
SEVENTEENTH ANNUAL
BiTS
Burn-in & Test Strategies Workshop
March 6 - 9, 2016
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive- Session 6
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Session 6

Jason Mroczkowski
Session Chair

BiTS Workshop 2016 Schedule

Performance Day

Tuesday March 8 - 1:30 pm

Cell-ebrating Test

"Vision Assist Method for Common Change Kit"

Brad Emberger, Zain Abadin – Advantest

"Test Cell Thermal Solution"

Gianluca Lombardi - Advantest

"Testing Magnetic Sensors"

Paul Ruo - Aries Electronics, Inc.

Larre Nelson - Kita USA

"Magnetically shielded test-cell for an integrated fluxgate sensor"

Gert Haensel - Texas Instruments

Loren Hillukka - Johnstech International Ltd.

BiTS 2016 Burn-in & Test Strategies Workshop

Magnetically Shielded Test-Cell For an Integrated Fluxgate Sensor

Gert Hänsel, Texas Instruments
Loren Hillukka, Johnstech International

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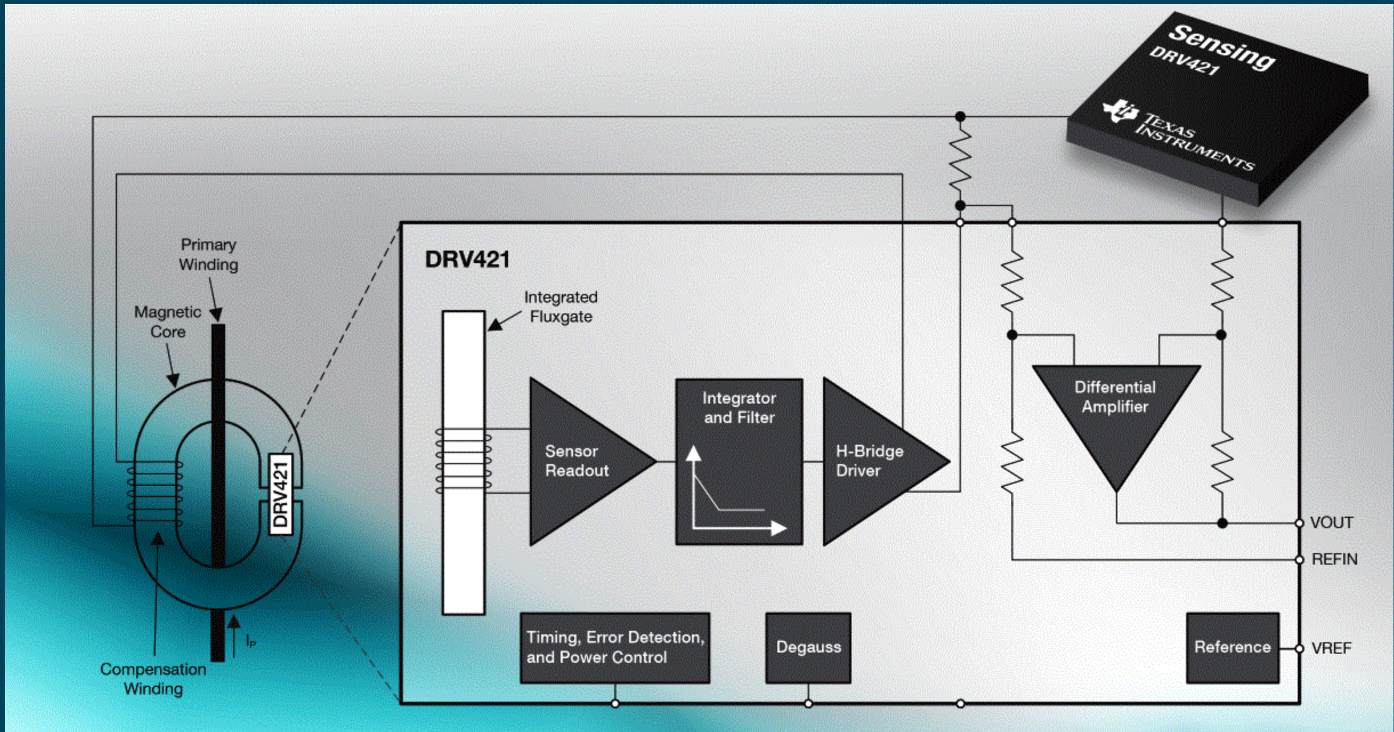
Contents

- TI's Integrated Fluxgate Sensor Chip
- Parameters for Production Test Cell
- Principles of Magnetic Shielding
- Simulations Based on Finite Element Method
- Solutions for Automated and Manual Test
- Risk Management
- Summary

