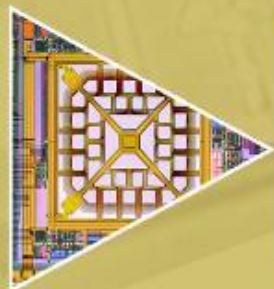
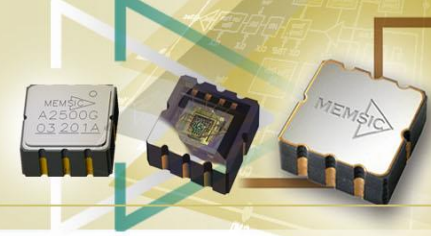


MEMSIC Advanced Sensing Solutions Overview

Q1 2015



Corporate Overview



❖ Company Profile:

- Founded 1999, HQ in Andover MA
- R&D Facilities in Milpitas CA, Andover MA, and Chicago IL
- 400k s.f. manufacturing facility in Wuxi, China
- IPO 2007, ~800 employees, Private Sept 2013

❖ Technology Leadership:

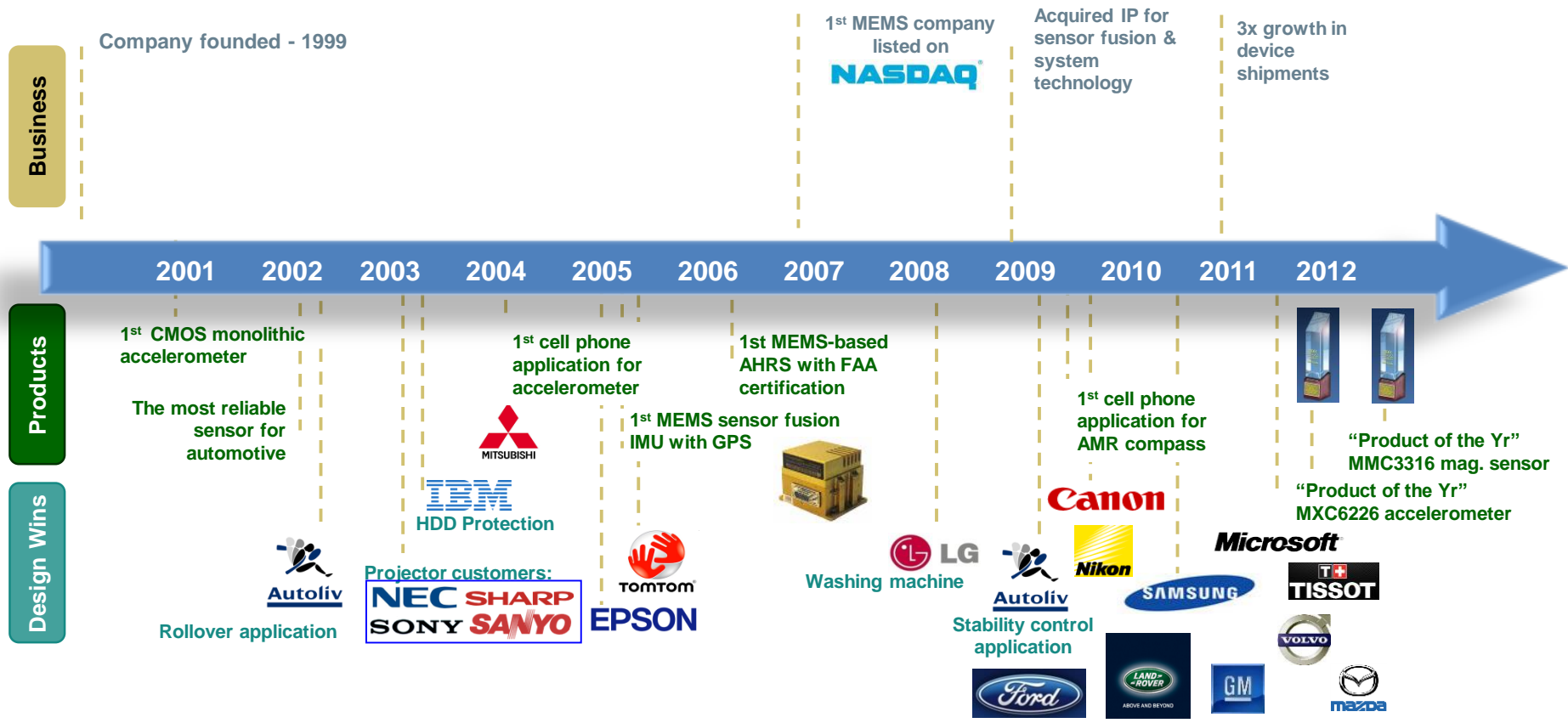
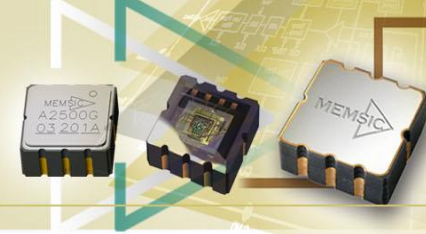
- First to bring high performance AMR Magnetic Sensors to Mobile Phone Market
- Only supplier of unique rugged, thermal-based MEMS accelerometers
- Leader in providing lowest power MEMS flow sensor
- One of the only vertically integrated sensor/system solution suppliers

❖ Proven Supplier:

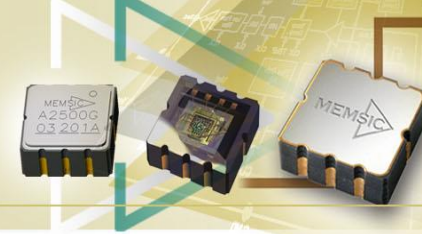
- Thermal MEMS accelerometers are used in Automotive Critical Safety Systems – 10's of millions shipped
- Shipped > 100M AMR magnetic sensors into phone market last year
- System products used in variety of demanding Avionics and Industrial applications
- Extensive Quality Certifications (driven by automotive, industrial and aerospace)



Company Milestones

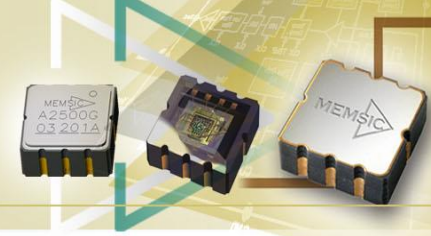


Expansive Market Reach

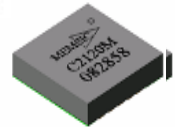
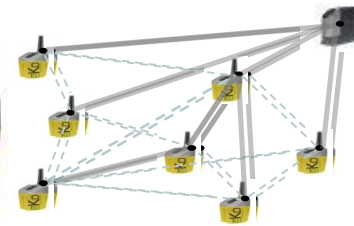


Technology and Product		Application Market	
	<p><u>MEMS Sensors</u></p> <ul style="list-style-type: none"> ■ Magnetic Sensors ■ Accelerometers ■ Gas Flow Sensors and modules ■ Current Sensing 	<ul style="list-style-type: none"> ❖ Mobile Phones ❖ Automotive ❖ LBS ❖ Consumer ❖ Industrial and Automation 	
	<p><u>Inertial Navigation System & Solution</u></p> <ul style="list-style-type: none"> ■ Inertial Sensing ■ Navigation System ■ Flight Display 	<ul style="list-style-type: none"> ❖ Aerospace ❖ Industrial Control ❖ Robot ❖ High-Speed Trains 	
	<p><u>Wireless Sensor Networks (WSN)</u></p> <ul style="list-style-type: none"> ■ X-mesh Network ■ Sensor Integration ■ Transceivers 	<ul style="list-style-type: none"> ❖ Environmental Monitoring ❖ Green Living ❖ Smart GRID ❖ Agricultural 	

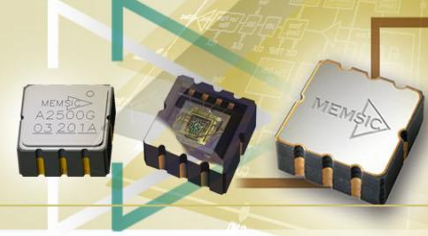
Product Line/Technology Overview



- ❖ Accelerometers
- ❖ Tip-over Sensors
- ❖ Flow Sensors and Modules
- ❖ Magnetic Sensors
- ❖ Single Chip Current Sensors
- ❖ Inclinometers
- ❖ Inertial Measurement Units (IMU)
- ❖ Algorithms for Heading and Navigation

