AsahiKASEI

The latest application examples for AKM Hall Effect Sensor

October 8th, 2013

ASAHI KASEI MICRODEVICES CORPORATION

Confidential

Agenda

- About AsahiKASEI & AsahiKASEI Microdevices
- Basic Principal of Hall Effect Sensor
- New Detection Principal of Hall Sensor
  - Magnetic Concentrator
- Recent Application Examples
  - Electronic Compass
  - Single Chip Pulse Encoder
  - Close Position Sensing
  - Current Sensor
- Conclusion

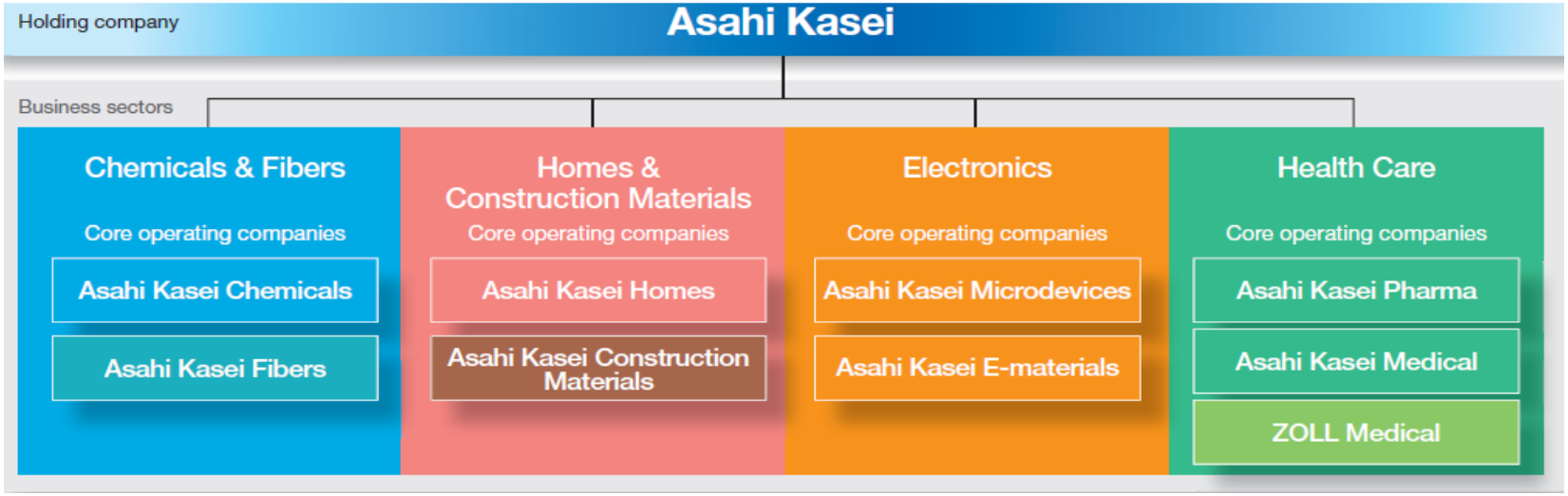
About AsahiKASEI

Group Mission

We the Asahi Kasei Group, contribute to life and living for people around the world.

Company Information

Established	: May 21, 1931
Consolidated sales	:¥1573 billion ($16.5 billion @ [USD/JPY] = 95)
Employees	: 25,409



About Asahi Kasei Microdevices

Trade Name	Asahi Kasei Microdevices Corp.
Main Business	Hall Elements, LSIs
Home Office	1-105 Kanda Jinbocho, Chiyoda-Ku, Tokyo 101-8101Japan
President	Makoto Konosu
Paid-in Capital	¥3,000 million ($31.5 million)

Quality Management System

ISO9001:2008
JQA-0899

ISO14001:2004
JQA-EM0561 (Nobeoka)

ISO/TS16949: 2002
JQA-AU0189

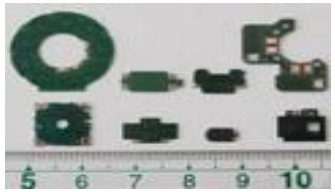
Main Business **LSIs , Sensors and more.**

Semiconductors

- ☐ Audio LSI
- ☐ RF Analog LSI
- ☐ Power Management LSI
- ☐ Current Drivers LSI

Magnetic Sensors

- ☐ Electronic Compass (Sensor/LSI Compound Product)
- ☐ Current Sensors
- ☐ Motor Control Hall Elements
- ☐ High Accuracy Position Sensor



Fine-Pattern Coils

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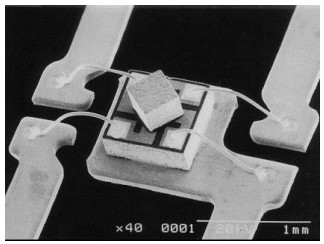
Basic Principles of Hall Effect

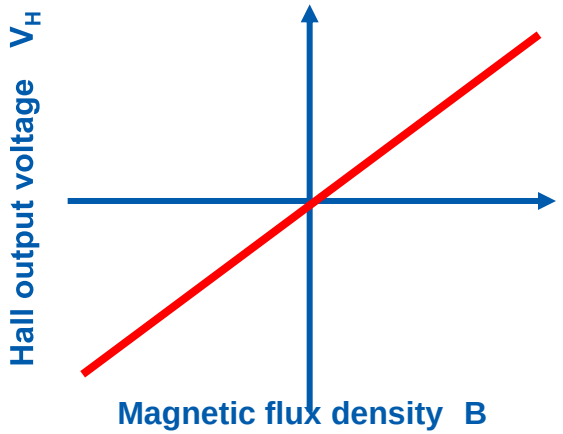
- Principle

  'Hall Effect' of semiconductor *discovered by Dr. Hall in USA in1879*

- Phenomenon

  On biased semiconductor film, Hall voltage(V_H) is observed in vertical magnetic field.



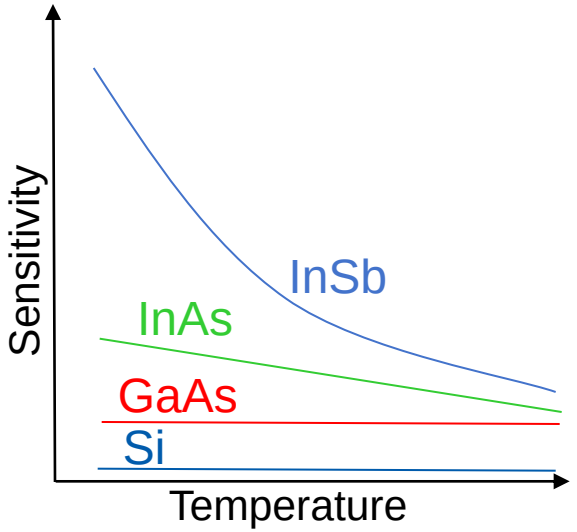


The output voltage of Hall element has a linearity against magnetic flux B.

Materials for Hall Sensor

- **Superior Mobility Semiconductor Material**
  → **III-V Compound Semiconductor（InSb/InAs/GaAs）**
- **AKM provides every kind of Hall Element Material**
  – Only one company in the World!!

Material	Mobility (cm^2/Vsec)	Sensitivity	Band Gap (eV)	Temperature Dependency
Si	1450	↓ Large	1.12	↑ Stable
GaAs	8000		1.43	
InAs	35000		0.33	
InSb	75000		0.16	

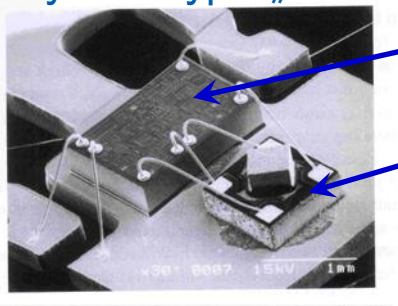


Magnetic sensor business in AKM

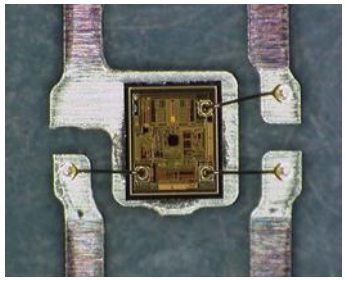
- **AKM Hall sensor business started in 1980**
- **Hall Elements**
  - **World Wide Share: ≧70%**
  - **Production Amount: ≧120Mpcs/M**
  - **Main Applications: DC Brushless Motors, Current Sensor, Consumer Goods, etc.**

- **Hall Effect ICs**
  - **Structure; 2 types**
    - **Hybrid type utilizing high sensitivity Hall elements**
    - **Silicon monolithic type**
  - **Production Amount : ≧40M/M**
  - **Main Applications: Mobile Phones, Switches, Motors of White Goods, etc.**

