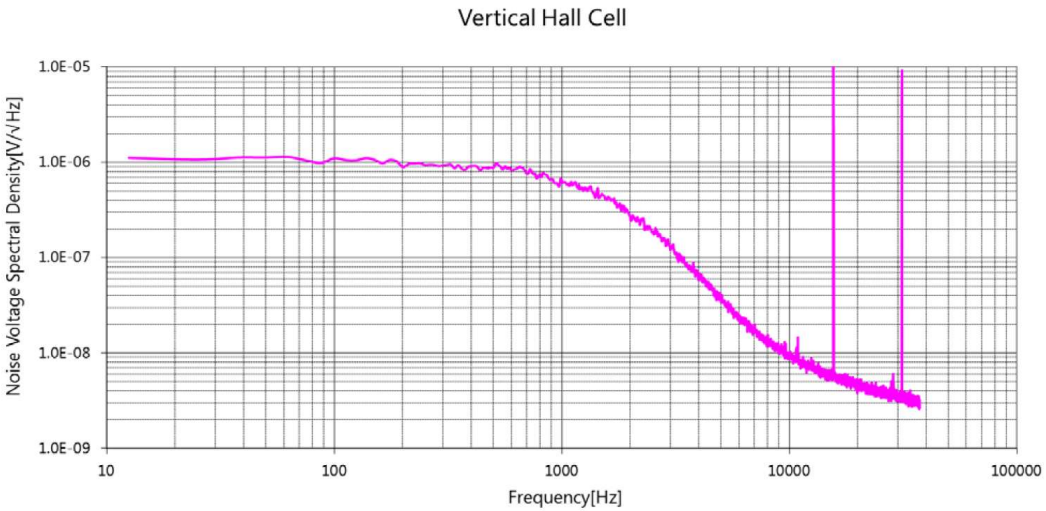


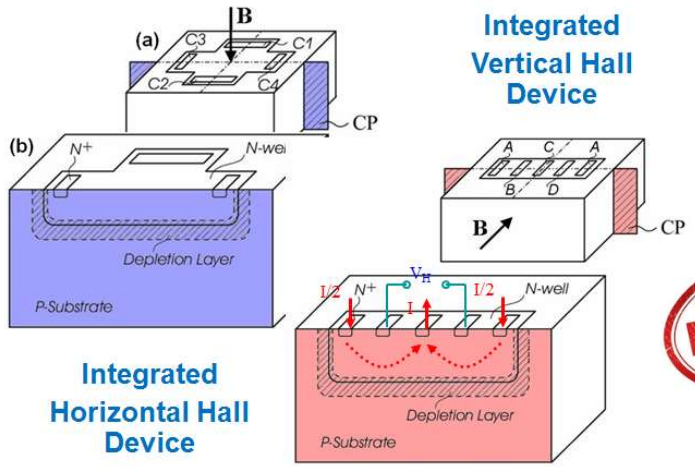


- Horizontal and vertical Hall devices are integrated in one single Si-chip
- Sensitive volume: 100µm x 100µm x 10µm
- Measures B_x,B_y,B_z at the same time



HIGHEST RESOLUTION AND SMALLEST MFSV





SENIS HALL PROBES

SENIS
magnetic & current measurement

1-, 2-, 3-Axis Integrated Hall Probes with and w/o On-chip Amplifier

High Temperature Hall probe for -40°C – +155°C

Fully integrated 3-axis Hall probe
with on-chip amplifier and signal processing

Vacuum suitable Probes

freqency bandwidth from DC up to 75 kHz

3-axis Hall Probe with Field Sensitive Volume
of 200 x 20 x 200μm³ (small cross on the chip)

The thinnest Hall probe, packed in ceramic packaging <250μm!