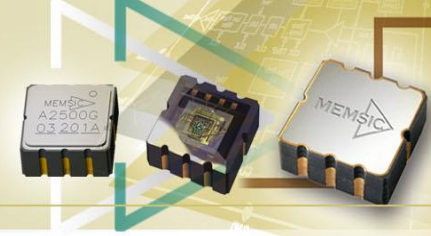


Thermal MEMS Accelerometers- Proven Technology

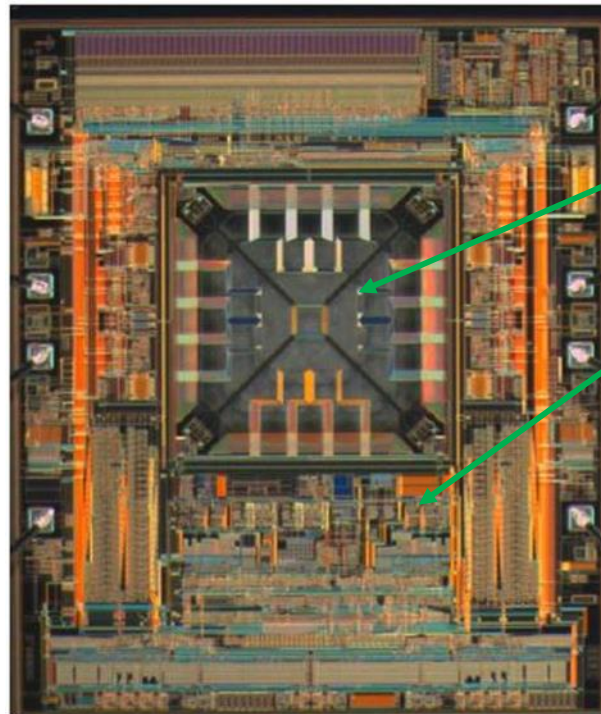


- ❖ >10 years of production, in variety of applications:
 - Automotive, phone, digital camera, projector, toys
 - Variety of industrial applications
- ❖ Have excelled in demanding Automotive applications:
 - Deployed in critical safety systems (Electronic Stability Control, Rollover, Fuel shut off)
 - 10's of millions MEMSIC thermal accels shipped into automotive safety application
 - Performance, reliability are key benefits
 - NO SENSOR RESONANCE means unmatched vibration immunity
 - 50,000g shock tolerance
- ❖ Very mature, proven technology

Monolithic MEMS Technology



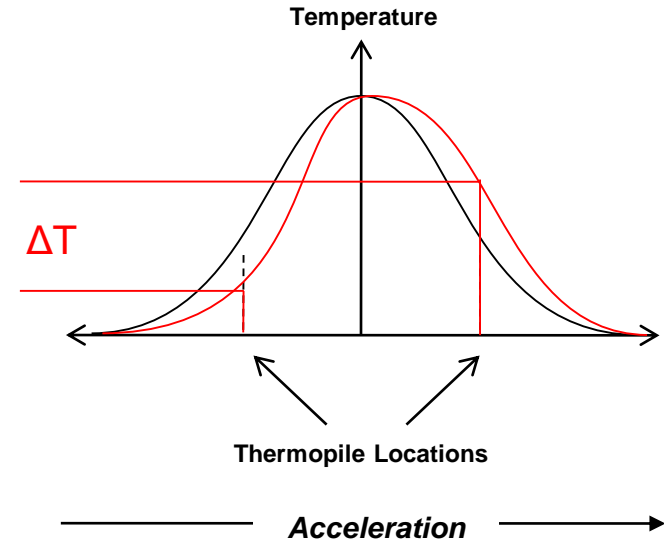
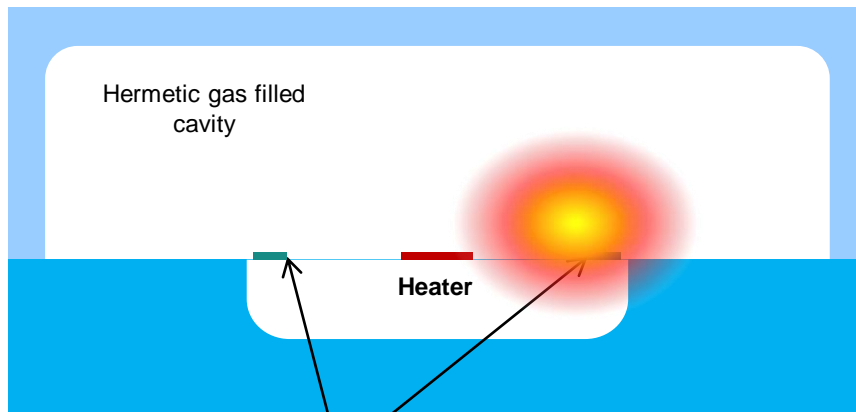
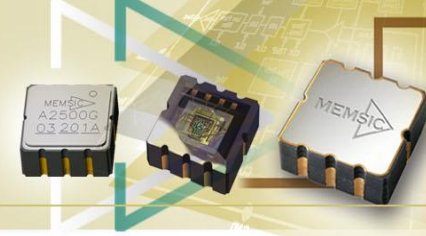
- ❖ **MEMSIC's** unique and proprietary approach integrates leading edge sensor technology with mixed signal processing circuitry onto a reliable, high quality, single chip using a standard CMOS IC process.
- ❖ **Enables Higher Level of System Integration for Intelligent Sensor SOC Roadmap**



Sensor (MEMS)

Electronics (CMOS)

Principle of Operation



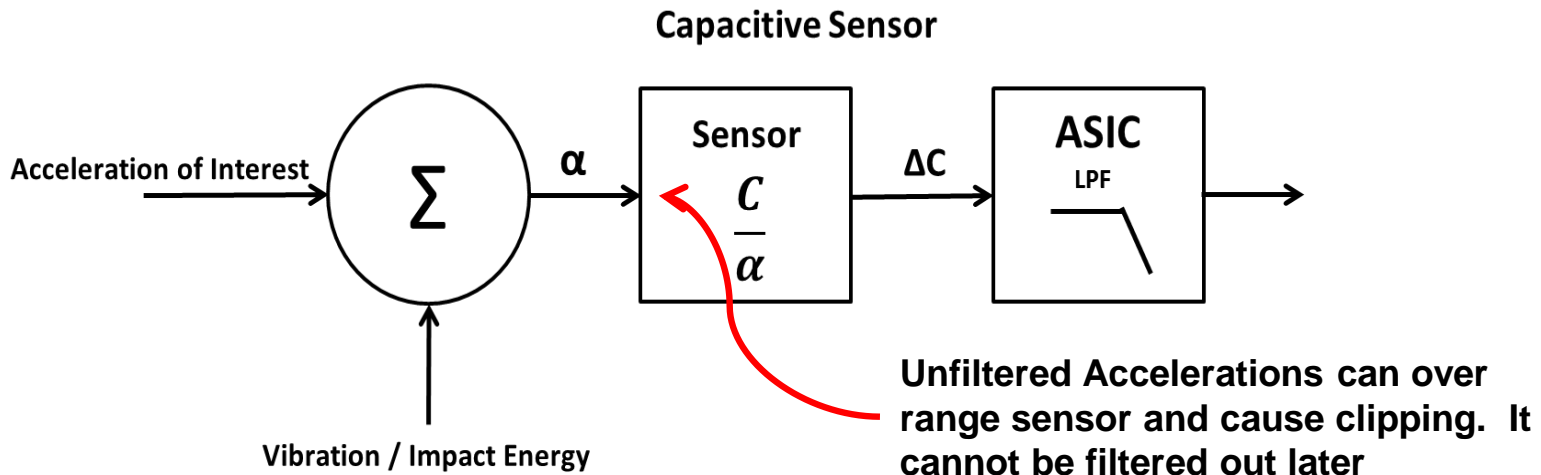
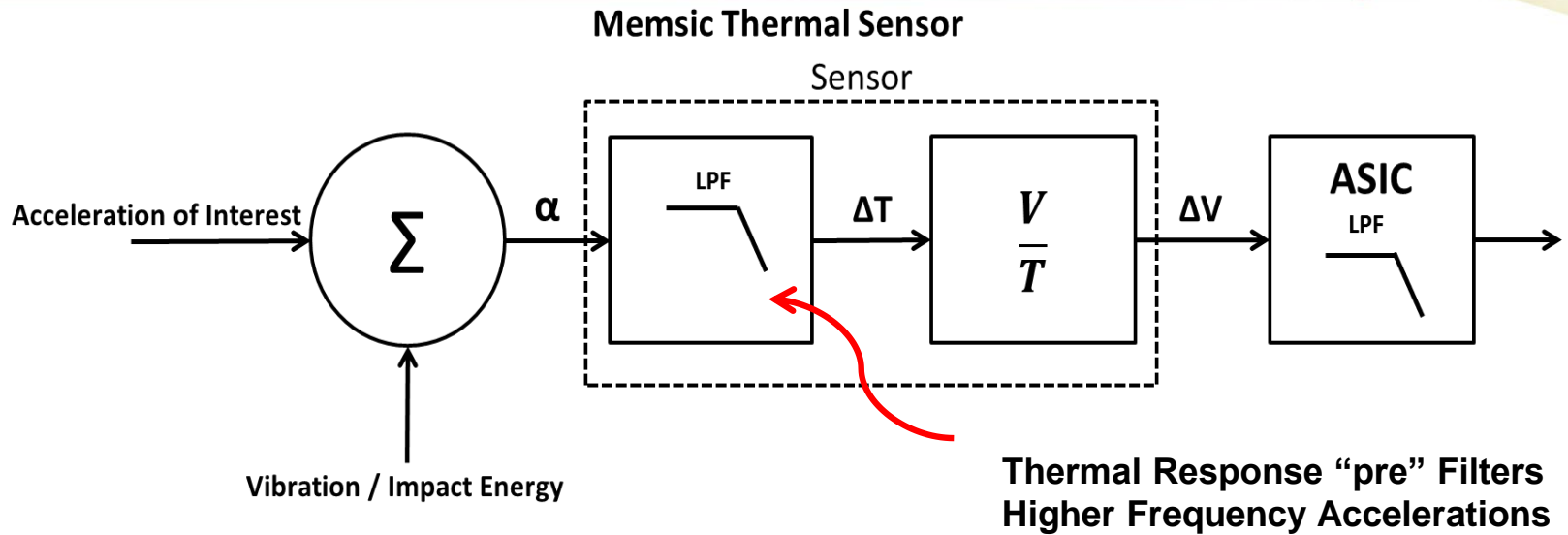
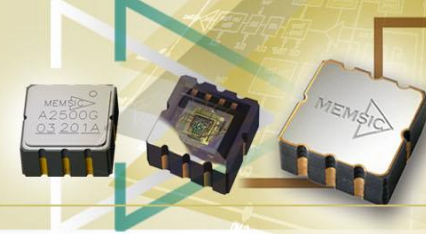
Temperature Sensors