《 Hybrid Type 》



《 Monolithic Type 》



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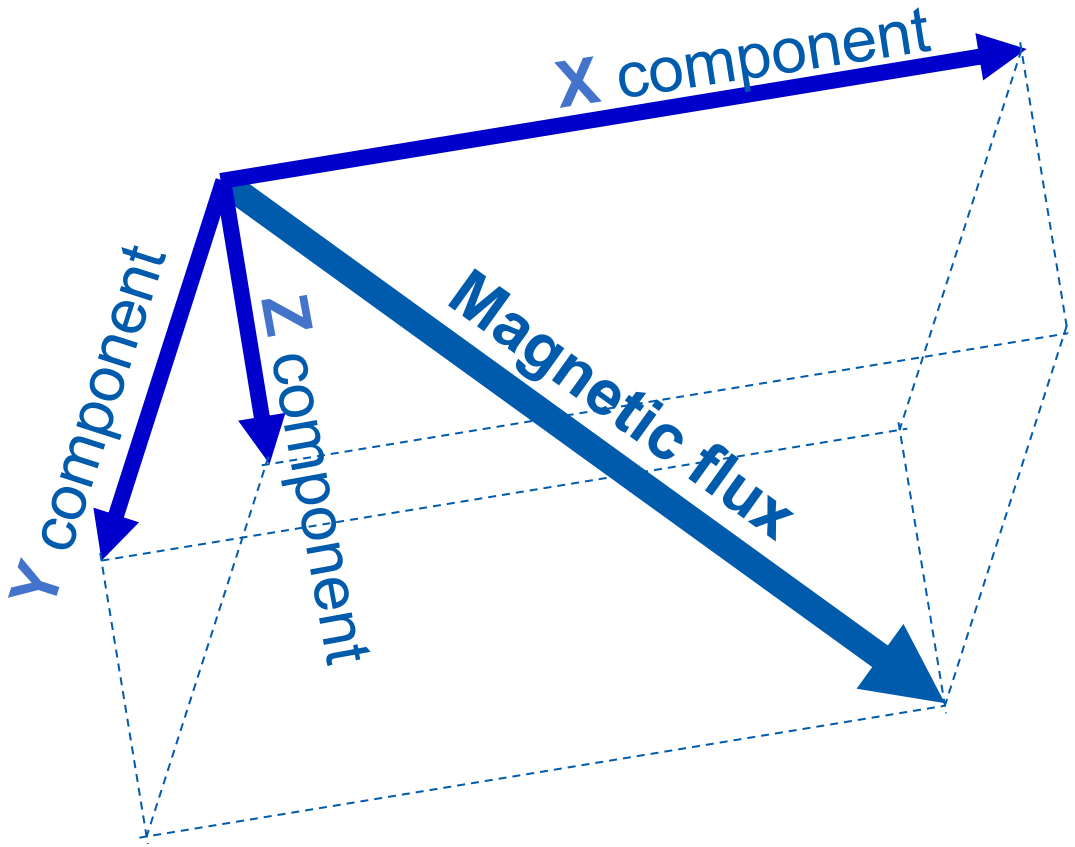
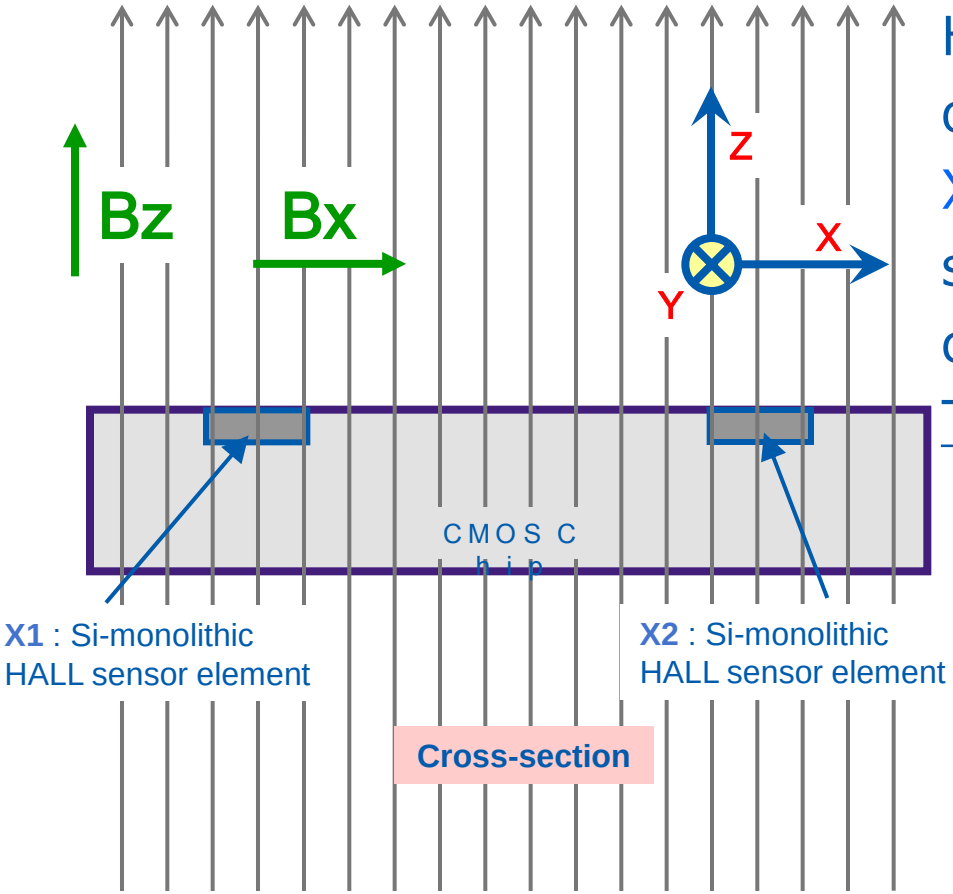
3 axis magnetic sensor tech. 1/5

A magnetic flux is a vector quantity.
One magnetic flux is resolved into the quadrature-component vector of arbitrary 3D coordinate systems.



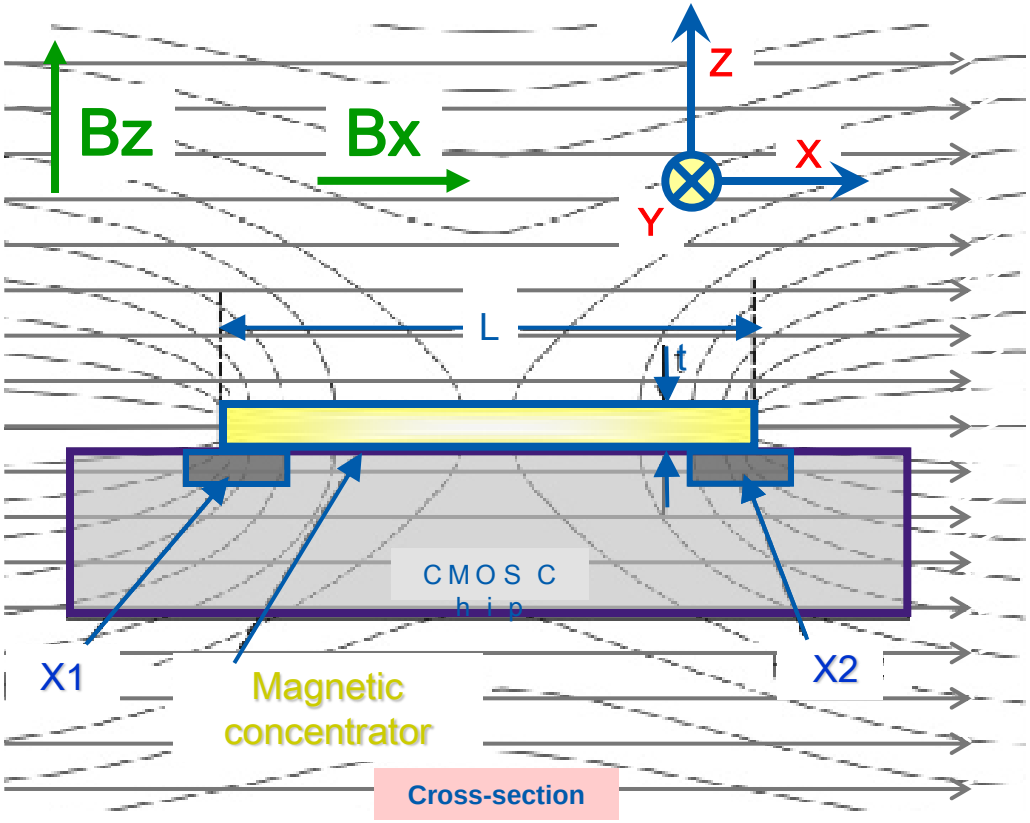
3 axis magnetic sensor tech. 2/5



Hall sensor X1 and X2 detect only the Bz component.
X1 and X2 do not have sensitivity for the Bx (By) component.
This is the point!

The HALL sensor detects a vertical component of magnetic flux to its surface (Bz).

3 axis magnetic sensor tech. 3/5



The magnetic concentrator can change the horizontal component of the magnetic flux into the vertical component.

By the horizontal component converted into the vertical component, X1 and X2 come to have sensitivity for the Bx and the By component.

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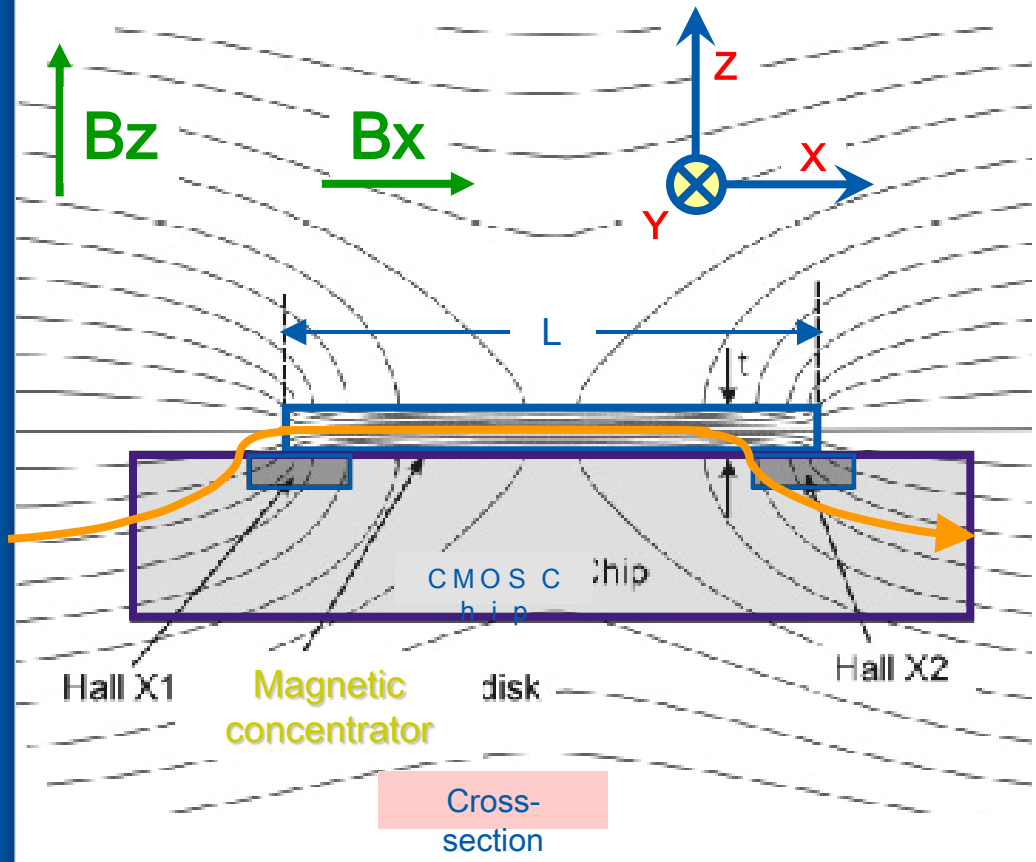
3 axis magnetic sensor tech. 4/5