UNIQUE PERFORMANCE:

- Fully integrated CMOS 1-, 2-, 3-axis (Bx, By, Bz) Hall Probe with or without on-chip amplifier & signal processing for offset, noise and planar Hall effect cancelling
- On-chip integrated temperature sensor for temperature compensation
- Very high spatial resolution: By: 0.045 x 0.005 x 0.045 mm³; Bx and Bz: 0.10 x 0.01 x 0.10 mm³
- Suitable for FxA and IxC Magnetic Transducers
- High angular accuracy: orthogonality error less than 0.1°
- Absolute accuracy: better than ± 0.1 % within ± 2T
- Magnetic resolution: <5uT @ 200mT and <10uT @ 2T
- Full scale range: 20mT – 20T, calibrated up to 2T
- White Noise (@ f > 10 Hz): 0.1 μT/√Hz @ 200mT
- Temperature Coefficient of Sensitivity: better than ± 100 ppm/°C (± 0.01 %/°C)
- High frequency bandwidth: from DC up to 75kHz for 1-axis; from DC up to 25kHz for 3-axis
- Virtually no planar Hall effect
- High immunity on electrostatic and inductive disturbances
- Negligible inductive loops on the Probe

Hall Probe A

Very robust *integrated Hall probe for F3A, F1A and IxC magnetic transducers and for OEM customers.*
Dimensions (length, width, thickness, in mm): ***16.5 x 5.0 x 2.3***
Distance to magnetic field sensitive area (front/top): ***1.0mm/1.0mm***

Hall Probe C

Ceramic Hall Probe *suitable for Very* ***High Temperature*** *Range: -40°C to +155°C. For F3A, F1A and IxC magnetic transducers and for OEM customers.*
Dimensions (length, width, thickness, in mm): ***8.0 x 4.0 x 0.9***
Distance to magnetic field sensitive area (front/top): ***0.5mm/0.35mm***

Hall Probe U (0.25mm thin!)

The thinnest Hall probe *in the ceramic package for F3A, F1A and IxC magnetic transducers.*
Dimensions (length, width, thickness, in mm): ***8.0 x 3.0 x 0.25***
Distance to magnetic field sensitive area (front/top): ***1.0mm/0.1mm***

Hall Probe H

Very long and thin *integrated ceramic Hall probe* ***with the protected Si chip*** *for F3A, F1A, IxC magnetic transducers.*
Dimensions (in mm) width, thickness: ***2.0 x 0.5***
length: HS ***8.0;*** *HM* ***46.0;*** *HL* ***71.0***
Distance to magnetic field sensitive area (front/top): ***0.3mm/0.25mm***

Hall Probe K

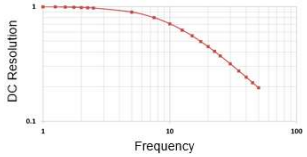
Very long and thin *integrated ceramic Hall probe* ***with the naked Si chip*** *for F3A, F1A, IxC magnetic transducers.*
Dimensions (in mm) width, thickness: ***2.0 x 0.25***
length: KS ***8.0;*** *KM* ***46.0;*** *KL* ***71.0***
Distance to magnetic field sensitive area (front/top): ***0.3mm/0.01mm***

Hall Probe L

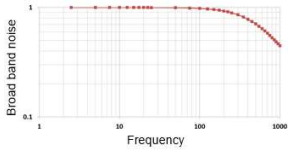
Very long and thin *integrated ceramic Hall probe* ***with the naked Si chip*** *for F3A, F1A, IxC magnetic transducers.*
Dimensions (in mm) width, thickness: ***0.65 x 0.1***
length: LS ***8.0;*** *LM* ***46.0;*** *LL* ***71.0***
Distance to magnetic field sensitive area (front/top): ***0.15mm/0.01mm***

PARAMETERS OF MLNT-3D

- Hybrid / Integrated 3-axis (Bx, By, Bz) Hall Probe
- Measurement range +/-2T
- Measurement of DC & AC magnetic fields up to 500Hz (-3dB)
- DC magnetic resolution 0.8 uT rms