Acceleration

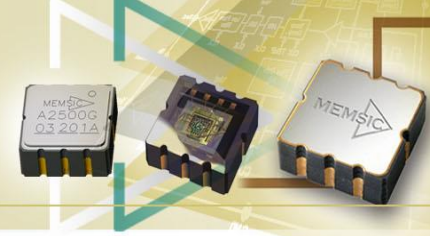
- ❖ Thermal accelerometer uses heated gas molecules as “proof mass”

- ❖ With acceleration the heat profile shifts in the direction of the acceleration.
- ❖ Temperatures at Sensor locations are NOT equal
- ❖ ΔT is proportional to Acceleration

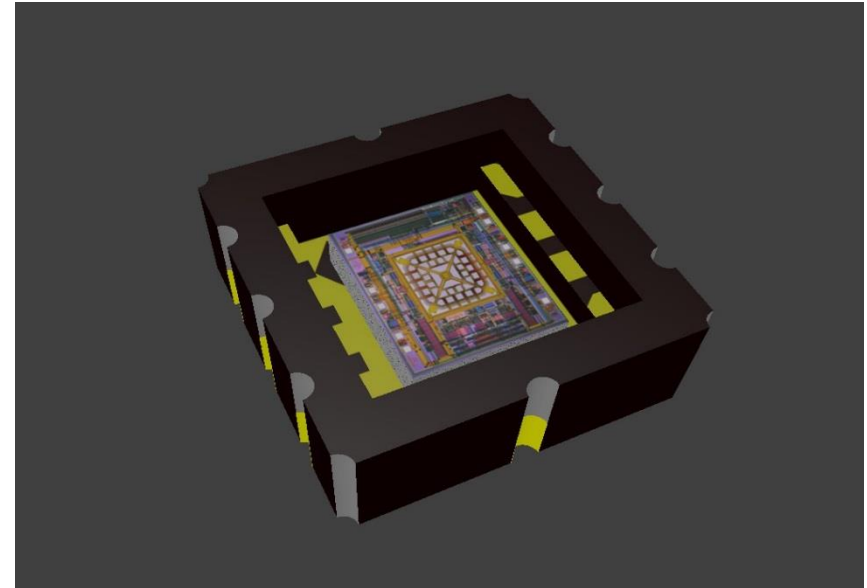
Vibration and Shock Tolerance



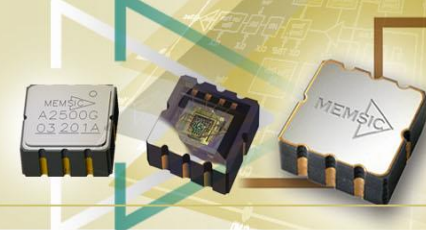
Key Benefits



- ❖ Monolithic CMOS Construction
 - No Moving Parts
 - No Resonance Error
 - Vibration Immunity and Rejection
 - High Reliability
 - Low Bias Drift
 - High Shock Survivability
 - No Temperature Hysteresis
 - Very Repeatable

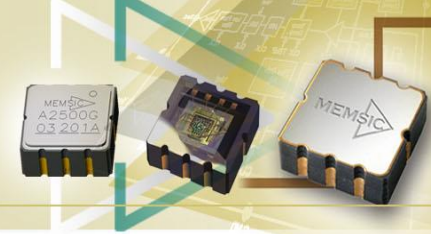


MEMSIC Tip-Over Sensor Solutions

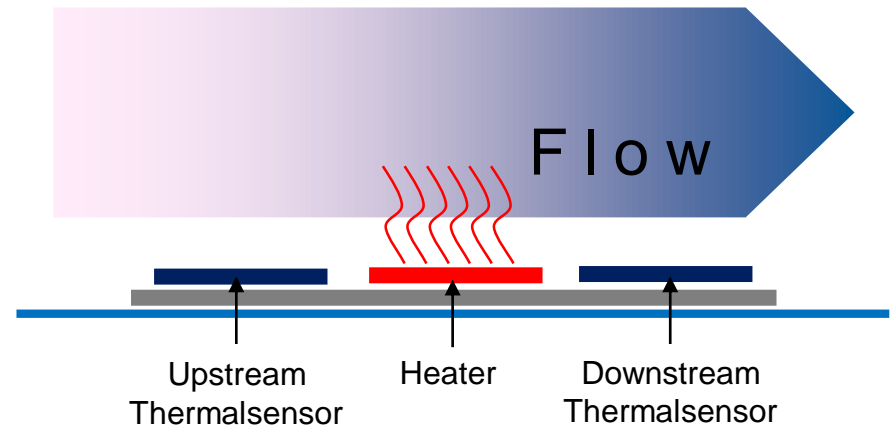


	MXD6240	MXD6241	MXC6244	MXC6245
Package	3x3 mm 6-pin LCC			
Built-in thresholds	8 (40°, 42.5°, 45°, 50°, 55°, 60°, 65°, 70°)			1 (45°)
Sensor BW	10 Hz			
FSR	+/-8 g			+/-2 g
Internal resolution	1 mg			
Angle programming	3 pins		I2C	
Vibration rejection @ >50Hz	>60 dB		>60dB (prog.)	15 dB
X/Y acceleration outputs	No		Yes, via I2C	
Output data rate	1.5 Hz		1.5 – 100 Hz	100 Hz
Self-Test function (fail = hi-z)	Yes (4 modes)		Yes (5 modes)	No
OUT[put] polarity	Run/Stop=0/1	Run/Stop=1/0	Prog.	
Samples	Now	Now	Now	Sept'14

Flow Sensor Features



MEMSIC's mass flow sensing module is based on patented MEMS thermal technology. It's rugged, accurate, and low power.



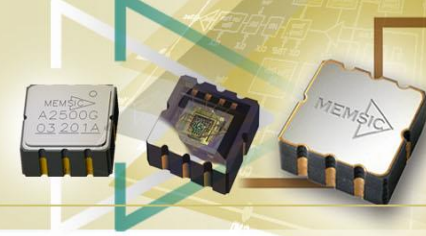
Features:

- Wide Dynamic Range
- High measuring accuracy
- High Repeatability
- Bi-directional Flow Sensing Capability
- Direct mass flow sensing
- Low pressure drop in system
- Very low power consumption

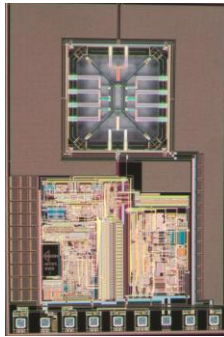
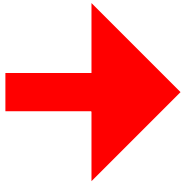
Applications:

- Medical, industrial flow measurement & control
- Process and Manufacturing Control, Automation
- HVAC and Heating/Cooling Systems
- Gas and Chemical Flow Measurement
- Environmental Health and Safety
- Food & beverage, etc.