Cross-section

It means,
X1 and X2 can detect Bz, vertical component and also bended horizontal components Bx or By.
Hall sensors detect both signals.

$$X1 = a \cdot Bx + c \cdot Bz$$

$$X2 = -a \cdot Bx + c \cdot Bz$$

$$X1 - X2 = 2a \cdot Bx$$

$$X1 + X2 = 2c \cdot Bz$$

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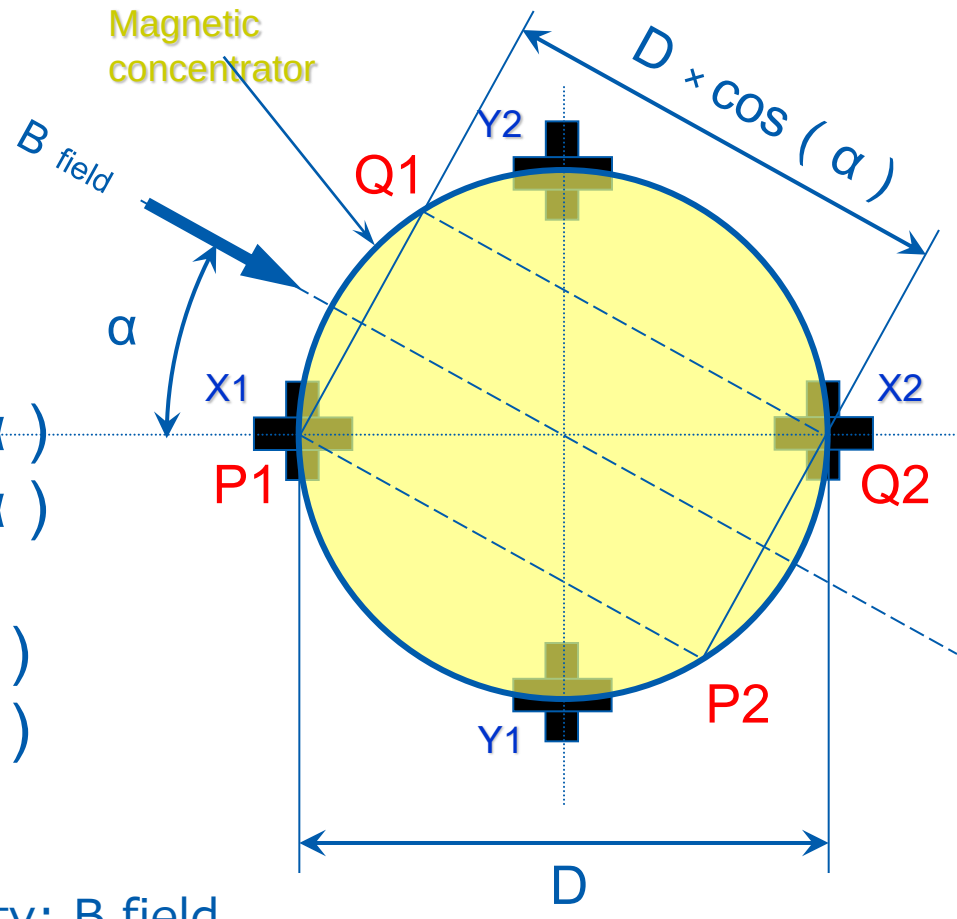
3 axis magnetic sensor tech. 5/5

Magnetic field intensity detected by Hall sensor X1 or X2 is as follows,

$$X1 = + B_{field} \times D \times \cos(\alpha)$$
$$X2 = - B_{field} \times D \times \cos(\alpha)$$

$$Y1 = + B_{field} \times D \times \sin(\alpha)$$
$$Y2 = - B_{field} \times D \times \sin(\alpha)$$



Top view

Horizontal magnetic field intensity: B field
Incident angle : α
Concentrator diameter: D

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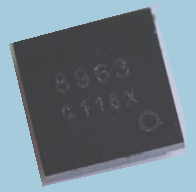
Size Reduction of Products

2013

AK09911C

Volume ： **1.9 %**

1.2×1.2×0.5mm



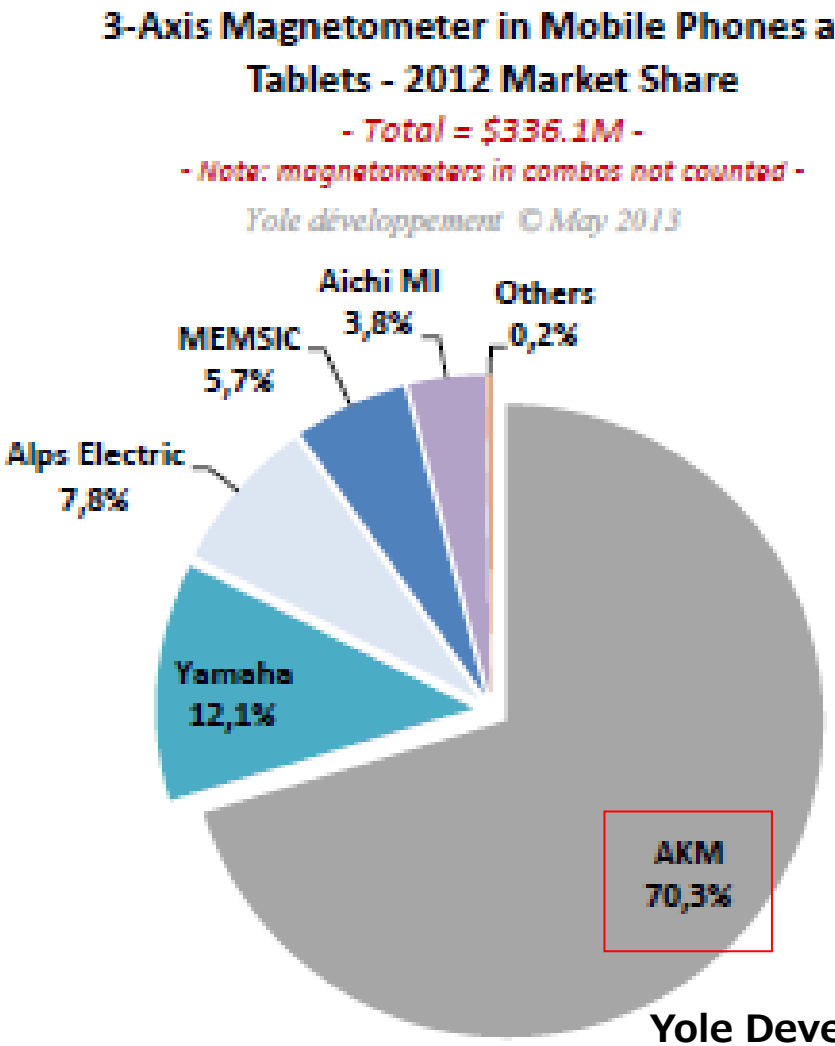
2004

[AK8970]

Volume ： 100 %

5.9×6.3×1.0mm

The biggest 3-axis E-compass supplier



Yole Development
MEMS for cell phone & tablets 2013

Strongest AKM's e-Compass solution

Components

- 1-Chip Solution
- Smallest size
- Highest quality
- Multiple supply chain

Software

- Auto calibration
- Direction calc.
- Self test
- Android, windows

Support

- Magnetic parts layout
- Performance evaluation & suggestions for improvement
- W/W Onsite support

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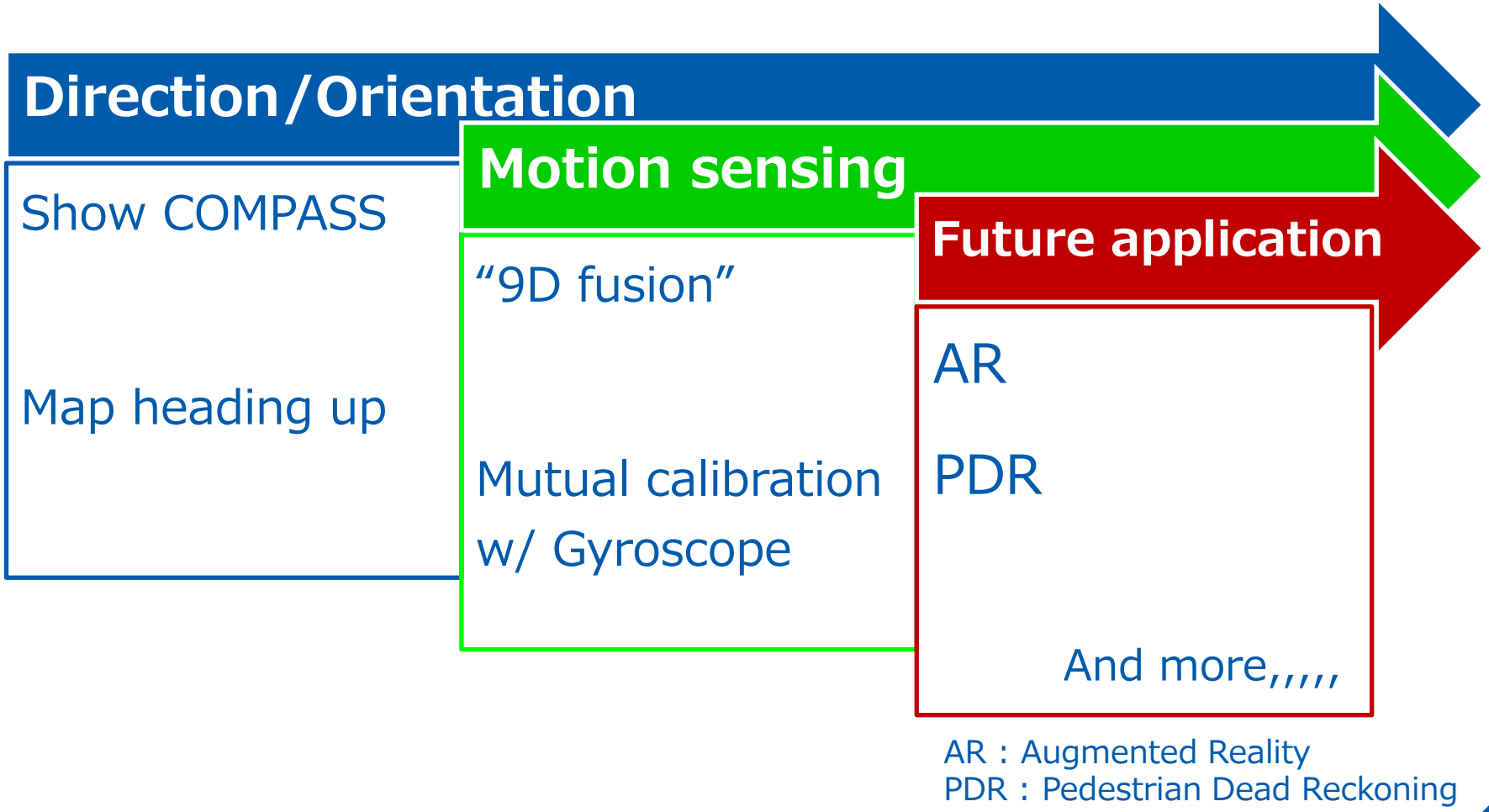
Evolution of e-Compass application



