TMR SENSORS AND THEIR APPLICATIONS

XtremeSense TMR Technology

December 2024



TMR technology provides the highest accuracy, highest speed Magnetic Sensor ICs available in the market today

Hall Effect and TMR bring value to market

Hall Effect Sensor

- Leading sensing technology with majority of market through 2030
- Most proven reliability over wide temperature ranges

Tunneling Magneto-Resistive (TMR) Sensor

- TMR technology adoption significantly accelerating over 10-year horizon
- TMR technology results in 100 to 1000x larger signal than Hall, delivering greater accuracy and speed with lower power consumption

20x Higher Resolution at 5 MHz: TMR Current Sensors facilitate the GaN/SiC transition and make xEV/EVCI power electronics more efficient, with increased reliability

8x Higher Resolution at 40K RPM: TMR Angle Sensors provide extreme precision and heterogeneous redundancy in a small form factor for safety critical motor control systems (ADAS)

<1 uW power consumption: TMR Sensors enable ultra-low power for battery powered applications

TMR technology to lead the high-performance Magnetic Sensing market of the future





The Future of Sensing: <u>XtremeSense TMR Technology</u>

XtremeSense TMR technology delivers unprecedented performance breakthroughs in magnetic sensing



XtremeSense Current Sensor



XtremeSense Switches/Latches



XtremeSense Angle Sensors





TMR preferred for Current Sensing in GaN and SiC Power Systems

Emerging preference for TMR Sensors in Coreless inverter applications as well



Better (20x) signal to noise ratio at high speed (5 MHz) vs. Hall \rightarrow more precise and efficient power control



High speed Sensor ICs facilitate fast switching for protection of GaN and SiC \rightarrow enhanced efficiency and reliability



Results in smaller, lighter and higher efficiency power electronics systems



TMR Current Sensor

Hall Current Sensor



TMR ICs facilitate higher efficiency and smaller automotive on-board chargers and clean energy power systems



TMR Angle Sensors preferred for BLDC motor position control



Better (8x) signal to noise ratio at high rotational speed (40K rpm) vs. Hall \rightarrow more accurate and more efficient motor control



TMR technology adds value across Industrial (Automation) motor applications

• Lower torque ripple / vibration, reduced audible noise, higher efficiency





TMR Switches ideal for very low power applications

Ultra low active power consumption for switches and latches (< 1 uW) ideal for battery operated applications



Unique Z-axis TMR as "drop-in replacement" across legacy hall sensor applications requiring very low active power



Axis of magnetic sensitivity





Typical TMR a

Traditional Hall and Z-Axis TMR



XtremeSense TMR is Less Sensitive to Stray Magnetic Fields

Robust Stray Field Immunity due to its axis of sensitivity.



At 10mm, **XtremeSense TMR** is only impacted by 2% of stray magnetic fields



TMR Current Sensors

XtremeSense Current Sensors

Integrated Conductor (Contact)

- CT41x
- CT42x
- CT43x
- CT40xx



Field Sensors (Contactless)

- CT100
- CT220
- CT45x





TMR Current Sensor Product Selection

Parameter	1 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	СТ220	CT41x/42x	CT430/431	CT45x
Туре	Contactless	Contactless	Integrated	Integrated	Contactless
Current Range	±20 mT	±1.5 mT, ±5 mT, ±10 mT, ±15 mT	±20 A, ±30 A, ±50 A, ±65 A	±20 A, ±30 A, ±50 A, ±65 A	Programmable, \pm 6 mT, \pm 24 mT
Bandwidth	1 MHz	30 kHz	1 MHz	1 MHz	1 MHz
Total Error over Temp	Е _{тот} < 3% FS	E _{TOT_3V} < 3% FS E _{TOT_5V} < 5% FS	Ε _{τοτ} < 1% FS	Е _{тот} < 0.7% FS	Ε _{τοτ} < 0.5% FS
Common Mode Rejection			\checkmark	\checkmark	\checkmark
Design Complexity	High	Medium	Low	Low	Medium
Package	SOT23-6, DFN-6	SOT23-5	SOIC-8	SOICW-16	SOIC-8/TSSOP-16