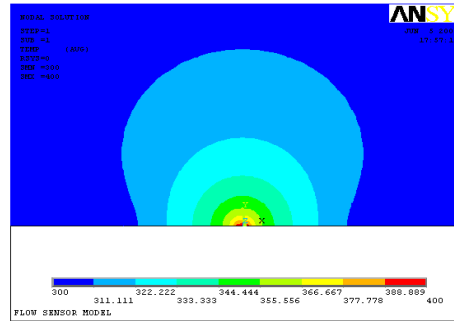
Flow Sensor Technology



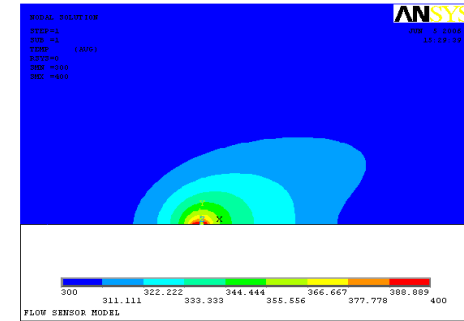
Gas Flow Direction



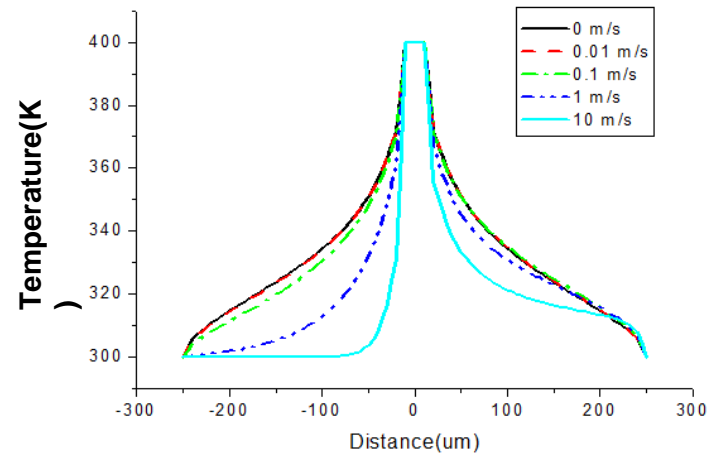
(a) Image of flow sensor



(b) Zero flow ($V=0$)

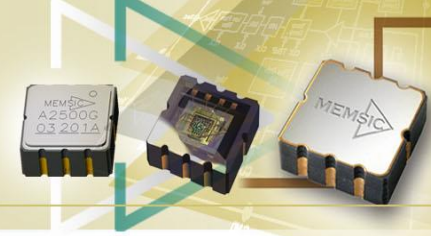


(c) Non-zero flow ($V > 0$ m/s)



(d) Heater Temperature VS Heater distance from Thermopiles

Flow Product Line

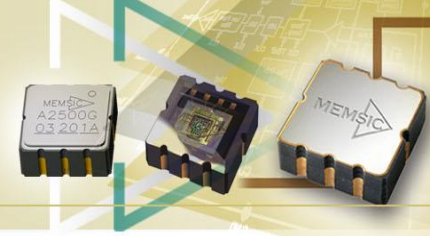


Part Number	Flow Range (SLM)	Accuracy	Output	Sleep Mode (μ A)	Supply Voltage (V)
MFA1100R	0.27 to 100	1.5% (10-100 SLM) 3% (0.27-10 SLM)	Analog	0.1	2.7 to 5.5
MFA1070	0.27 to 70	1.5% (10-70 SLM) 3% (0.27-10 SLM)	Analog	1.0	2.7 to 5.5
MFC2030 *	0.27 to 30	3% (3-30 SLM) 0.1% fsr (<3SLM)	I ² C/Analog	1.0	2.7 to 5.5

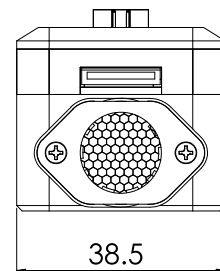
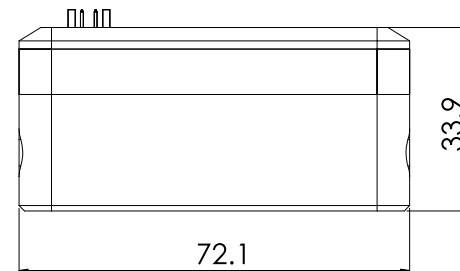
* In product development stage



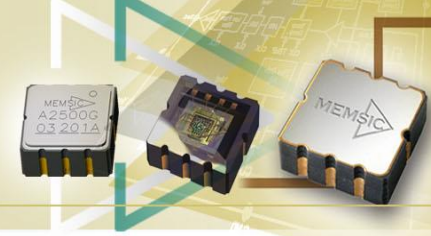
MFC 2030 Key Features



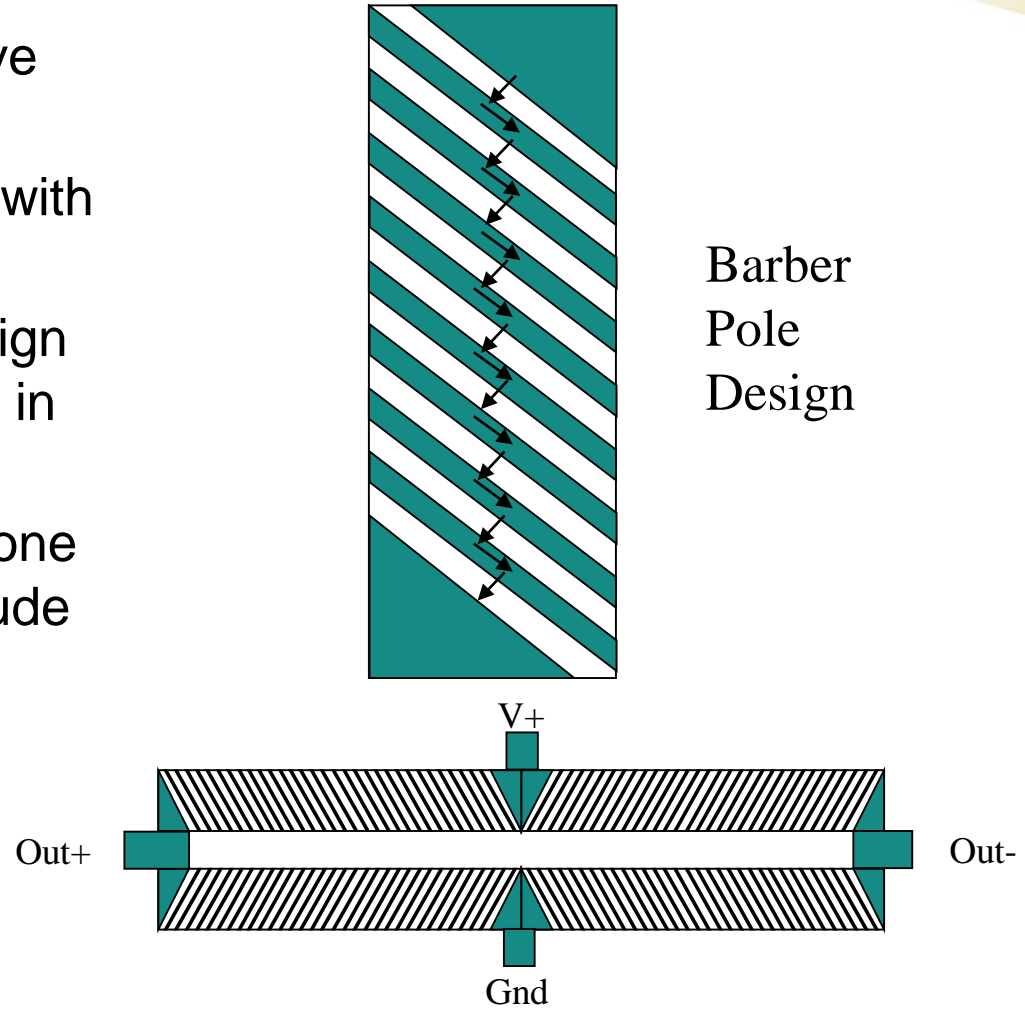
- ❖ Bi-directional flow
- ❖ Greater than 3% accuracy (f.s.r.)
- ❖ Segment leading power consumption
- ❖ Low pressure drop
- ❖ Highly configurable firmware (v1.0) with digital I2C interface, user friendly GUI
- ❖ Modular, scalable platform
- ❖ Mechanical design allows for a variety of gas line and mounting configurations