AR : Augmented Reality
PDR : Pedestrian Dead Reckoning

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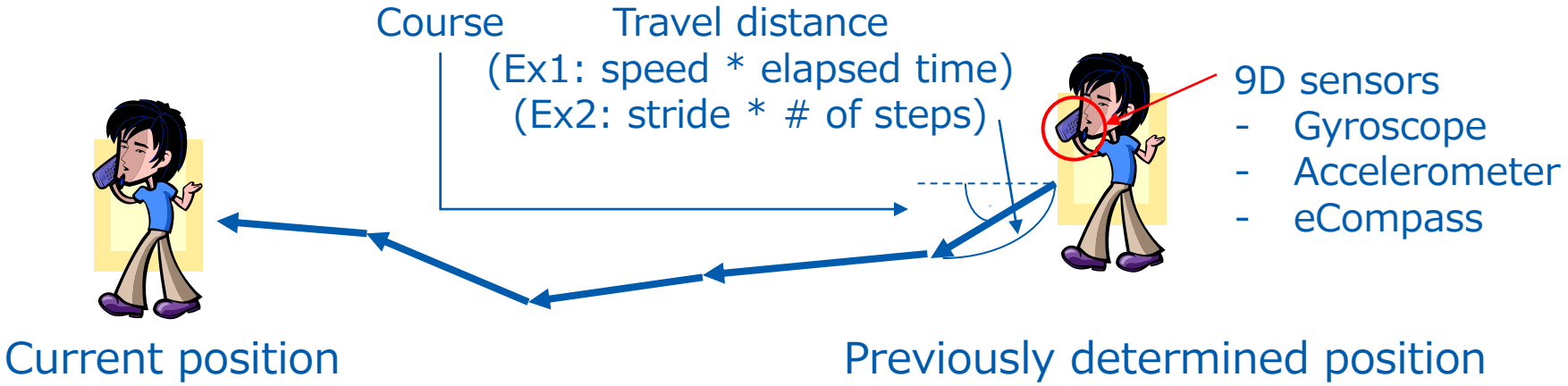
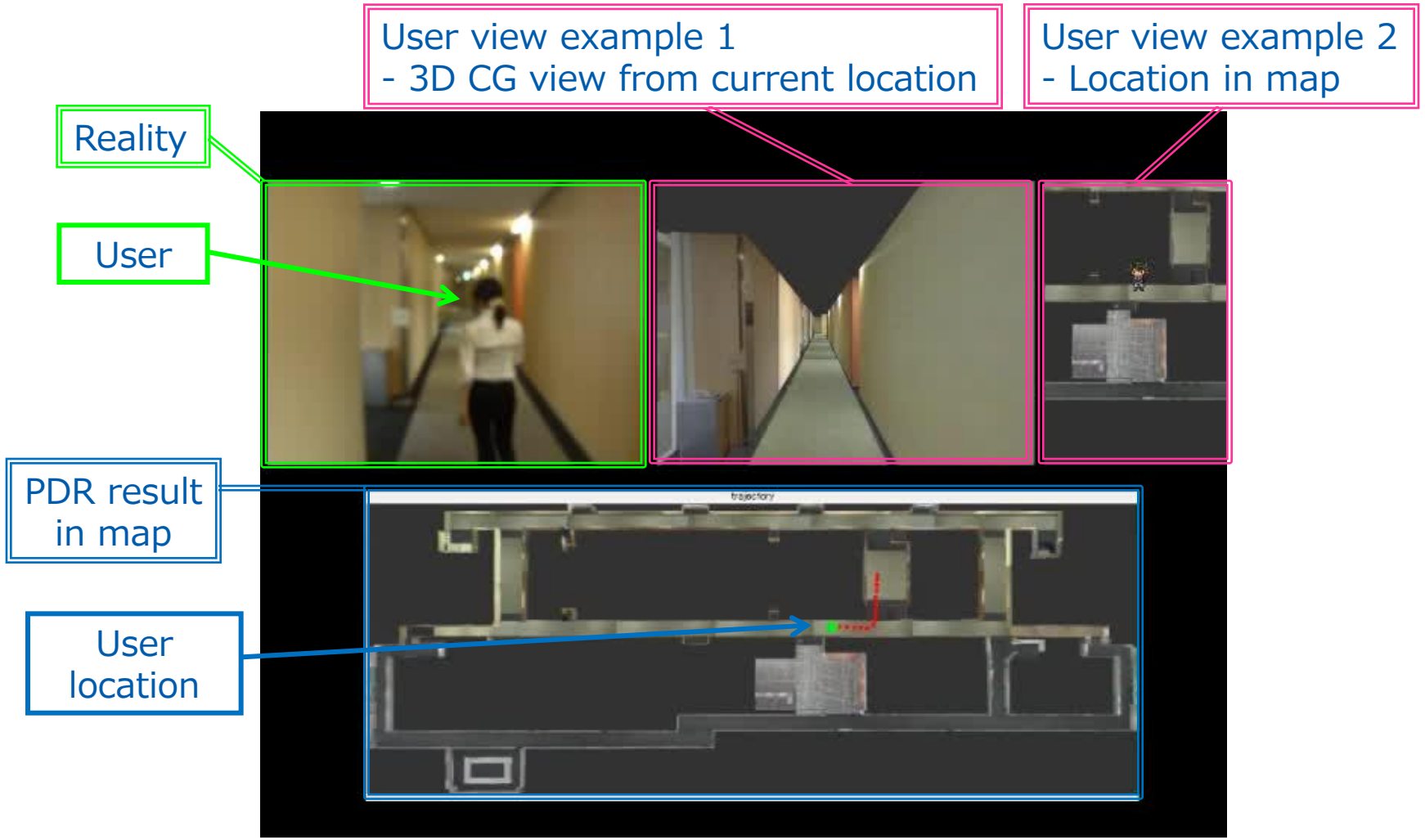
What is Pedestrian Dead Reckoning ?

- ***Dead reckoning*** **is a *relative* positioning technology.**
  - It calculates current position by
    - using a previously determined position, and
    - advancing position based on travel distance and course.
- **PDR is the *Pedestrian* (Walker) version of DR.**



Demonstration Video (at AKM Tokyo Office)



Benefit of PDR in Location-based Service

	Now			Under development		Future
	GPS	Network triangular		PDR		Combination
	Random	Random		Predictable		Controllable
Location Errors	Vary depending on ■Satellite constellation (time & place) ■Weather condition ■Surroundings	Vary depending on ■Infrastructure (Cellular / Wi-Fi) ■RF condition	+	Accumulate along ■Elapsed time ■Sensor signal noise	=	Reset time to time Accumulate after occasional reliable location
Service Availability	Outdoor	Indoor / Outdoor		Indoor / Outdoor		Indoor / Outdoor

- PDR enables indoor location service at no cost for infrastructure.
- Combination of PDR with GPS / Network triangular further enables reliable indoor location service over a long time period.