TMR Current Sensors – CT430 has super-hero performance

Description

Ultra-Low Noise Galvanic Isolation <1% Total Error 1MHz Bandwidth



Package: SOICW-16

Features

- Supports AC & DC Current
- Current range ±20A to ±65.0 A
- Resolution (SNR): <10 mA_{RMS}
- Immunity to common mode fields
- 1 MHz Bandwidth
- Total Error: ±0.7%
- 5kV Isolation
- Over-Current Detection (OCD™)
- Supply Voltage:
 - CT430 = 4.75 V to 5.50 V
 - CT431 = 3.00 V to 3.60 V
- Operating Temperature:
 - -40°C to +125°C

Advantages

- Immunity to external interreference
- <1% Total error over temperature
- 8mm creepage
- AEC-Q100

Applications

- Solar/Power Inverters
- Motor Drives
- HVAC, UPS, BMS
- Appliances



TMR Contactless Current Sensors – CT45x Differential Common Mode Field Rejection









Bus Bar With 'U' Cutout



TMR Position Sensors

TMR Switches



Features

- ✓ Low Power consumption 100nA
- ✓ High Sensitivity and resolution
- ✓ Small LGA package 1.5mm²

Product Selection Guide					
Product Name	Polarity	Sensitivity Axis	Output Type		
CT811x	Unipolar	X-axis			
CT812x	Bipolar	X-axis	Push-pull & Open- drain		
CT813x	Omnipolar	X-axis			





TMR SWITCH SENSORS

Smart Door Lock





Dead bolt implementation

Benefits of Allegro XtremeSense TMR:

- High Sensitivity for accurate dead bolt position detection
- Long battery life with < 110 nA active current consumption
- Digital output for easy interface

Cylinder knob implementation





TMR SWITCH SENSORS

Medical Devices

Benefits of Allegro XtremeSense TMR:

- Small package size (LGA) for integration in disposables
- Long battery life with < 110 nA active current consumption
- TMR sensor can be used as wake-up device for other electronics (low active current)
- Very high sensitivity allows for lower cost smaller magnets







TMR SWITCH SENSORS

Wireless Ear buds

Benefits of Allegro XtremeSense TMR:

- Small package size (LGA) for integration in small personal electronics
- Long battery life with < 110 nA active current consumption
- TMR sensor used as open/close detect for charging
- Very high sensitivity allows for lower cost smaller magnets







TMR Linear Sensors

Linear

Features

- ✓ Low Power consumption < 1μ A
- High Sensitivity and resolution
- ✓ Both planar and out-of-plane sensitivity axis

Product Selection Guide				
Product Name	Sensitivity @ 3.3V	Sensitivity Axis	Output Type	
CT100	12mV/mT	X-axis	Differential	
CT130	2.5mV/mT	Z-axis	Differential	
CT815x	154mV/mT	X-axis	Single-ended	
CT220	990mV/mT	X-axis	Single-ended	



Linear Applications – Axis of sensitivity

Human Interface

- Game controller, triggers, sliders , joysticks
- Power Tools , triggers, dials, throttle
- Medical, pipettes, syringe, surgical instruments, catheters
- Audio, analog vibration sensing
- Video and Camera, image stabilization
- Wearables, shoe compression, gesture ID

Machine Interface

- Magnetic Ruler, absolute position encoder
- **DC motor**, 3-phase position feedback
- Dynamic motion analysis, shock absorbers, table balance





TMR LINEAR SENSORS

Magnetic Keyboard

Benefits of Allegro XtremeSense TMR:

- Faster Actuation
- Adjustable Actuation point
- linear output
- Faster Response time
- More durability over mechanical or optical
- Lower Power consumption compared to Capacitive or Hall Effect