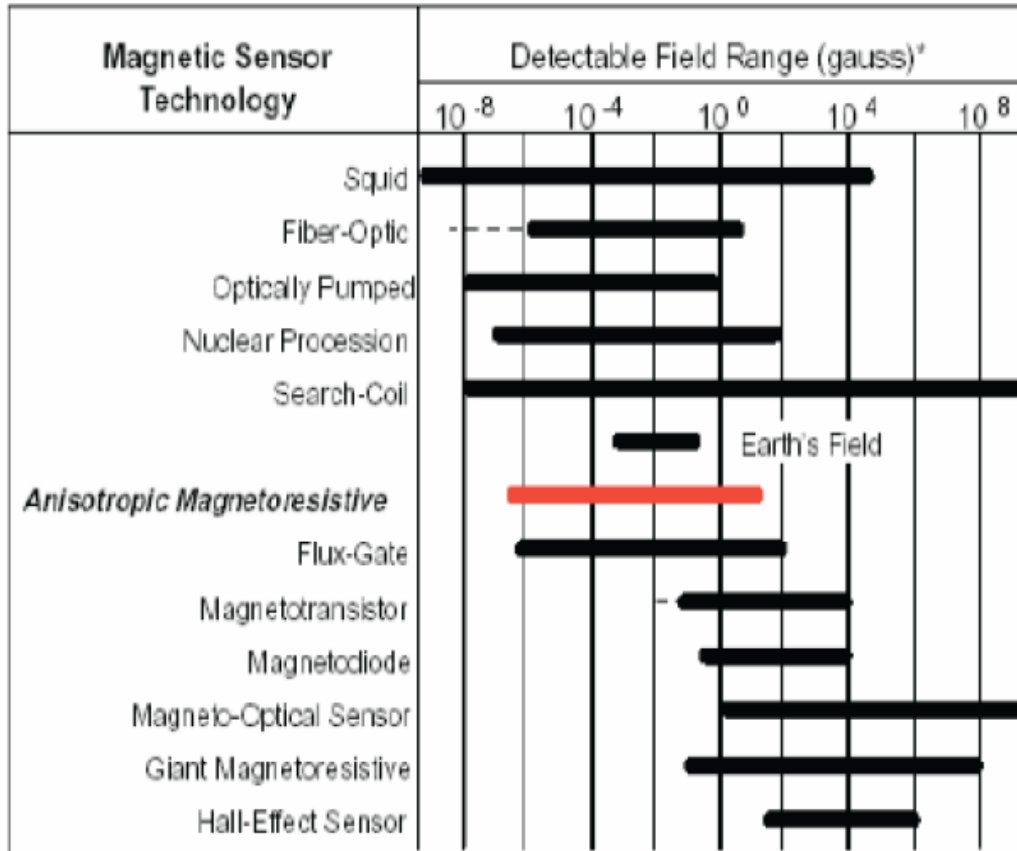
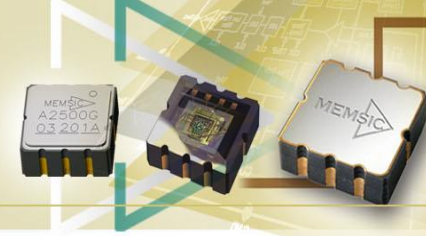
AMR Based Magnetometer Operation



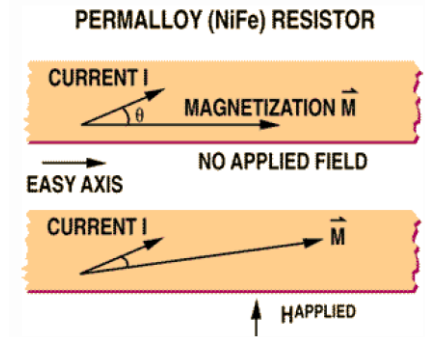
- ❖ Anisotropic Magneto Resistive (AMR)
- ❖ Material resistance changes with applied magnetic field
- ❖ A 45 degree barber pole design helps to linearize the change in resistance $\Delta R/R$.
- ❖ Patterned to form a Wheatstone bridge to detect both magnitude and direction of field along a single axis.



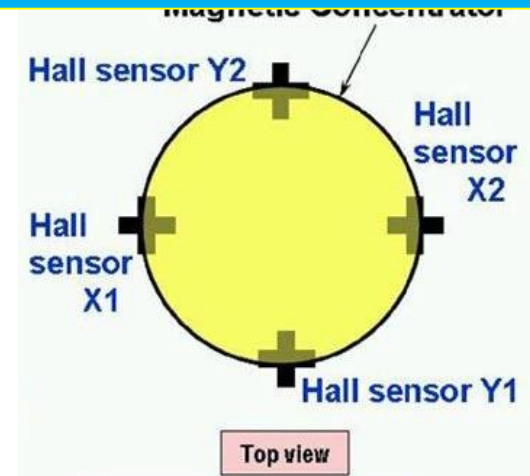
Physics and Magnetic Field Range vs. Sensor Technologies



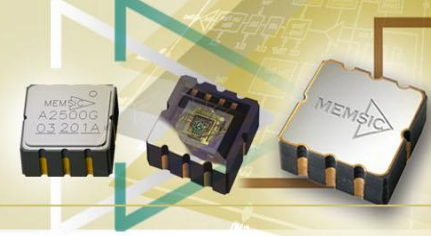
* Note: 1gauss = 10^{-4} Tesla = 10^5 gamma



AMR does NOT need concentrator



Magnetic Sensor Products

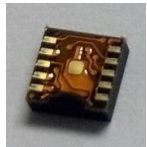


Magnetometer / Compass

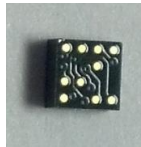
❖ **Definition** - Device that measures the strength and/or direction of magnetic fields

Applications

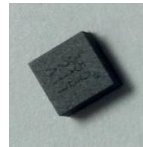
- Compass in Mobile Devices
- Position Sensing
- **Current Sensing**
- Position Sensing
- Automotive Systems
- Medical
- Metering
- Military
- Gesture Recognition
- Asset Tracking



MMC3140MS



MMC3280MA



MMC3416PJ

MEMSIC – A Leader in the Compass Market

❖ Unique AMR technology enables:

- Highest accuracy and linearity
- High Bandwidth
- Low power consumption
- Lowest noise vs available sensors

❖ Unique packaging technology enables:

- Low-cost package capturing superior performance
- High yield
- High reliability

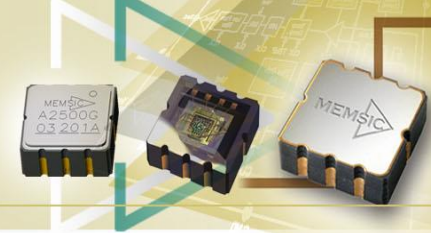
Large TAM

❖ Worldwide volume will reach >800M units this year¹

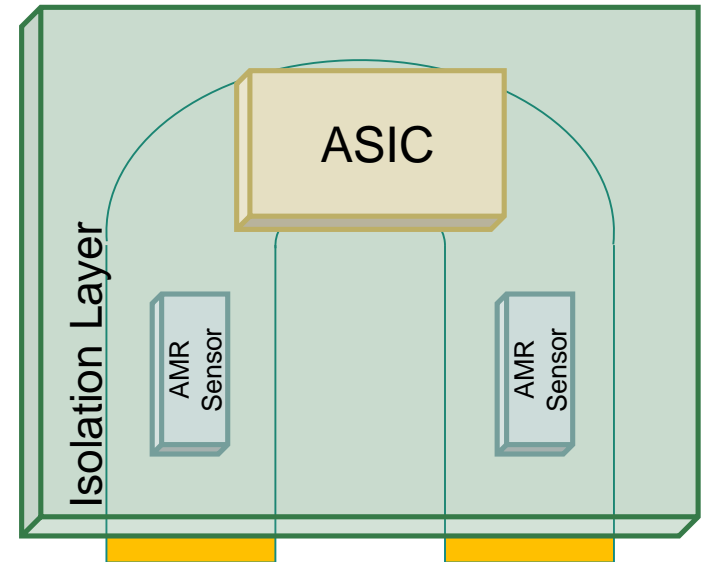


(1) Source: Yole Development

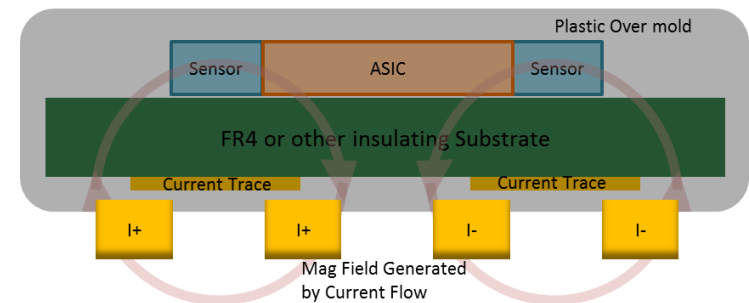
Isolated Single-Chip Current Sensors



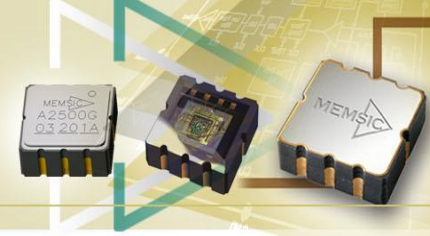
- ❖ Current Through Low-Loss Trace Generates Sensed Magnetic Field with Galvanic Isolation
- ❖ AMR Sensor Bridge is optimized for:
 - Optimizing Differential S/N & Common mode error rejection
 - Intrinsic High BW >1M Hz
 - High Dynamic Range – Sensitive from mA to 50A+
- ❖ Design scalable to Multiple Applications
 - Allowing for larger full-scale current ranges (100A+)
 - Package Options to support higher Isolation Voltages
- ❖ Aligns to a Wide Spectrum of Applications:
 - AC and DC Power Supplies up to several kV.
 - 3 phase current Motor drives, Automation
 - Cloud Storage, Server and UPS Systems
 - Solar Optimizers, Micro-Inverters technology
 - Grid-Tie, Solid State Transformers and Relays
- ❖ ASIC architecture allows for High Accuracy, options for Analog or Digital Output (SPI, I2C, etc)