- Broadband noise 2 uT



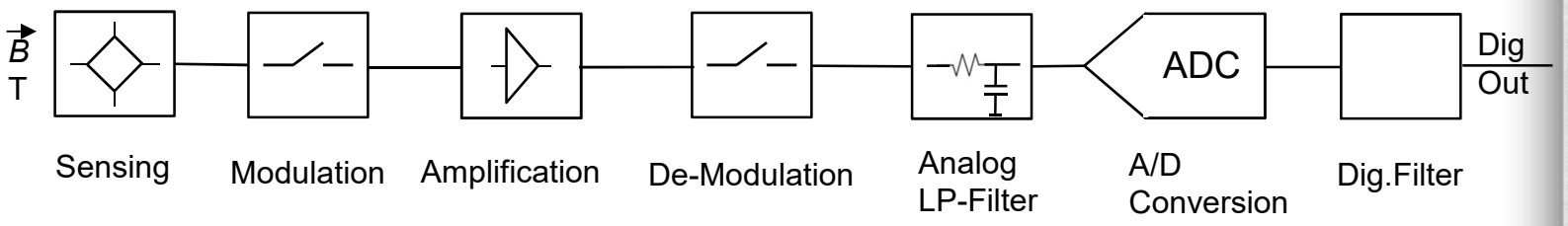
- 24-bit A/D Convertor
- External Trigger (Synchronization between probe position and measurement)
- A temperature sensor on the probe for temperature compensation
- Miniaturized electronic box (145mmx45mmx45mm)

MLNT-3D

- 3-axis Hall
- Hybrid probe
- 0.8uT to 2T
- Accuracy 0.01%
- DC to 500Hz
- Mini Box

INCREASING RESOLUTION AND BANDWIDTH

Block Diagram of a Teslameter



HIGH-PRECISION 3D TESLAMETER 3MH6

3MH6

- **3-axis Hall (Single Si-chip)**
- **MFSV: 100x10x100µm**
- **Accuracy 0.005% (50ppm)**
- **Resolution 1ppm**
- **DC to 2.5kHz**

HIGH-PRECISION 3D TESLAMETER 3MH6

SENIS
magnetic & current measuremen

- Integrated 3-axis Hall Probes (Bx, By, Bz)
- MFSV: 100x10x100µm
- Interchangeable probes
- Very high magnetic DC resolution better than 1ppm (@2T range: 1µT for planar and 2µT for perpendicular components of field)
- DC Accuracy: 0.005% (50ppm)
- Selectable magnetic field ranges (100mT, 500mT, 2T, 20T)
- Frequency bandwidth: DC – 2.5kHz (-3dB)
- Selectable sampling rate up to 7.5ks/sec
- Selectable averaging time from 133µs
- High temperature stability: < 20ppm/ ° C
- 24-bit A/D Convertor

- 3-axis Hall
- Single Si-chip
- 100x10x100µm
- Resolution 1ppm
- Accuracy 0.005%
- DC to 2.5kHz