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Demonstration Video of PDR

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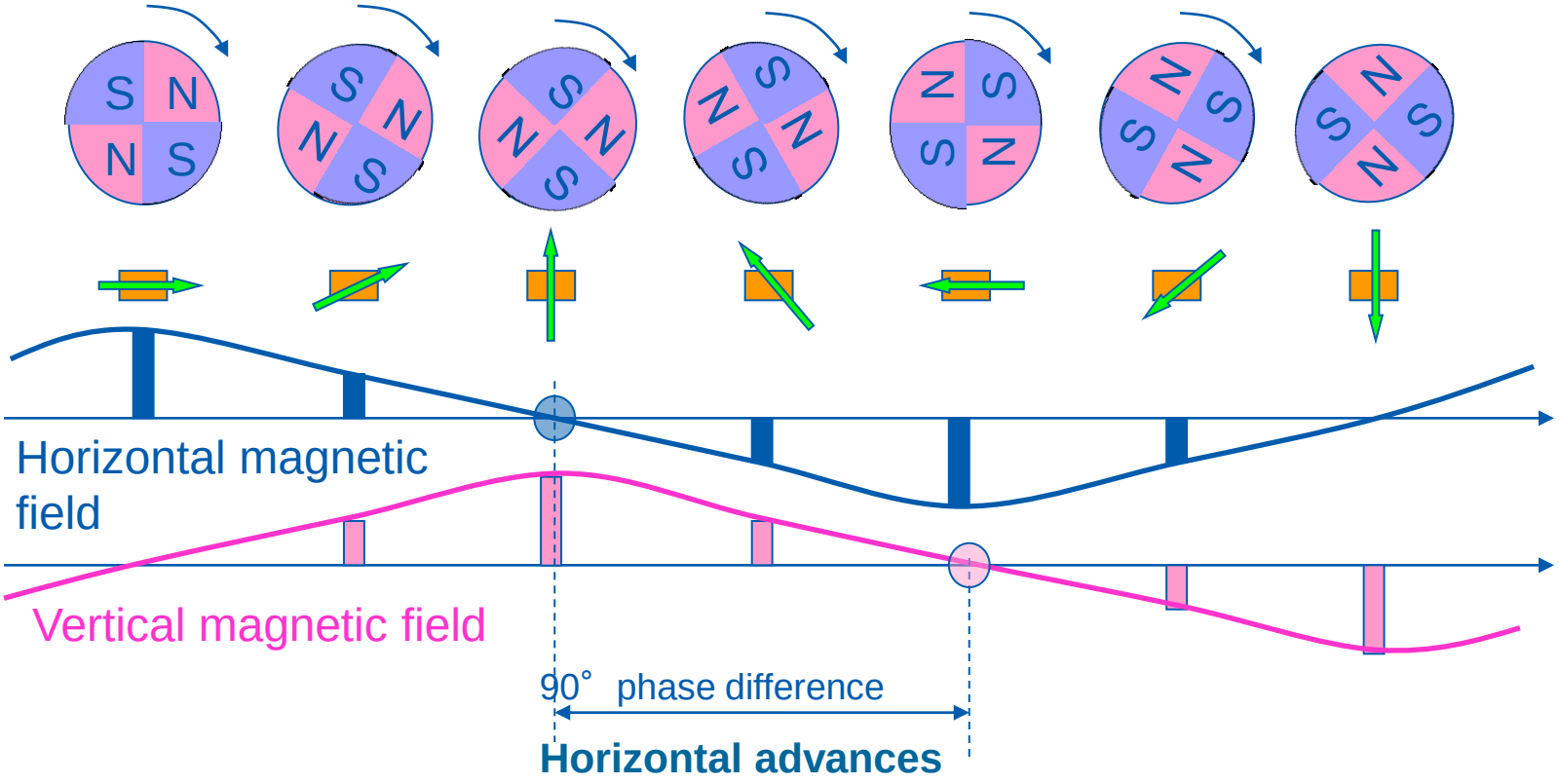
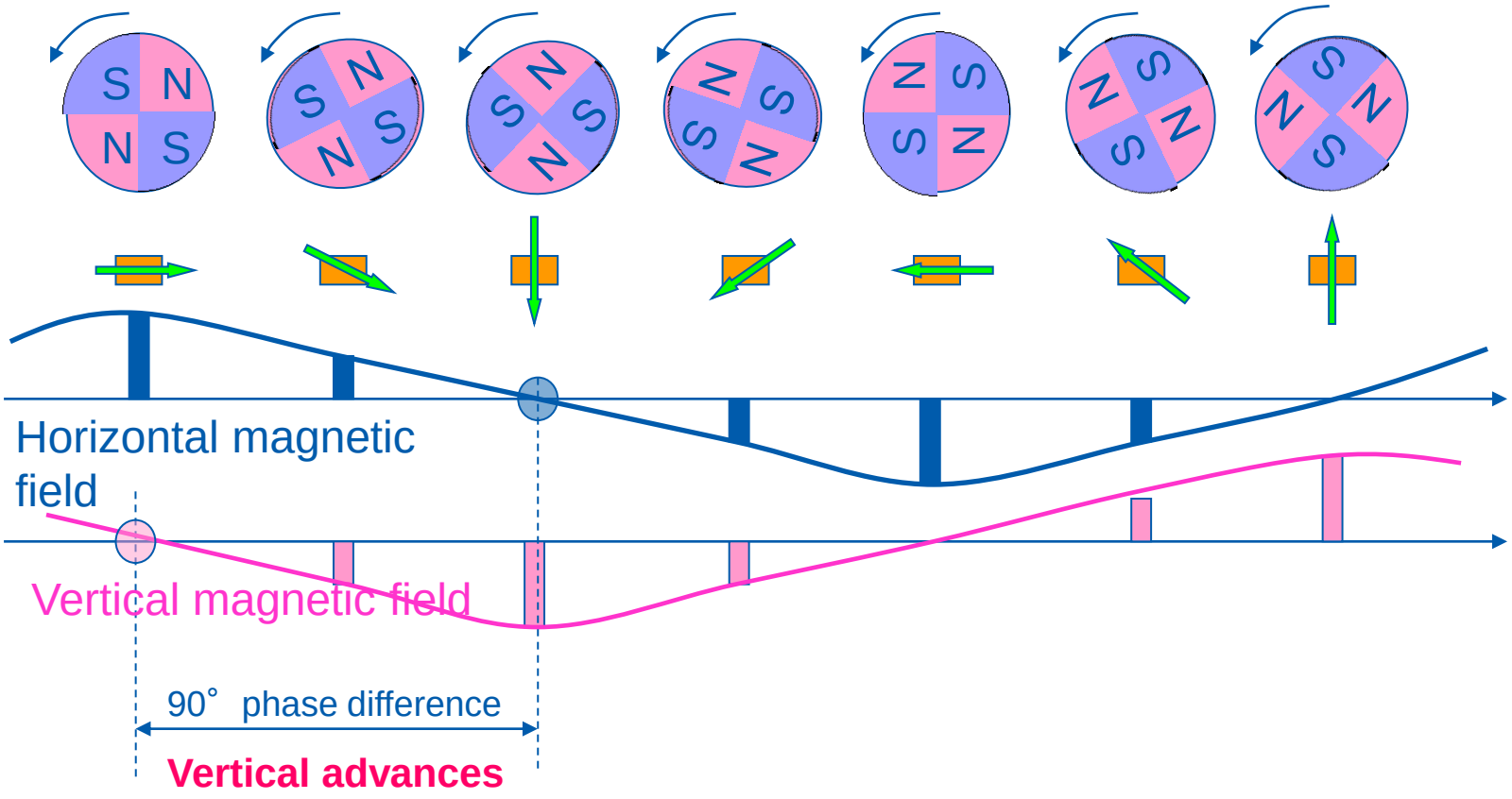
Vertical and Horizontal MFD (rotational direction: CW)

MFD: Magnetic Flux Density



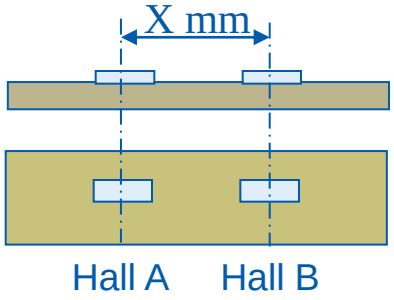
Vertical and Horizontal MFD (rotational direction: CCW)



Conventional Solution

Competing technology: 2 Hall ICs or Dual Hall IC

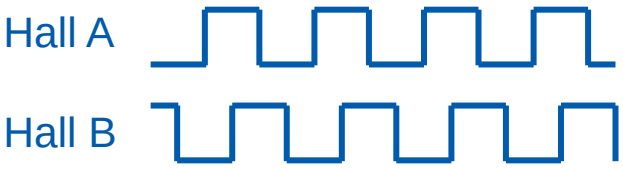
Two Hall ICs are attached to the PWB.
Two Hall effect devices are fabricated on One die (chip).



2 Hall ICs

Dual Hall IC

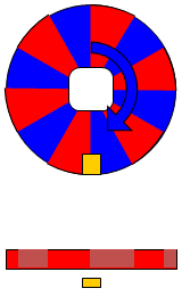
90 degree out of phase in electrical angle

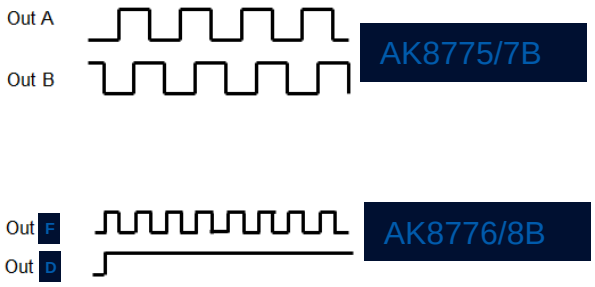


Demonstration Video of Single Chip Encoder

Features & Benefits

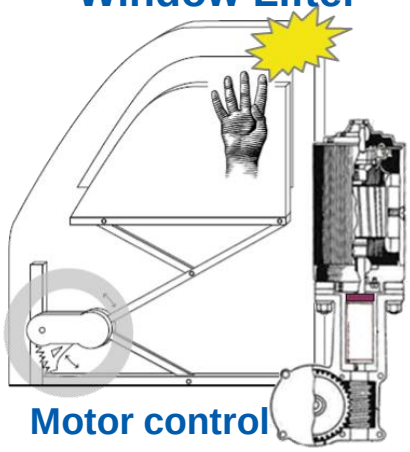
- No need for 2 Hall Effect Latches
- Provides more freedom of the location on PCB
- Detects both vertical and horizontal magnetic fields
- Smaller package
- “Pitch free” - Fits to a variety of magnetic rings
  (Number of magnetic poles)

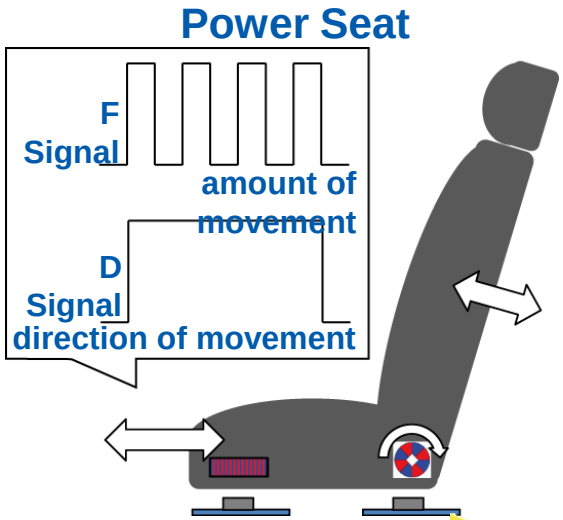


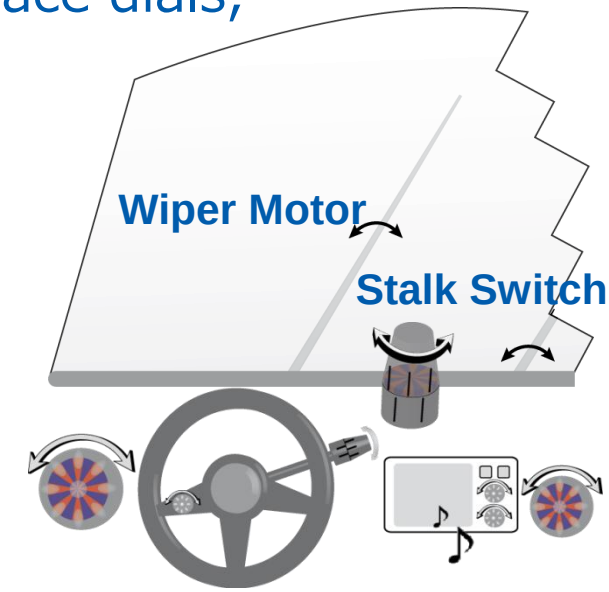


Target Applications

- Motor Control for power windows, doors, sunroofs, windshield wipers, etc.
- Position Control for power seats, interface dials, headlight angle, etc.