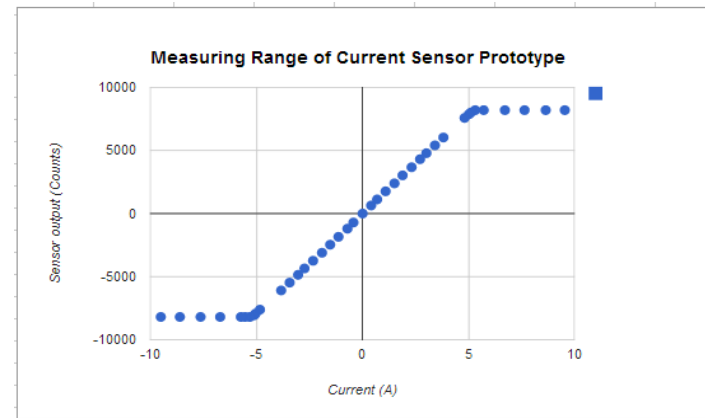
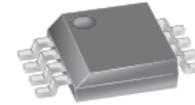
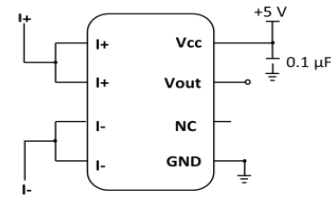
Thickness of FR4 Substrate Determines Isolation and Field Strength



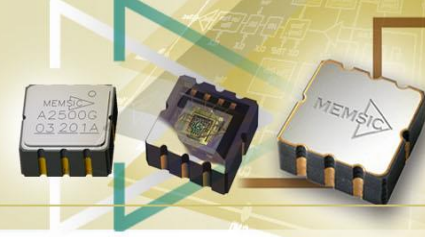
Isolated-High Accuracy Current Sensor (+/-5A and +/- 20A Overview)



- ❖ Utilizes Proprietary AMR Sensor Bridge
- ❖ Isolation 1kV-2.1kV + (Isolation from Sense Pins to All others)
- ❖ $\pm 5A$, 20A Range (scalable to currents above 100A) Higher Currents on Roadmap
- ❖ Linear, Bi-Directional Sensing of AC and DC Currents
- ❖ Total Error <2% of Measured Value (including all variation, temp)
- ❖ Fast Response, Bandwidth > 1MHz
- ❖ Trace Resistance <1.0m Ω max, reducing series Vdrop and power dissipation
- ❖ Analog (Voltage) or SPI digital output with 16-bit resolution.
- ❖ Single Supply Operation (3.3V/5.0V)
- ❖ S08 Footprint ~ (6.0 x 4.9 x 1.75) mm

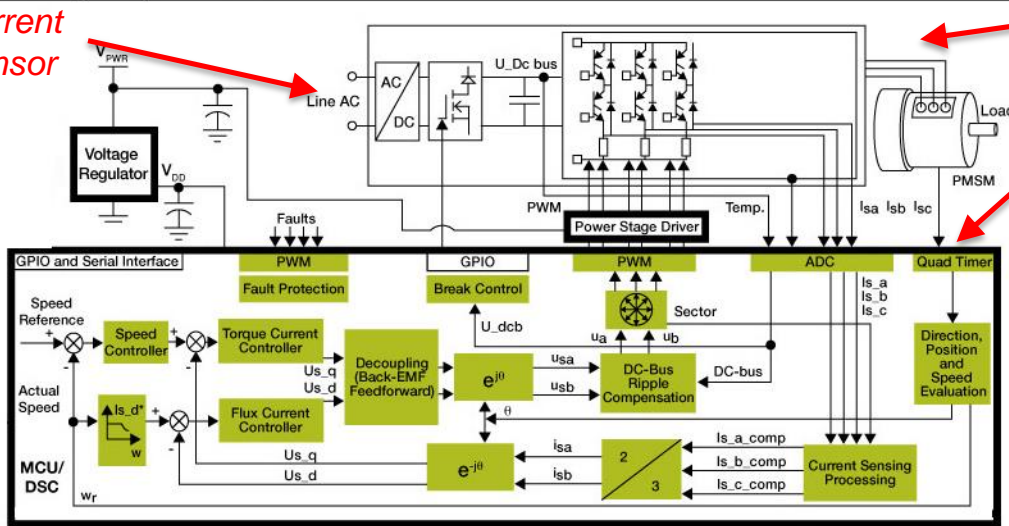


Motor Control for Automation, Robotics



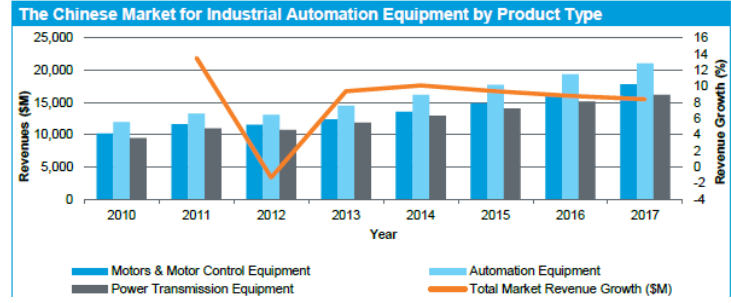
Permanent Magnet Synchronous Motor

Current Sensor



Current Sensor

Efficiency. mA -> 20-50A+FSR

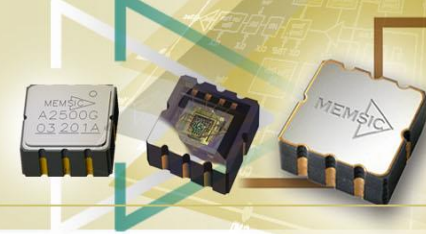


❖ Opportunity

- Analog Output, High Bandwidth (300kHz+), Isolation up to 2kV for 3 Phase inputs
- Isolation 1kV – 2.1kV by application
- Linearity and Accuracy of Current Sensing = Efficiency and Good Torque/Speed Control

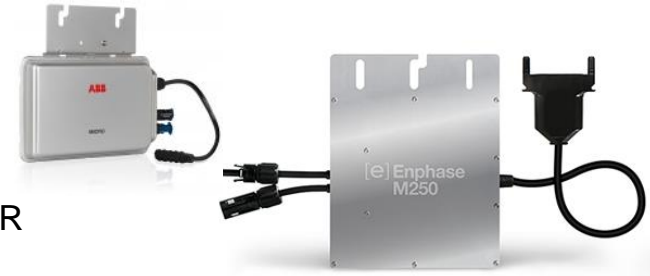


Inverter Market for Solar, EV



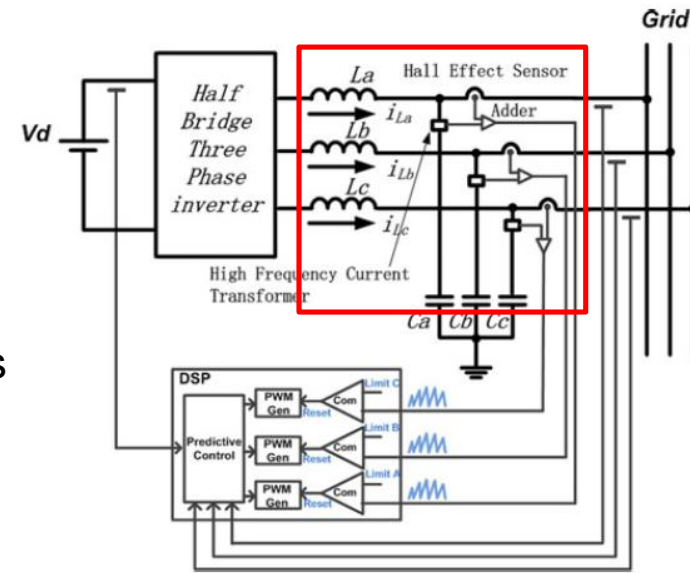
Inverters

- ❖ Convert DC power to AC Grid tie power
- ❖ High DC Working Voltage (~600+ Volts), up to ~10kV
- ❖ Total solar inverter market is >7.5M Inverters/yr but growing at higher CAGR
- ❖ 2.5M Micro Inverters per year (< 300W), Central Optimizer 5M/year
 - Micro Inverter Market expanding with higher efficiency, PFC ZVS Topologies
 - Often monitoring DC current with shunt and OP Amp, Hall Devices and Current Transformers
 - Also Monitoring AC current, THD, DC Injection into AC, with current sensor