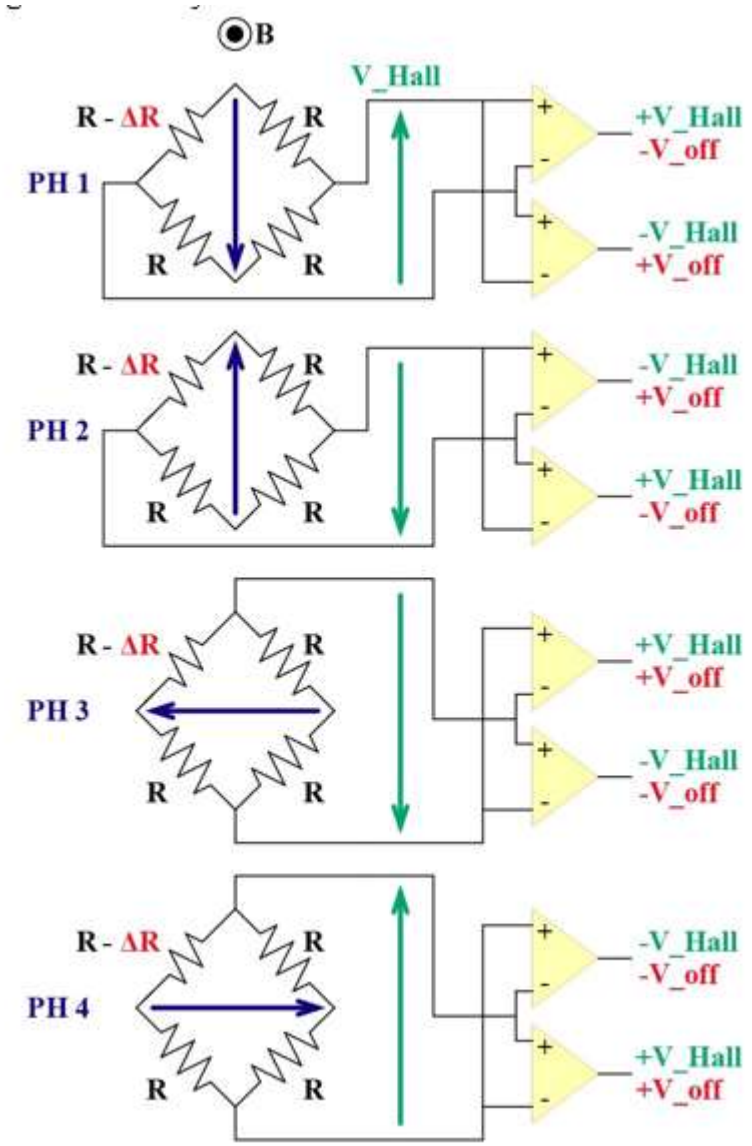
HIGH-PRECISION 3D TESLAMETER 3MH6

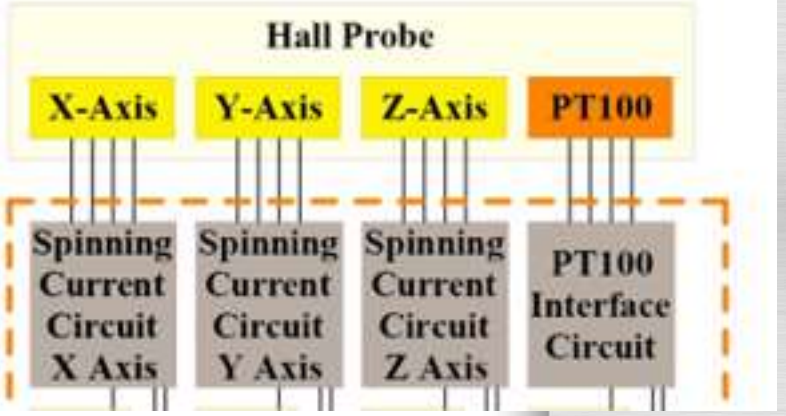
- **TFT LCD graphic display (107 x 71mm) for Bx, By and Bz and the Hall Probe temperature**
- **Numerical, graphical and statistical measurement visualization**
- **Embedded computer (GUI on Android)**
- **Remote data acquisition & visualization PC Software runs on Windows 7/10/XP (USB 2.0)**

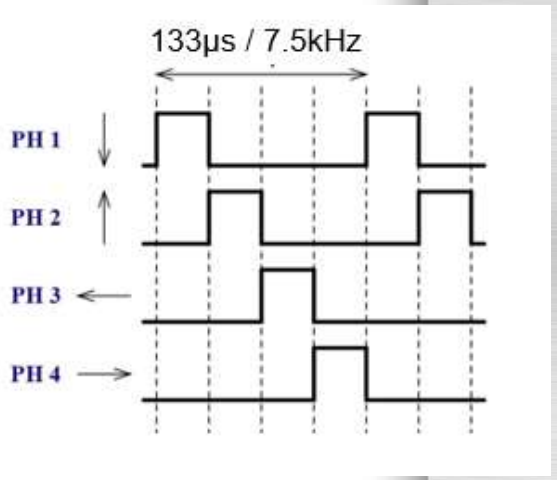
NEW 3MH6 TESLAMETER vs. 3MH5

- No f-limitation due to the presently used analog low-pass filter
  -> f-bandwidth DC – 2.5kHz (-3dB)
- Efficient suppressing of switching spikes and noise
- Incorporated fast computer
- Temperature stability control of the electronic box
- Sensitivity matrix allows 0.1° probe angle accuracy
- External Encoder allows Synchronization btw. probe position and measurement
- Interchangeable Hall probes