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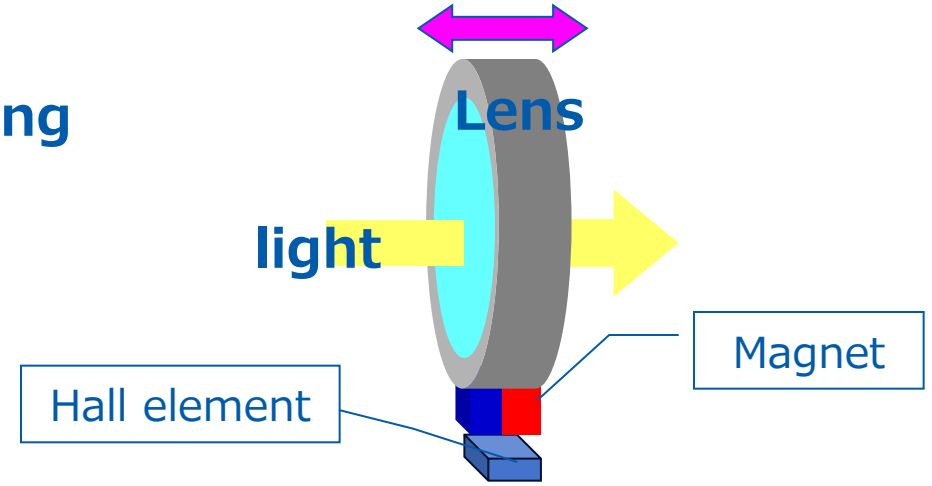
*"**Close Position Sensing**" is dialect word in AKM.*

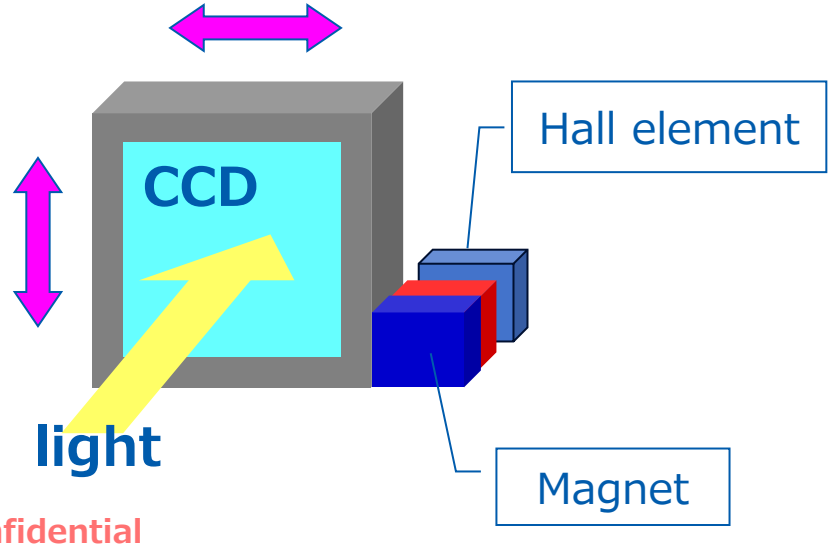
It means "precise position sensing" technology.

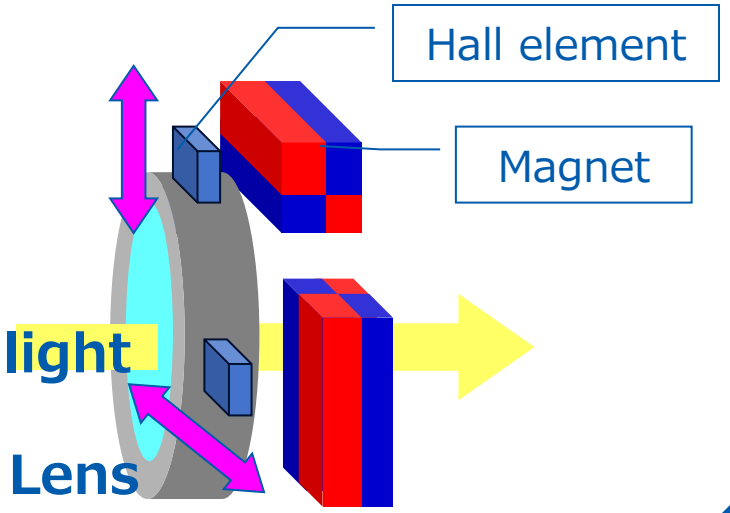
CPS in DSC/DVC & Smartphone

- **Auto Focus/Zoom lens position sensing**



- **Position Sensing for Anti-Shake/OIS**





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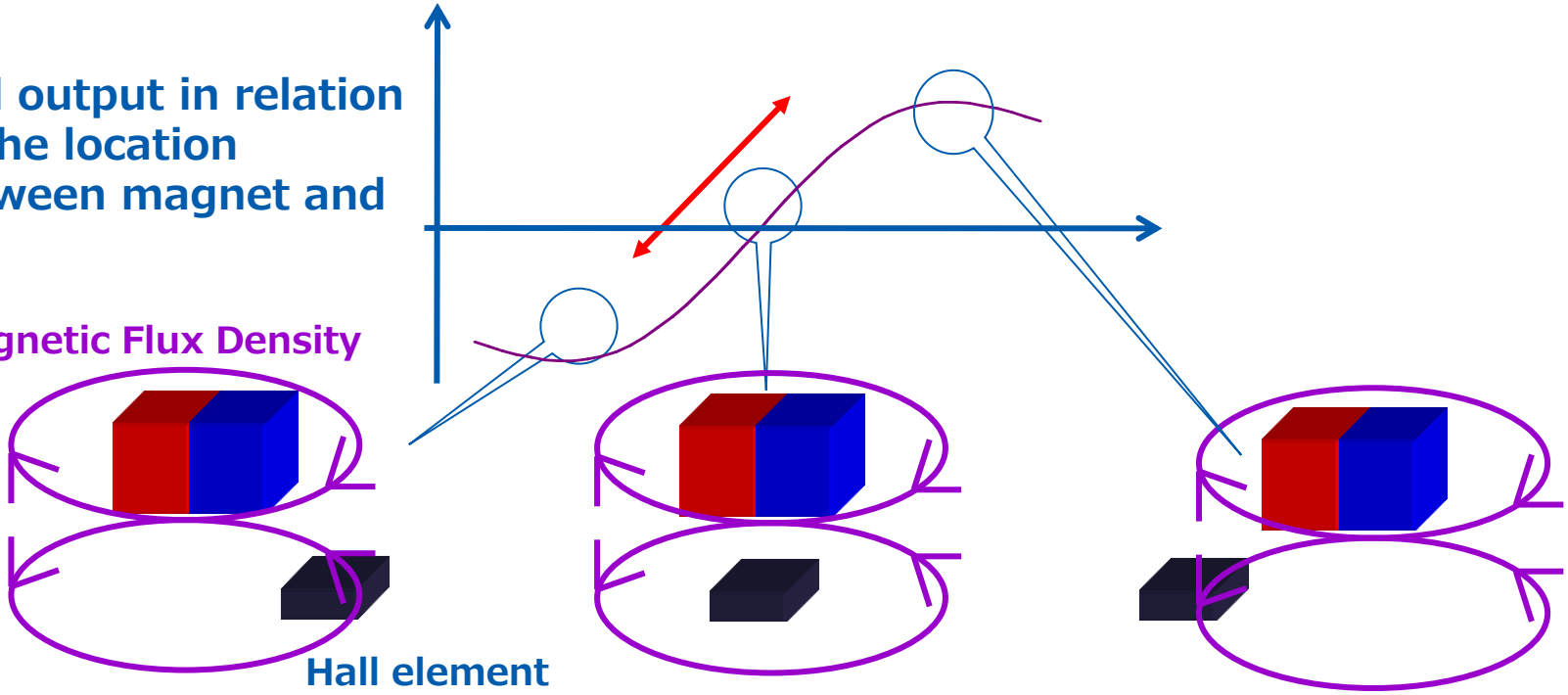
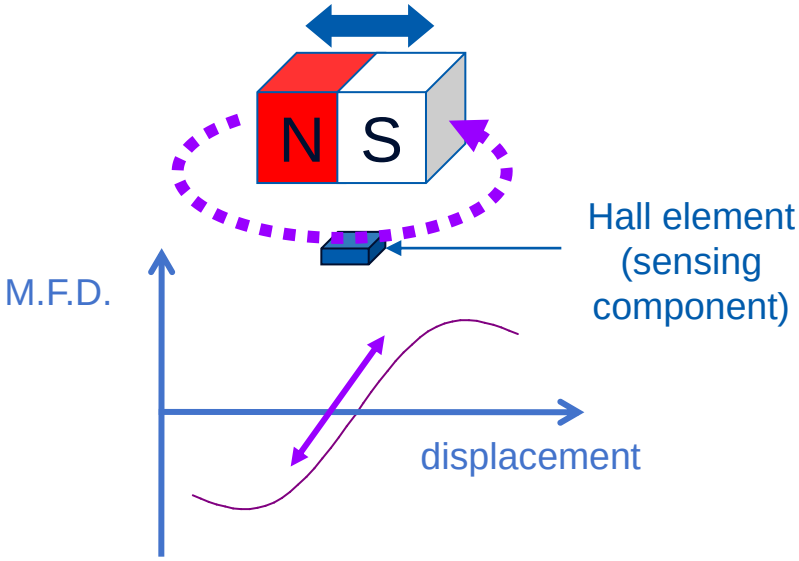
CPS – Configurations

Hall output in relation to the location between magnet and HE.