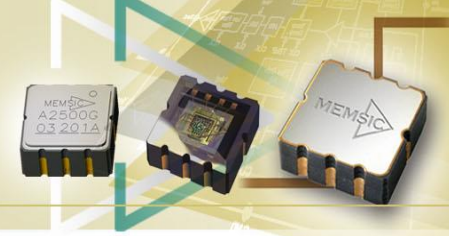


Additional Inverter Opportunity for:

- Industrial Automation
- Grid-Tie, Battery Backup/UPS
- Electric Vehicle, Potentially Commercial Power Tools

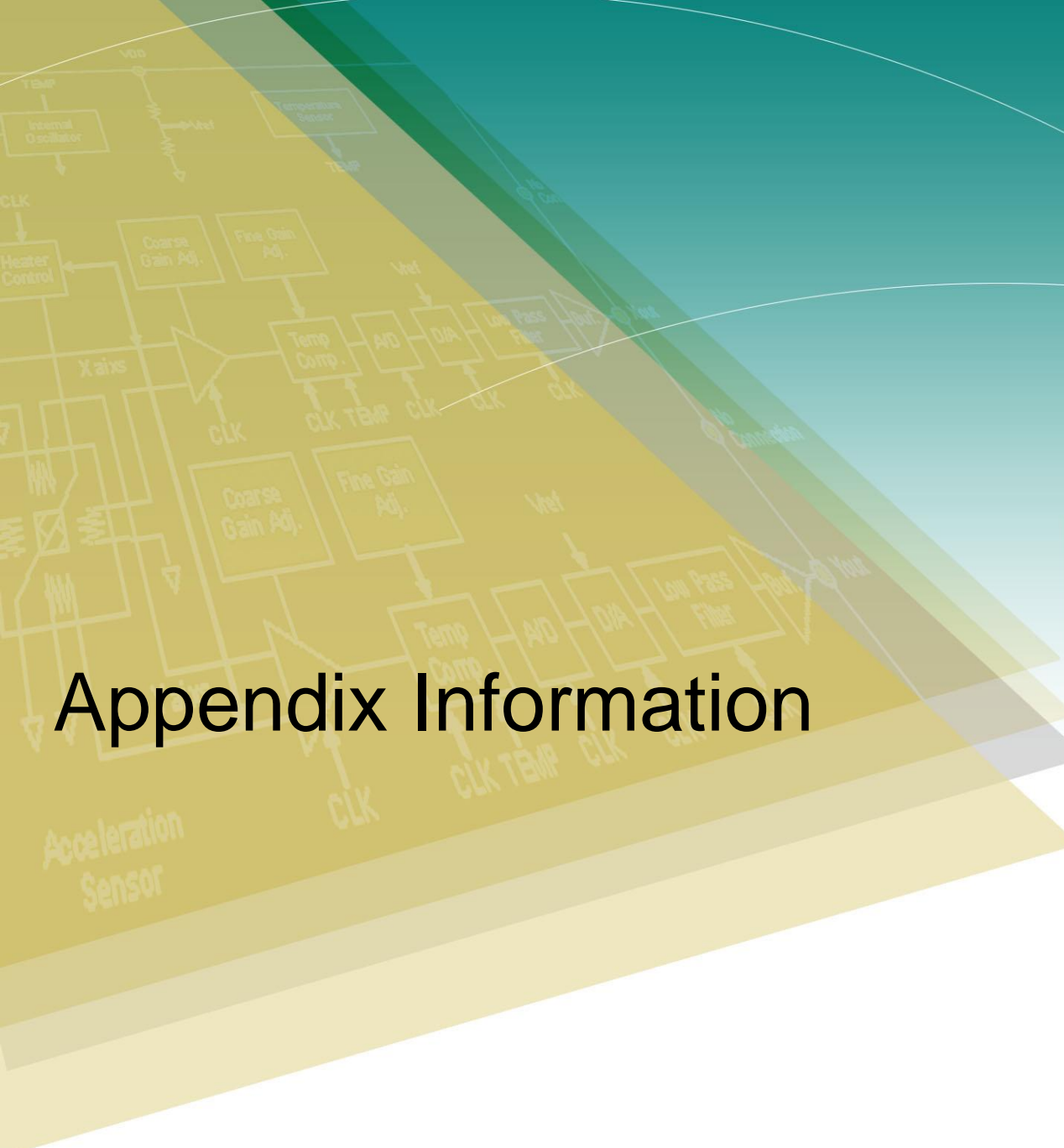


Quality and Reliability

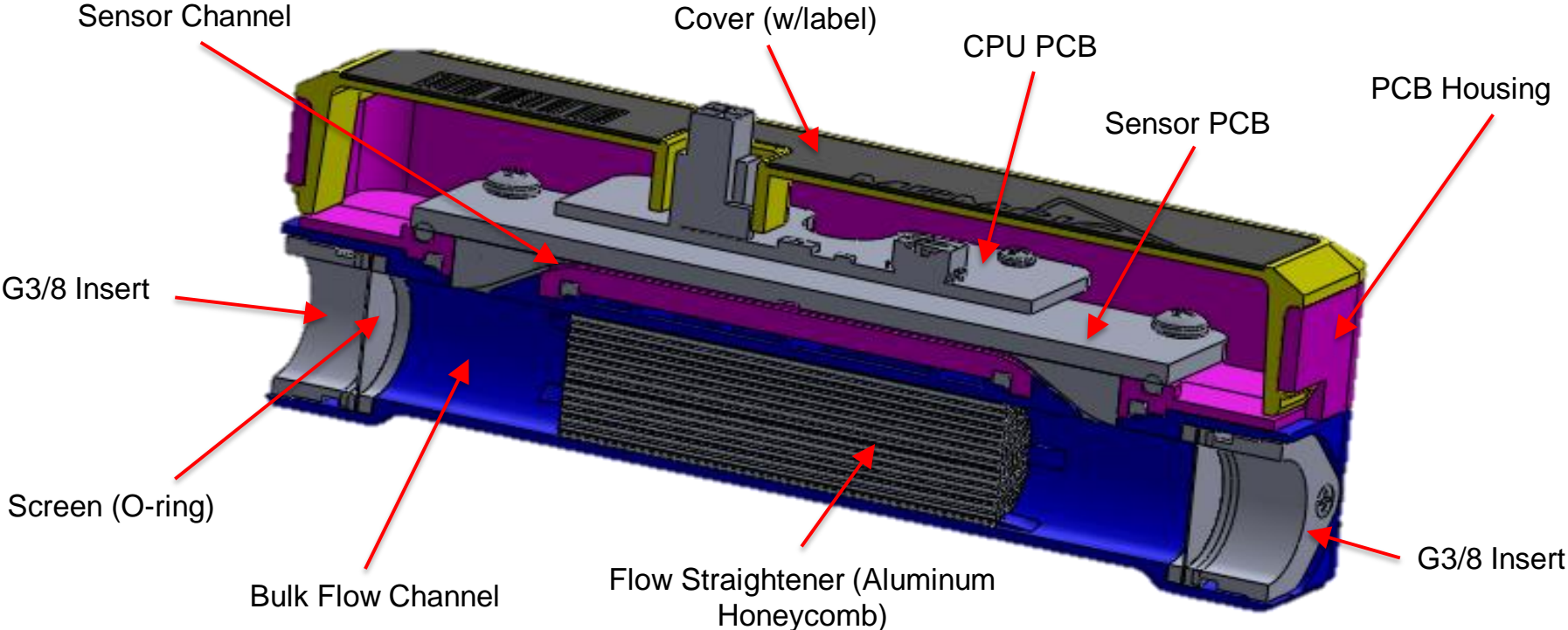
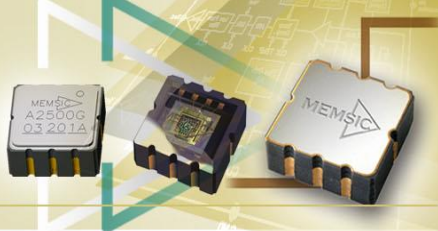