SPINNING CURRENT







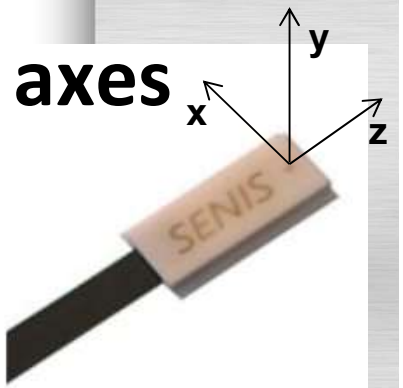
3MH6: BANDWIDTH vs. RESOLUTION

Data rate [sp/s]	10	100	500	2000	7500
Averaging time [ms]	100	10	2	0.5	0.133
Resolution [µT rms]	0.8	1	2	3	5
f (-10ppm) [Hz]	0.03	0.27	1.4	5	10
f (-100ppm) [Hz]	0.08	0.8	4	18	30
f (-0.1%) [Hz]	0.25	2.5	12.5	50	90
f (-1%) [Hz]	0.78	7.8	39	155	300
fc (-3dB) [Hz]	4.4	44	220	880	2500

Conditions: - Range ±2T
- Probe cable length: 2m
- Internal Sampling rate: 30ks/s
- Bandwidth: DC to fc(-x), f (-x): B signal frequency at which the measurement error with respect to DC reaches x.

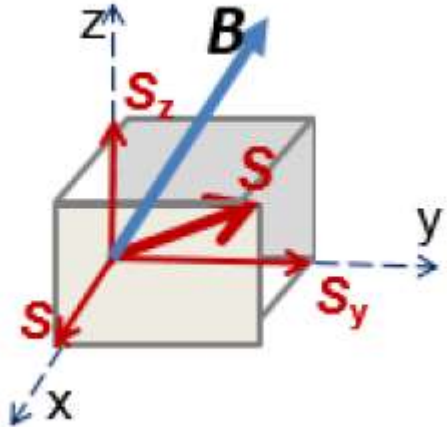
Underlined are the frequency values that are limited by the analog LP filter.

Calibration of angle error of the sensitivity axes -> less than 0.1°



1 - axis Hall magnetic sensor:

$$V_1 = S_1 \cdot B \Rightarrow V_1 = (S_{1X} \quad S_{1Y} \quad S_{1Z}) \begin{pmatrix} B_X \\ B_Y \\ B_Z \end{pmatrix}$$