DRV421 Closed Loop Current Sensing



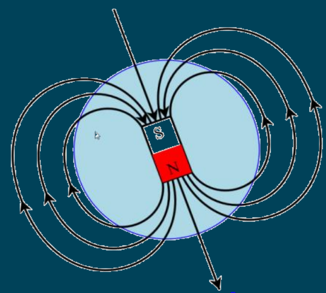
- Primary current is sensed and compensated. Measure I_{comp} @ VOUT, REFIN
- Size of magnetic offset defines the accuracy of the measurement

DRV421 Data Sheet: Magnetic Offset

6.5 Electrical Characteristics

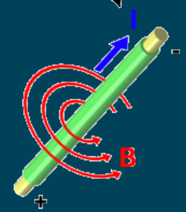
All minimum and maximum specifications at T_A = +25°C, V_{DD} = 3.0 V to 5.5 V, and I_{COMP1} = I_{COMP2} = 0 mA (unless otherwise noted). Typical values are at V_{DD} = 5.0 V.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
FLUXGATE SENSOR FRONT-END					
Offset [(1)]	No magnetic field	–8	±2	8	µT
Offset drift	No magnetic field		±5		nT/°C



DRV421 offset measurement overlaid by:

- Earth magnetic field: B = 25…65µT
- Industrial sources like powerlines e.g. from ATE and handling equipment up to several hundreds of µT



→ Shielding of magnetic fields during ATE Test essential

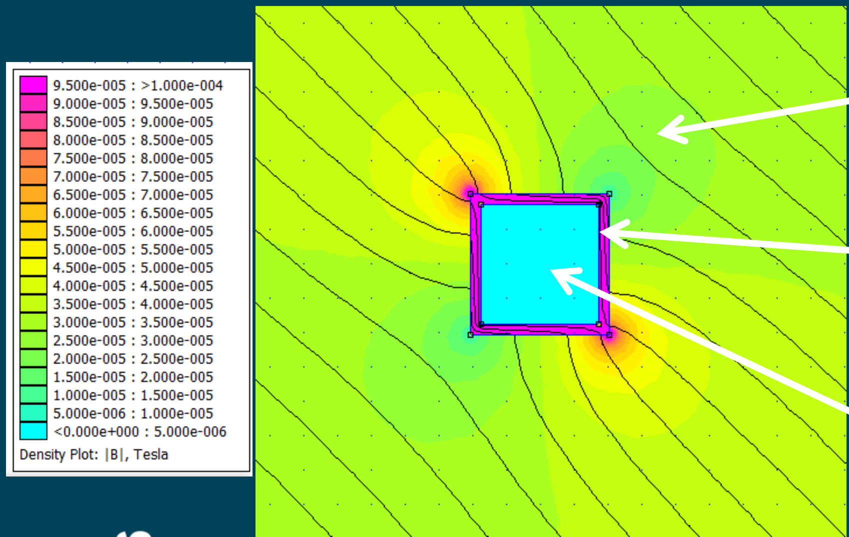
Parameters for Shielded Test Cell

- Offset test executed at final test at 25°C
- Use ATE and handling equipment already introduced at final test site: Eagle ETS364 and Delta-Matrix handler

- Enable hot temperature test for characterization
- DRV421 comes in QFN-20 4.0mm x 4.0mm package
- Allowed remaining B-field for DRV421: -100nT…+100nT

Principles of Magnetic Shielding

- Magnetic shielding does not block magnetic flux but redirects it providing a path for the magnetic field lines around the shielded volume
- Magnetic shielding is based on the application of material with high magnetic permeability μ_r like MuMetal



Boundary condition simulates earth magnetic field with $B_x = B_y = 25\mu T$

Closed container as ideal shield with high μ_r material, redirecting magnetic flux

Magnetic flux inside shield reduced by a factor of 2500 to $B_x = B_y = 10nT$

Material Properties of MuMetal

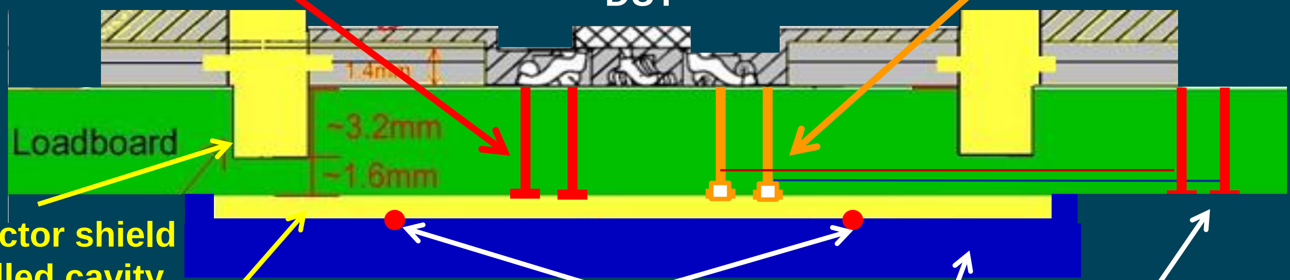
- **MuShield Magnetic Shielding Material Type analysis:**
  - Nickel: 80.00% Molybdenum: 4.20% Manganese: 0.50%
  - Silicon: 0.35% Carbon: 0.02% Iron: Balance
- **DC Magnetic Properties**
  - μ_r at B = 4000µT: 50,000 (iron 3,000...5,000)
  - μ_r max = 200,000
- **Curie Temperature**
  - 860°F (460°C): MuMetal needs to be annealed above this temperature
- **Melting Point**
  - 2650°F (1454°C)
- **Specific Gravity**
  - 8.74
- **MuMetal is very sensitive to mechanical stress**

