NVE CORPORATION

Leaders in Practical Spintronics

This Presentation

> About NVE

- Sensor Products
- Isolator Products
- New Product Roadmaps
- Distributor/Rep Support Resources

NVE History

- Government-funded Honeywell spinoff in 1989
- World's first commercial GMR sensors in 1995
- World's first non-optical isolators in 2000
- Approved by U.S. Department of Defense
- Demanding customers include Abbott, Broadcom, Sonova, and military/aerospace companies





NVE Overview

Publically traded (Nasdaq: NVEC)



- > ~\$300 million market capitalization
- >\$80 million shareholders' equity



Demanding Customers





Certifications

ISO9001:2015 — Certified UL — Registered VDE — Certified (basic and reinforced insulation) IATF 16949 — Letter of conformance AEC Q100/Q101 — Approvals pending



NVE's Prestigious Awards and Accolades



"GMR can be considered one of the first real applications of the promising field of nanotechnology."

> -Nobel Committee October 2007

NVE Sensor Lines

Analog-Output Sensors

- AA-Series GMR Magnetometers (measure fields and currents)
- ALT025 Low-Power, Low Hysteresis TMR Magnetometer
- AB-Series GMR Gradiometers (measure field gradients)
- **ABL-Series** GMR Analog Gear Tooth Sensors
- AAT-Series TMR Angle Sensors

Digital-Output Switches

- AD-Series MSOP/SOIC Digital Switches
- ADL/AHL/AHT-Series 1.1 mm Nanopower Digital Switches
- AFL-Series 2.5 mm TDFN Lower Voltage Digital Switches
- AKL-Series Digital Gear Tooth Sensors
- ADT-Series TMR Angle/Rotation Sensors

Smart Magnetometers

- SM124 GMR, 10 Oe, 10% accuracy, 10 kS/s, 2.5 mm TDFN, low-cost
- SM225 TMR, 150 Oe, 2% accuracy, 15 kS/s, 2.5 mm TDFN
- SM324 TMR, 20 Oe, 0.3% accuracy, 300 S/s, 2.5 mm TDFN

Smart Angle Sensors

- ASR002 TMR, ±1°, 20 kS/s, SPI, 2.5 mm TDFN
- ASR001 TMR, ±0.5°, 3 kS/s, I²C, 3 mm TDFN



The Four "Bs" of NVE Sensors

Boxes—Miniaturization of medical and other devices

Bullet-proof—Inherently reliable; proven in medical

Batteries—Power as low as nanowatts

Brains—Easy interface to the Internet of Things; I²C / SPI interfaces



NVE Sensor Markets



- Industrial control
 - **AD-Series** for proximity and cylinder position
 - **AAT** for angle sensing
 - GT for gear-tooth speed
 - SM/ASR-Series smart sensors
- Automotive
 - SM-Series smart sensors for current sensing
 - ASR-Series smart angle sensors
- Consumer / small electrics
 - 1.1 x 1.1 mm ADL/AHL/AHT-Series proximity sensors



- Energy
 - AAT and ADT-Series for meter rotation



- Medical devices
 - Custom sensors

Use Case: Cylinder Position Sensing





Parts used:

AD-Series GMR Switches

> Applications

- Robotics and mechatronics
- Proximity sensing
- Security

> Advantages vs. Hall

- More precise and repeatable
- More sensitive

Disadvantages vs. Hall

- Hall effect is cheap

www.nve.com/application-thumbnails



Use Case: Current Sensing





GMR ADL024 Sensitivity = 12 mV/V/A = 60 mV/A @ 5V (60 mΩ shunt equivalent)

In-plane sensitivity allows sensing over a PCB trace



Use Case: Gear-Tooth Sensing

Features

- ABL sensors provide sinusoidal analog outputs
- AKL sensors provide current modulated digital outputs with 50% duty cycle
- Large analog peak-to-peak signal
- > Up to 150°C
- Packages as small as 2.5 mm x 2.5 mm

Key Part

<u>NVE GT Sensor</u> (click for GT sensor product specifications)

Advantages

- > Wide airgap range
- Wide operating temperature
- Small PCB footprint
- > Use inexpensive ferrite magnets





Use Case: Process Control Proximity Detection



Part used: SM124 Smart Magnetometer

- High-sensitivity sensor (1 mT)
- Very simple software (1-byte data, no commands, automatic repetative read)
- Fast prototyping using Arduino



Use Case: Bluetooth Tape Measure



Part used: ASR002 Smart Angle Sensor

- Concept to production in three months
- Sensor has a good combination of accuracy and speed
- Simple software
- Fast prototyping using demo board and pseudocode
- Minimal parts count on demo boards