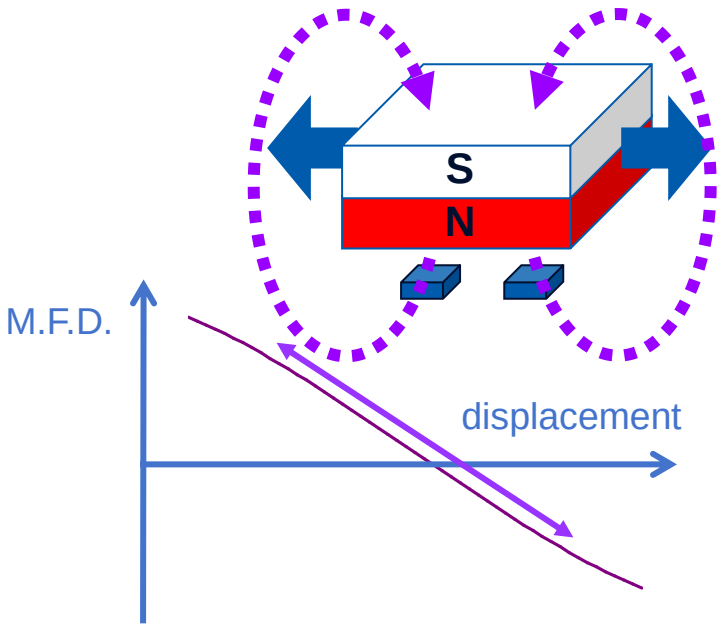


CPS- Layout Examples

Example 1



Example 2



Demonstration Video of Closed AF

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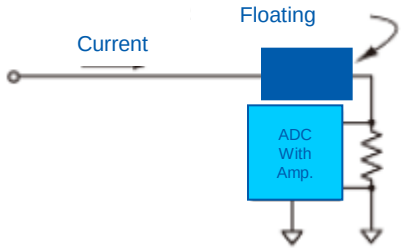
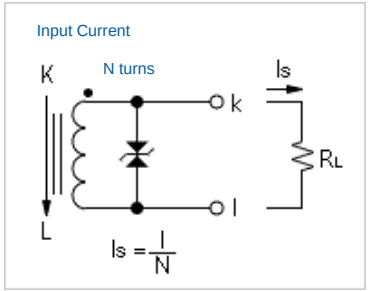
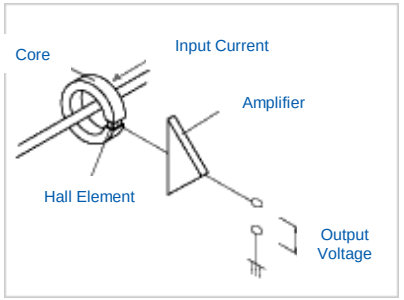
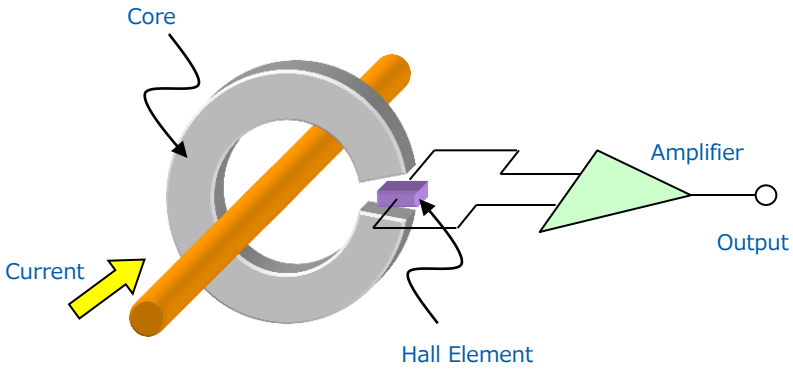
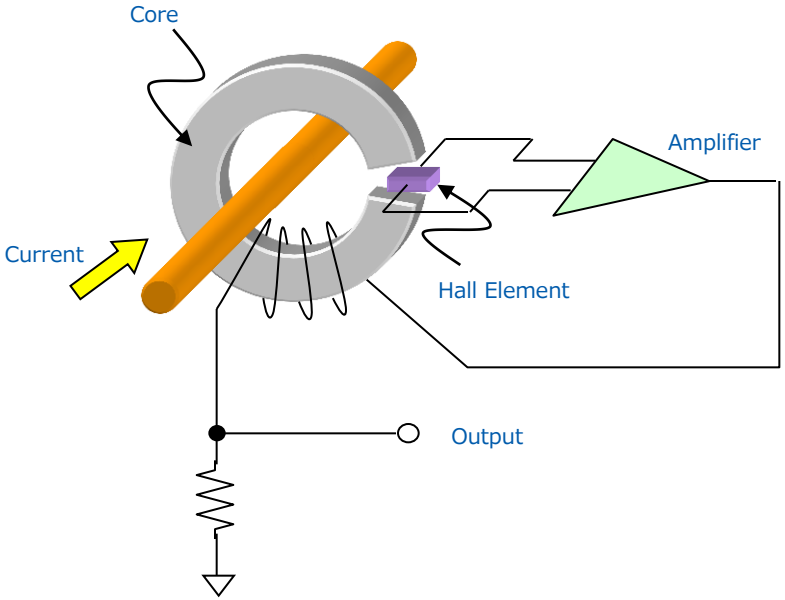
Current Sensing Methods

Sensor	Advantage	Disadvantage	Example
Shunt Resistor	Cheap	Power Loss >15A Calibration Design Tech.	
ACCT (AC Current Transducer)	Isolated	Only AC Calibration Phase Delay Big Size	
DCCT (with Magnetic Sensors)	**DC&AC Low Power Loss Isolated Easy to use Fast response**	**(Cost) (Calibration)**	

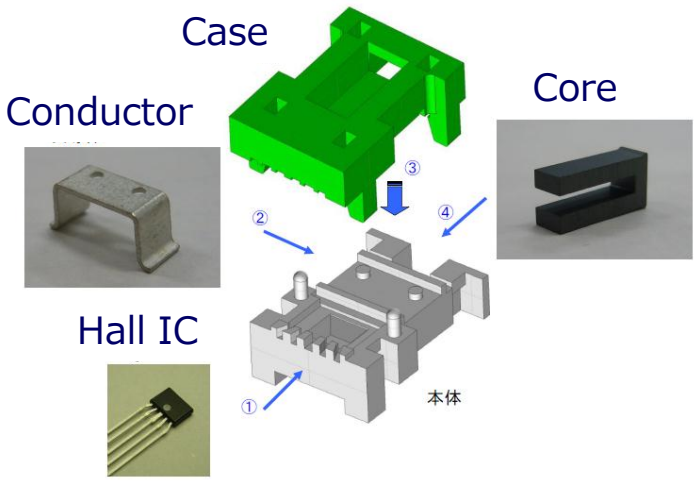
2. Current Sensing Methods: DCCT

Open Loop Type	Closed Loop Type
	
Advantage: **- Small size** **- Cheap (about Half of Closed's cost)** **Disadvantage:** **- Accuracy (about 10%)**	**Advantage:** **- High Accuracy (less than around 5%)** **Disadvantage:** **- Big size** **- Expensive (twice of open type's)**

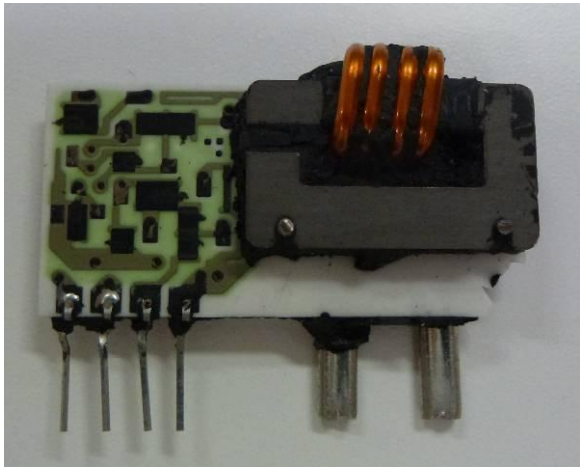
Features of AKM's Current Sensor

AKM Current Sensor is **Open Loop type DCCT**
with High Accuracy (almost compatible to Closed type)

<AKM (CQ209x)>



<Others>



PCB Core+Conductor

+ Package + Trimming

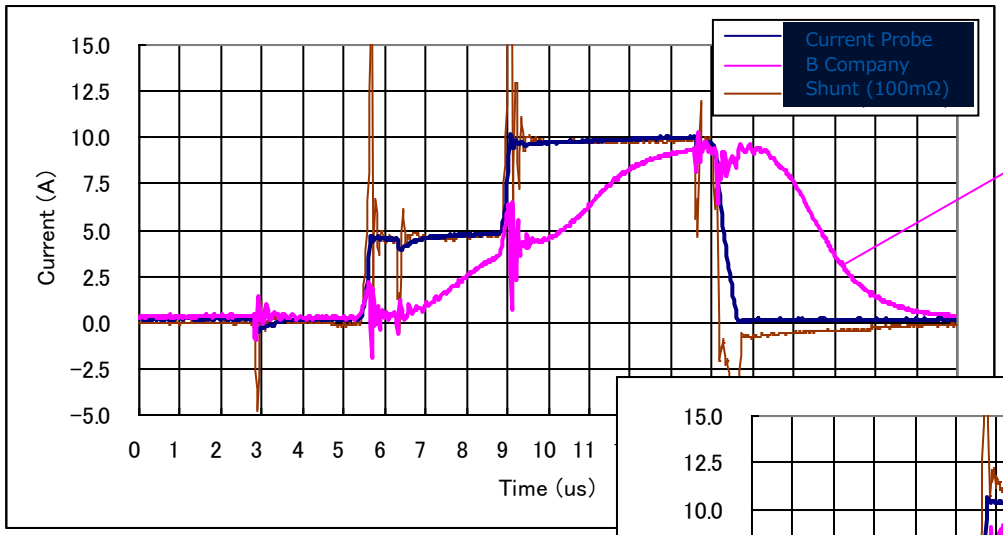
Features of AKM's current sensors:

- **Simplicity**: realizing low cost and high reliability
- **High Accuracy and Fast Response**:
  achieved by the combination of Ⅲ-Ⅴsemiconductor Hall element and trimming LSI

AKM's Unique Technology

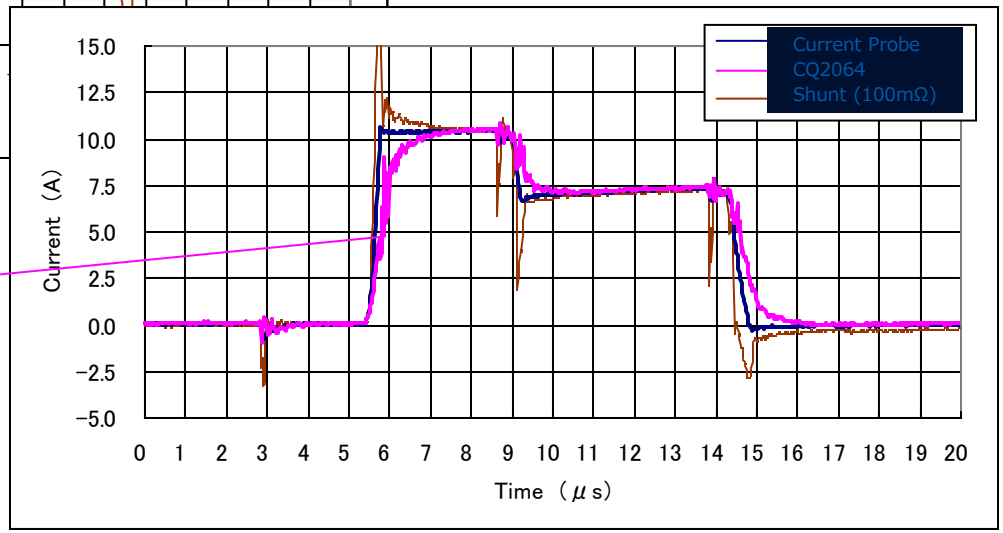
Features of AKM's Current Sensor

Fast Response: The fastest among open loop type



Other Company's

Response time: 3~5μs



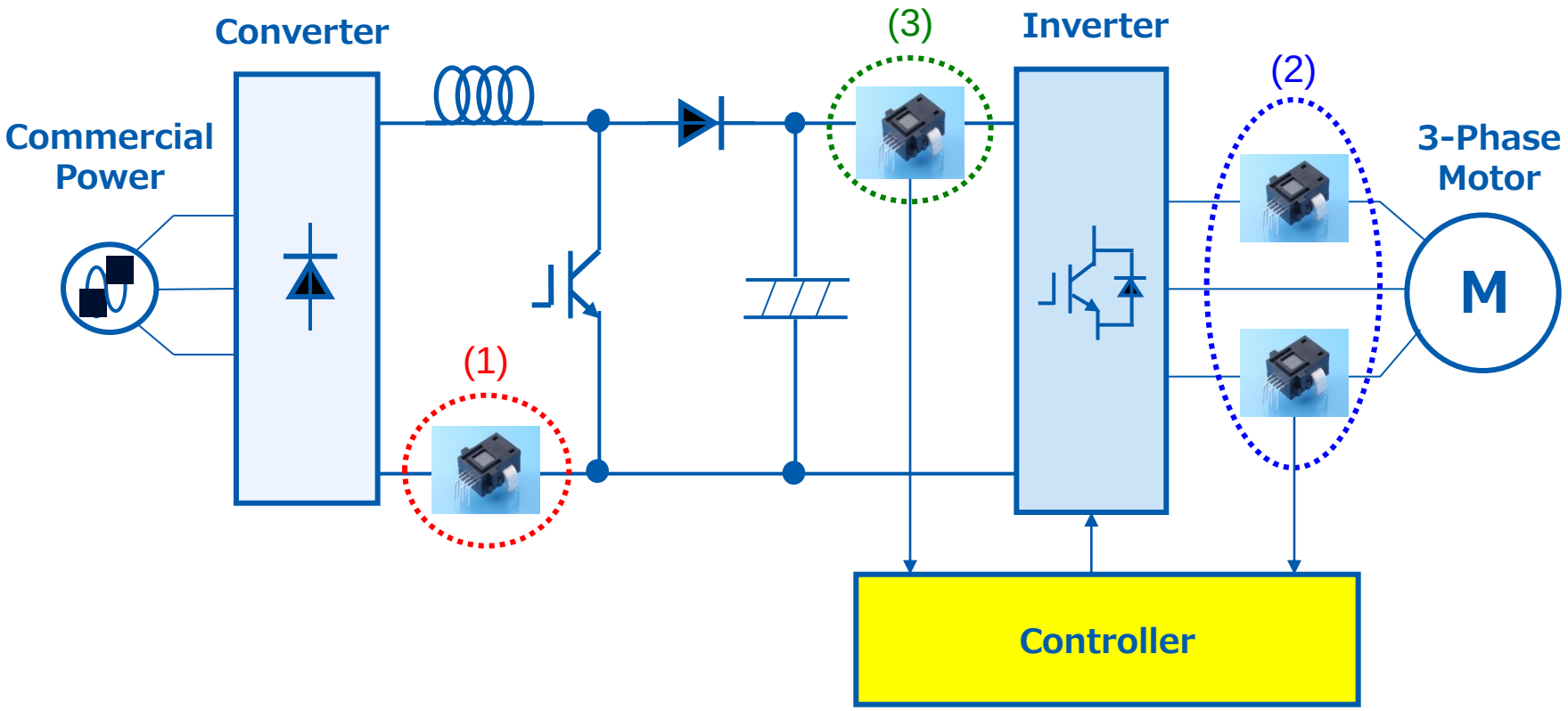
AKM's (CQ-2064)

Response time: 1μs!

Fast response time realizes:

1. higher inverter controllability 2. faster over-current protection

Applications: Inverter (Air Conditioner, Servo Motor)

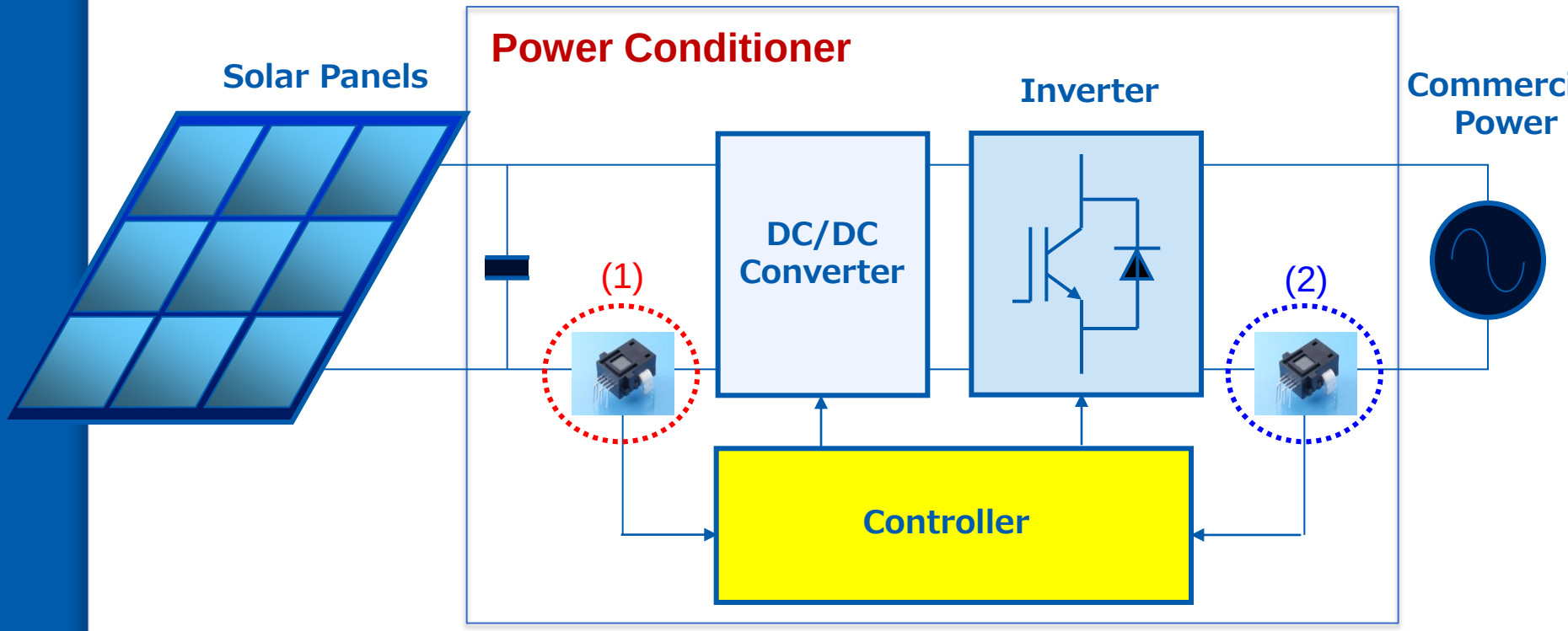


(1) Power Factor Control(PFC):
reduction in electrical distortion on a commercial power line

(2) Vector Control: improvement in motor efficiency

(3) Over-current Detection: for safety design

Applications: Power Conditioner



(1) DC Current Detecting
- **MPPT Control**
- Over-current Protection

(2) AC Current Detecting
- **Inverter Control**
- Over-current Protection
- Power Monitoring

MPPT (Maximum Power Point Tracking):
Power controlling method done by DC/DC converter, which maximizes the generated power by optimizing voltage/current of each solar panel.

Confidential

Conclusion

1. AKM has quite many options in product lineup, and can provide customers with best solution with W/W on-site support, following their requirements.

2. AKM is going ahead with new development like magnetic concentrator, and will expand the possibilities for new applications.

Creating For Tomorrow

ASAHI KASEI MICRODEVICES CORPORATION

Thank you very much for your attention.