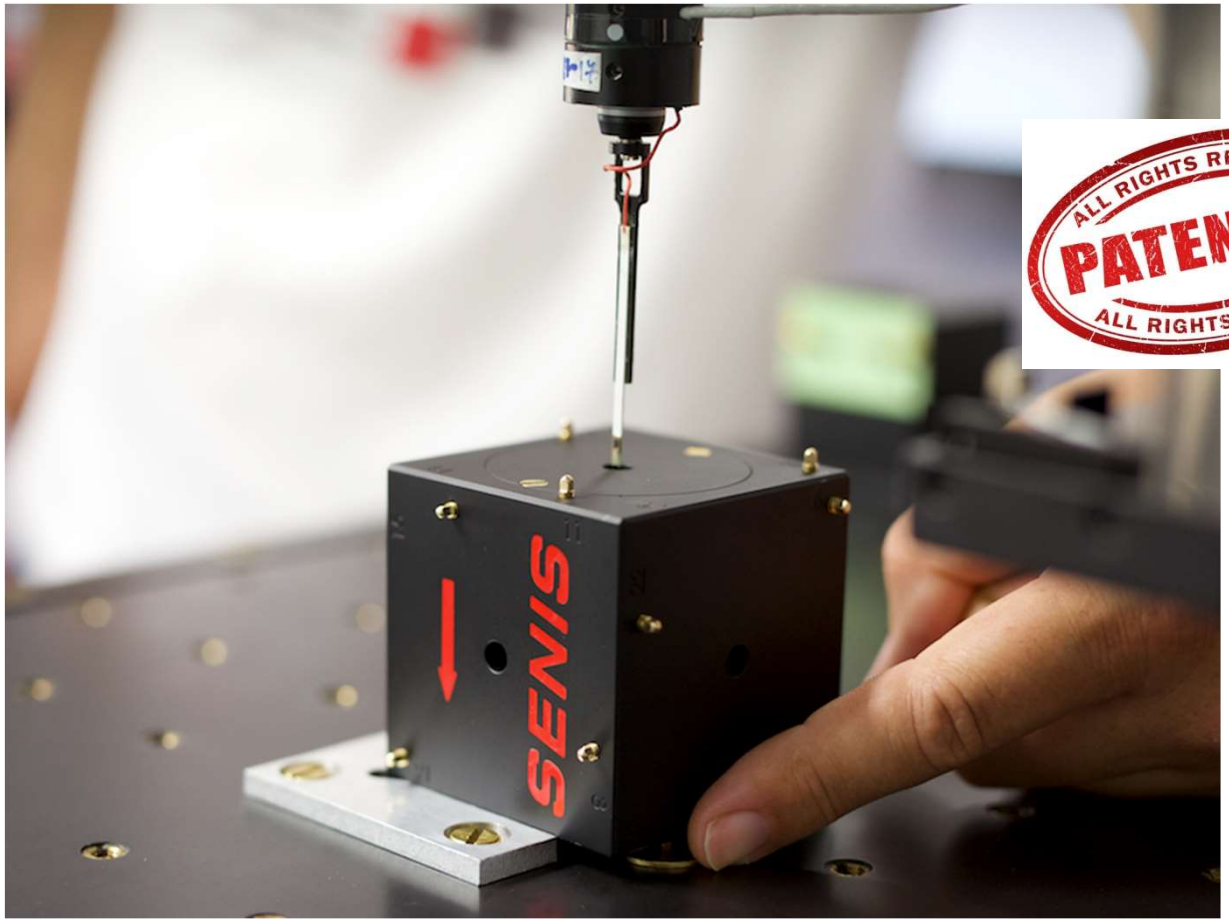


3 - axis Hall magnetic sensor:

$$\begin{pmatrix} V_1 \\ V_2 \\ V_3 \end{pmatrix} = \begin{pmatrix} S_{1X} & S_{1Y} & S_{1Z} \\ S_{2X} & S_{2Y} & S_{2Z} \\ S_{2X} & S_{3Y} & S_{3Z} \end{pmatrix} \begin{pmatrix} B_X \\ B_Y \\ B_Z \end{pmatrix} \Rightarrow V_3 = (S_3)\, B \Rightarrow B = (S_3)^{-1}\, V_3$$

(S_3): Magnetic Sensitivity Tensor of a 3-Axis Hall Probe

CALIBRATION CUBE



OUR PRODUCTS and SERVICES....

SENIS
magnetic & current measurement

CALIBRATION SERVICES:
ISO 17025
Application in process

3D Magnetic Field Measurement at single spot

Compact and thin
1-, 2-, 3- Axis Hall Probes

High accuracy and resolution
Analog Transducers and
Digital Teslameter

Handheld USB 3D Teslameter

Fast, high resolution mapping of magnetic field (Bx/By/Bz) around permanent magnets, electromagnets and electronic circuit PCBs

Bus Bar current sensor modules
(f-bandwidth of DC to 200kHz)
Clamp-on Closed-Loop and
Open-Loop
(highest accuracy and resolution)

3D Hall sensor
Fast magnetic angle sensor
Any Axis Hall sensor

SENIS
magnetic & current measurement

▶▶▶ Our World Records:

the only fully integrated 3-axis Hall Probe on the market

the smallest and thinnest 3-axis Hall Probe

magnetic field transducer & teslameter

with the highest resolution

and the highest frequency bandwidth

magnetic field measurements with the highest accuracy

Thank you!

SENIS AG
Switzerland
Phone: +41 43 205 2637
Phone: +41 43 205 2638
e-mail: info@senis.ch

www.senis.ch