Analog Sensors



Digital Switch Sensors





Digital, Bipolar, and Omnipolar Sensors



- Memory/data storage
- Latching/digital sensors



- Vector magnetometry
- Current sensing



Current amplitude



Nanopower Switch Sensors

Ultra-low power

- Continuous GMR (~30 μ A)
- Duty-cycled GMR (~100 nA)
- Continuous TMR (~1 μA)

Ultraminiature

- 1.1 mm x 1.1 mm x 0.4 mm

Ultrasensitive

- As low as 1 mT switching

Low voltage

- Industrial (2.4 4.2 V)
- Medical (0.9 V 2.4 V)





GMR Analog Sensor Advantages Over Shunts

- No insertion loss
- > Larger signals (30 times more than a 2 m Ω shunt)
- Inherent isolation
- Unlimited common mode voltage (vs. 63V for typical analog front-ends)
- > Omnipolar to rectify AC inputs
- Inherent signal limiting (shunt overcurrent can overdrive amplifiers)
- Low parts count (no amplifier or transient suppression)





Smart Sensors





- Angle sensors for rotation
- Magnetometers for proximity or current
- Factory calibrated
- Linearized and temperature compensated
- Ultraminiature TDFN packages





Smart Sensors

Part	Proximity, Current, or Angle	Tech- nology	Accur- acy	Speed (Samples/s)	Interf- ace	Features	Status
SM124		GMR	5%	10,000	I ² C, Digital Threshold	Low Cost	Introduced Q4 '18
SM225		TMR	2%	15,000	SPI	High Accuracy / High Spd	Introduced Q2 '19
SM324		TMR	0.3%	300	l ² C, Digital Threshold	Very High Accuracy	Introduced Q3 '18
ASR001		TMR	0.5°	2,500	l²C; PWM, Analog	High Accuracy	Samples Q3 '19
ASR002		TMR	2°	12,500	SPI	High Speed	Introduced Q1' 19



NVE Isolator Overview

NVE—Leaders in Practical Spintronics

Advantages: Boxes; Baud; Batteries; Bullet-Proof

Unique technology

> New products





The IsoLoop four "Bs":

Boxes—MSOPs, QSOPs, SOICs, and True 8 mm creepage Baud—Highest speed; lowest jitter Batteries—Low power consumption Bullet-proof—Unlimited barrier life; best isolation voltage; radiation tolerant; low emissions



NEWE Low-Power TMR Isolators (IL29xx / IL01x)



- > < 0.3 mA/channel typ. I_{DDQ}
- > 1/4 power of flagship isolators
- ➤ 10 Mbps
- ➢ RS-485 and data couplers
- ➤ 2.5 kV isolation



IsoLoop Isolator Features (all part families)

- ➢ Up to 150 Mbps <u>usable</u> baud rate
- > 100 ps jitter
- Very low EM emissions and susceptibility
- Radiation tolerant
- Best isolation voltage (to 6 kVrms)
- Polymer/ceramic barrier; 44000-year life
- Unique MSOP packages
- Unique True 8 (8 mm creepage) packages



Isolator General Structure











Best-in-Class Isolation Barrier

- > Unique polymer/ceramic composite barrier
- Not susceptible to partial discharge, which degrades barrier
- Best isolation voltage (to 6 kVrms)
- Best Working Voltage (to 1 kVrms)
- > Highest barrier resistance $(10^{14} \Omega)$
- > No aging or diffusion (44000 year barrier life)



IsoLoop Product Families

- > **New** IL01x low-power TMR isolators
- IL700/IL200 high-performance isolators
- IL700VE/IL200VE high-voltage isolators
- IL400/IL3000 isolated network transceivers
- IL500-Series cost-effective isolators
- IL600-Series passive-input isolators
- IL800-Series top-of-the-line isolators



IL700/IL200 Series High-Performance Isolators



















IL700/IL200 Series High-Performance Isolators

- > 110 Mbps, 3 ns PWD, 100 ps jitter
- > No clocks or RF carriers for superior EMC
- Excellent AC and DC magnetic immunity
- Several variants
 - IL700-1 Series

World's smallest isolators (MSOP-8; QSOP-16)

– IL700S Series

Fastest (150 Mbps); lowest PWD (300 ps)

- IL700T Series

Highest operating temperature (125°C)

– IL700V Series

Highest isolation voltage (6 kV)