- ❖ Mission critical to a huge segment of our business
- ❖ MEMSIC Semiconductor:
 - TS16940 (Automotive) Certified: TUV
 - Outgoing Quality Level: < 100ppm
 - Ongoing Reliability Monitor Program (ORM) – FIT Rate < 10
- ❖ MEMSIC Transducer Systems (MTS)
 - ISO9001 Certified: TUV
 - Ongoing efforts for 2013 AS9100 (Aerospace)
- ❖ MEMSIC Corporate Quality
 - QMS Certification: ISO9001/TS16940/AS9100: 2013

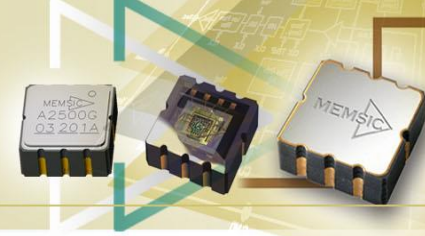
Appendix Information



MFC 2030 Design Features

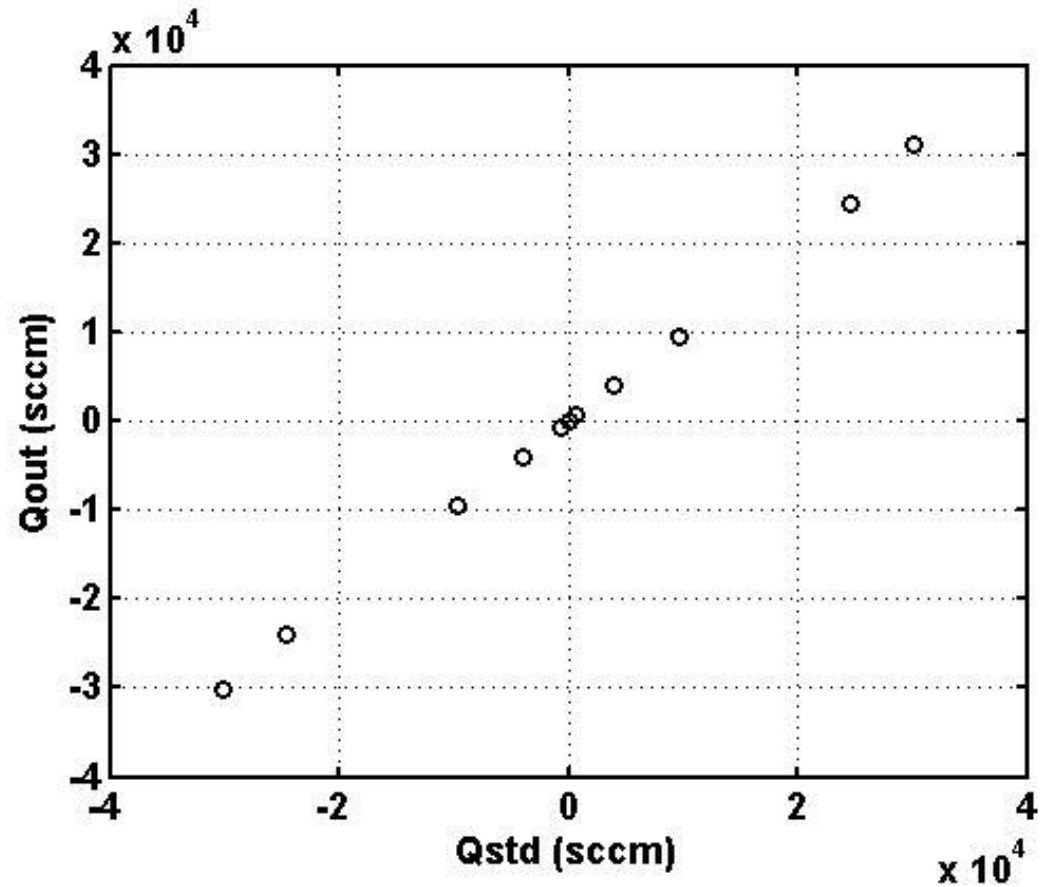


Calibrated Accuracy/Linearity Verification

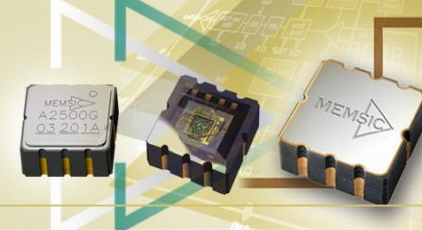


❖ MFC2030 Test Result

- Drycal flow rate vs. Calibrated output

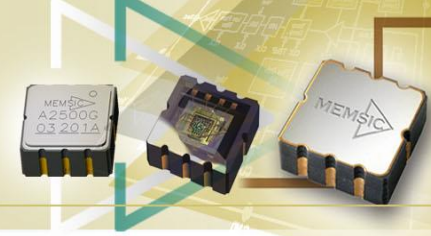


MEMs Accelerometer Selector Guide

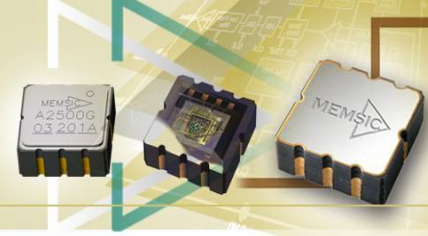


Part Number	Axes	Range (+/- g)	Output	Sensitivity	Offset Drift (mg/°C)	Bandwidth (Hz)	Noise (mg rms)	Supply Voltage (V)	Size (mm)	Temperatur Output	Automotive Qualified	Temp. Comp. (ON OFF)
MXP7205VF	2 (XY)	5	SPI	800 c/g	0.1	29	2.7	4.5 - 5.2	5 x 5		X	On
MXP7205VW	2 (XZ)	5	SPI	800 c/g	0.1	29	2.7	4.5 - 5.3	5.5 x 5.5		X	On
MXR7305VF	2 (XY)	5	Analog	0.25 V/g	0.3	27	3.1	4.5 - 5.3	5 x 5		X	On
MXR7250VW	2 (XZ)	5	Analog	0.25 V/g	0.3	27	3.1	4.5 - 5.3	5.5 x 5.5		X	On
MXR9150MZ	3 (XYZ)	5	Analog	0.15 V/g	1.0	17	2.5	2.7 - 3.6	7 x 7			On
MXC6232xMP	2 (XY)	2	I2C	512 c/g	0.8	17	0.7	2.7 - 3.6	5 x 5	X		On
MXC6226XU	2 (XY)	2	I2C	64 c/g	0.3	10	0.6	2.5 - 5.5	3 x 3			On
MXC6226XC	2 (XY)	2	I2C	64 c/g	0.6	10	0.9	2.5 - 5.5	1.2 x 1.7			On
MXD6235MP	2 (XY)	2	PWM	12.5%/g	1.5	17	1.6	2.7 - 3.6	5 x 5			On
MXC6235xQB	2 (XY)	1.5	I2C	512 c/g	0.1	8	0.4	2.7 - 3.6	5 x 5	X		Off
MXC6232xEP	2 (XY)	1.5	I2C	512 c/g	0.8	17	2.9	2.7 - 3.6	5.5 x 5.5	X		Off
MXR6500MP	2 (XY)	1.7	Analog	0.5 V/g	1.5	17	1.6	2.7 - 3.6	5 x 5			On
MXR9500MZ	3 (XYZ)	1.7	Analog	0.5 V/g	1.0	17	2.5	2.7 - 3.6	7 x 7			On
MXD2020EL	2 (XY)	1	PWM	20 %/g	0.4	17	0.8	3.0 - 5.3	5 x 5	X		Off
MXD6235QB	2 (XY)	1	PWM	12.5%/g	0.1	8	0.4	2.7 - 3.6	5 x 5			Off
MXR7900CF	2 (XY)	1	Analog	0.9 V/g	0.1	19	1.3	4.5 - 5.3	5 x 5		X	Off
MXA2500EL	2 (XY)	1	Analog	0.5 V/g	0.4	17	0.8	3.0 - 5.5	5 x 5	X		Off
MXR2999EL	2 (XY)	0.5	Analog	1 V/g	0.4	17	0.8	3.0 - 5.3	5 x 5	X		Off

Current Magnetic Sensor Selector Guide



Part Number	Axes	FSR (+/- G)	Interface	Sensitivity	Noise (mG rms)	Supply Voltage (V)	Supply Current* (mA)
MMC246xMT	2	6	I2C	4096 c/G	0.8	1.62 - 3.6	0.05
MMC328xMA	3	8	I2C	512 c/G	1.0	1.62 - 3.6	0.3
MMC3316xMT	3	16	I2C	512 c/G	2.0	1.62 - 3.6	0.1
MMC3416xPJ	3	16	I2C	2048 c/G	1.5	1.62 - 3.6	0.02
MMC3524xPJ	3	24	I2C	1024 c/G	2.0	1.62 - 3.6	0.02



Thank you !

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