TMR Angle Sensors

Angle

Features

- ✓ Absolute Angular Error < 0.25°
- ✓ Insensitive to airgap variation
- ✓ Differential Analog outputs

	Product Select	lion Guide
	Product Name	Operating
	CT310	25mT
tett		

Product Selection Guide					
Product Name	Operating Range	Angular Error	Output Type		
CT310	25mT – 90mT	0.25 °	Differential SIN and COS		



TMR ANGLE SENSORS

Industrial Motors

Benefits of Allegro XtremeSense TMR:

- Angular error < 0.25 is ideal for precision motor position
- Incremental plus absolute position
- Insensitive to airgap variations
- Differential Analog outputs







Additional Information

XtremeSense TMR: Product List

Product Portfolio	Allegro Product	Key Differentiator	Product Portfolio	Allegro Product	Key Differentiator	
	<u>CT110</u>	High Linearity/High Resolution Contact Current Sensor	Switches and Latches	<u>CT8111</u>	Integrated Unipolar TMR Switch/Latch	
	<u>CT415</u>			CT8112		
	<u>CT416</u>	TMR Current Sensor with Ultra-Low Noise and <1% Total Error		CT8122	Integrated Bipolar TMR Switch/Latch	
	<u>CT417</u>			CT8131		
	<u>CT418</u>			CT8132	Integrated Omnipolar TMR Switch/Latch	
	<u>CT425</u>		Position Sensor	<u>CT8150</u>	Ominpolar TMR Analog Sensor with Dual Analog and Digital Output Operation Capability	
Current Sensors (0 - 50A)	<u>CT426</u>	TMR Current Sensor with Ultra-Low Noise and <0.7% Total Error		CT8152		<u>ال</u>
	<u>CT427</u>			<u>CT100</u>	1D TMR Linear Sensor with Analog Differential Outputs	ō.
	<u>CT428</u>			<u>CT310</u>	2D TMR Angle Sensor with Sine/Cosine Outputs	534
	<u>CT430</u>				AM067-	03.24
	<u>CT431</u>	TMR Current Sensor with Ultra-Low Noise, <0.7% Total Error and				
	CT432	Common-Mode Field Rejection in SOICW-16 Package				
	<u>CT433</u>					
Current Sensors (0 - 1000A)	CT220	High Linearity, High-Resolution TMR Contactless Current Sensor in Miniature Form Factor				
	<u>CT450</u>	TMR Contactless Current Sensor with 1 MHz Bandwidth and Programmable Gain				
	CT452	TMR Coreless, Differential and Contactless Current Sensor				
	CT453	with Programmable Gain				
	<u>CT455</u>					
	CT456	I MHZ BANGWIGTH CONTACTIESS CUIPENT SENSOR				



XtemeSense TMR Sensors and Target Applications

SENSOR



Current Sensors



Switch Latch



Linear Sensors



	Current	Position	Application/Use case
xEV Powertrain	۲		Current for OBC, DC-DC, Inverter, & PDU power conversion and SiC/GaN protection Position for motor position and battery disconnect unit
ADAS	۲		Current for in-phase current sensing in EPS and EMB motors Position sensor for motor position, pedal and low power system wake up
Body Electronics		\bigcirc	Position for in-cabin motors, user interface, infotainment and HVAC systems
Clean Energy	۲		Current for power conversion in solar, EV charging, and Energy Storage Position for EV plug and solar tracker
Data Centers	۲		Current for power conversion and protection in power supply units and server motherboards
Industrial	۲		Current for in-phase current sensing in VFDs, Servo Drives, and E-Bikes Position sensors for motor commutation and motor position sensing
Consumer	۲	۲	Current sensor for fault monitoring and protection Very low power position sensor for battery operated personal, medical, gaming etc.



Angle Sensors



Thank You

Please visit <u>allegromicro.com</u> for more information