IL700/IL200 Series Key Specifications

Parameter	Min.	Тур.	Max.	Units
Data Rate (S-Series)	100 (130)	110 (150)		Mbps
PWD (S-Series)		3 (0.3)	3	ns
Propagation Delay		10	15	ns
Pulse Jitter		100		ps
Transient Immunity	30	50		kV/μs
Quiescent Current		1.5	2	mA/ch
Temperature Range Std. IL700 Series T-Series IL200 Series	-40 -55 -40		+100 +125 +85	°C





IL400 and IL3000 Series Isolated Transceivers















Isolated Network Transceivers

- ➢ RS-422, RS-485, PROFIBUS, and CAN
- > Digital or passive input versions
- ➤ Up to 40 Mbps
- Rigorous PROFIBUS compliance
- True 8 mm creepage available
- > QSOP and narrow-body versions





IL600-Series Passive Input Isolators

- Current-sensitive passive inputs
- CMOS or open-drain output
- Wide input voltage range
- Very high transient immunity
- Inherent failsafe output





IL600-Series Passive-Input IsoLoop® Isolators





IL610A



IL611A













Evaluation Boards



- Dozens of sensor and isolator boards
- Show best practices
- Work out of the box
- ➤ Many are <\$100</p>



Isolator Packages













VE-Series Ultra-High Voltage Isolators

Best-in-class high-voltage performance

- 6 kVrms isolation
- 1 kVrms Working Voltage per VDE V 0884-11
- 12.8 kV surge immunity per VDE V 0884-11
- >600 V CTI per IEC 60601
- True 8 mm creepage per IEC 60601





True 8[™] (True 8 mm Creepage) Package





True 8[™] (True 8 mm Creepage) Package



	End	Pin-to-end	Surface Metal	Typical
Package	Width	Spacing (total)	Subtraction	Creepage
Ordinary wide-body package	7.4 mm	0.7 mm	0.5 mm	7.1 mm



NVE Isolator Markets



Industrial control (interfaces; networks)



Medical instruments





 Automotive (CAN interfaces; battery management systems)



Use Case: Switch-Mode Power Supplies

Features

- 2500 or 5000 V_{RMS} isolation
- 1000 V_{RMS} Working Voltage
- > 300 ps pulse width distortion
- > 100 ps pulse jitter
- 50 kV/µs transient immunity
- Best-in-class EMI
- > 44000 year barrier life
- SOIC16WB, PDIP, SOIC8, or MSOP8



- Smallest footprint
- Shortest propagation delays
- Most reliable isolators

Key Parts

- LM5035CSQ PWM Controller
- LM5110 Dual Gate Driver or equivalent
- NVE IL711 Isolator (click for datasheet)





Use Case: Isolated SPI Interfaces

Applications

- Industrial controls
- Battery Management Systems
- Hybrid/electric vehicles

Features

- 2500 or 6000 V_{RMS} isolation
- 30 kV/µs min. transient immunity

Parts 1 1

- NVE IL717, 2.5 or 6 kV, four-channel wide, narrow, or QSOP isolators (click for datasheet)
- Microchip PIC16F74 microcontroller or similar
- Microchip MCP3001 ADC or similar

Advantages

- Half the board area of other isolators
- Lower EMI than other isolators
- More transient immunity than other isolators









Competitive Advantages (vs. ADI, TI, and SiLabs)

- To 6 kV isolation vs. 5 kV
- Up to 1000 Working Voltage vs. 600 V
- > Barrier resistance $10^{14} \Omega$ vs. $10^{12} \Omega$
- ➢ Barrier life 44000 years vs. 12 60 years
- > No carriers or refresh for much better EMI
- Better high-frequency magnetic immunity
- Instant power-up
- Smaller (MSOPs; narrow-body; QSOPs)
- True 8 mm creepage in JEDEC package



IsoLoop Isolator Summary

- > Revolutionary technology
- > An industry leader
- Boxes; Baud; Batteries; Bullet-Proof
- Broad product line
- Extraordinary support

Sensor New Product Roadmap



Isolator New Product Roadmap







Distributor/Rep Support Resources

Demos and Evaluation Kits

Videos

nve.com > Videos; www.youtube.com/NveCorporation

Reference Designs

nve.com/sensor-reference.php; nve.com/isoapps-reference.php

Sensor Web Apps and Calulators www.nve.com/spec/calculators.php

GitHub Repositories (software, datasheets, and manuals) github.com/NveCorporation

> Application Thumbnails www.nve.com/application-thumbnails

Competitive Isolator Cross Reference www.nve.com/xref/

> **Competitive Bulletins** http://www.nve.com/competition