Considerations for Design of Shield

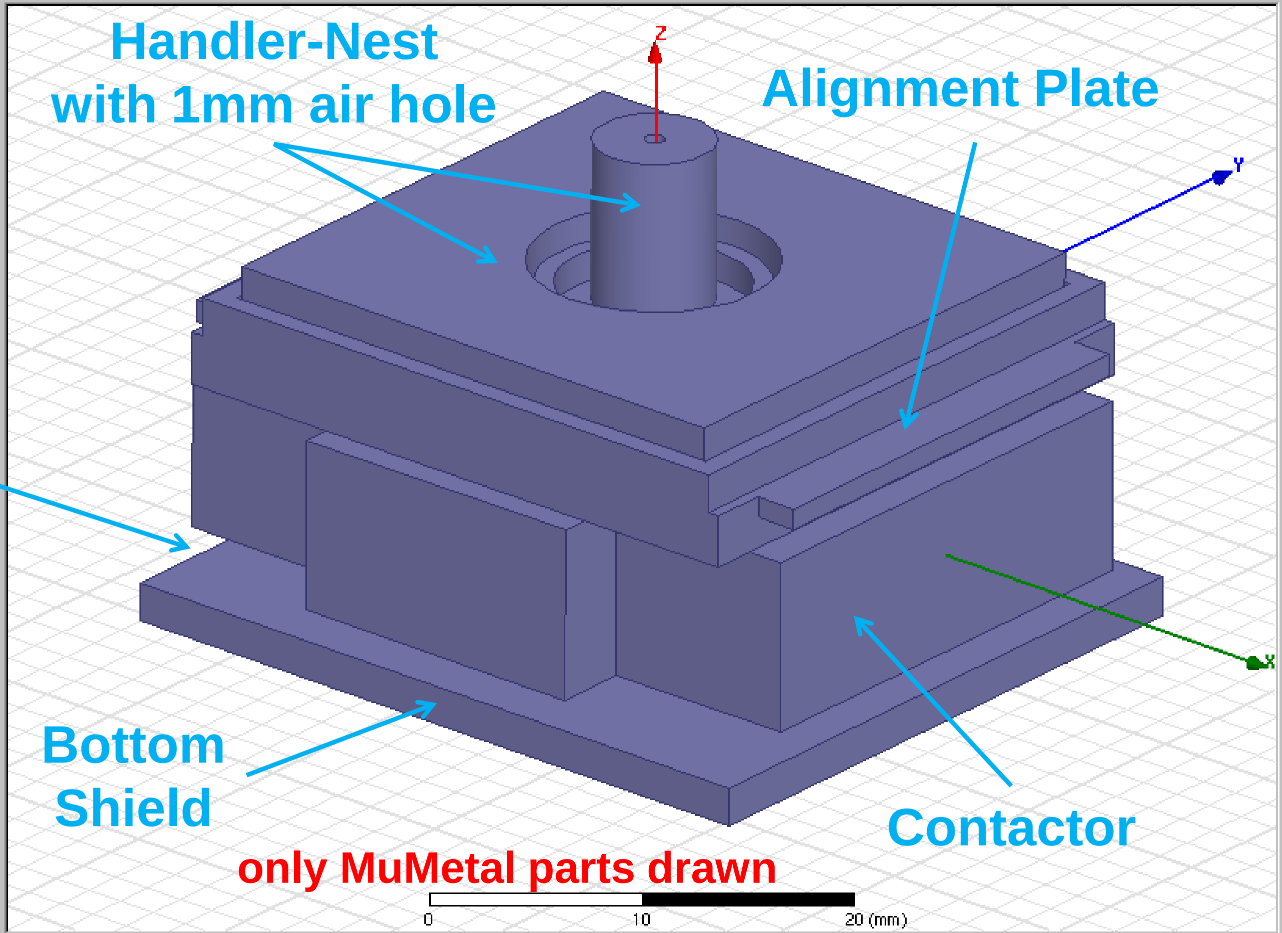
- Use finite element methods to simulate the effectiveness of the designed shield prior to manufacturing
  - FEMM4.2 – 2D simulation tool (free download in web)
  - ANSYS-Maxwell – 3D simulation tool (under license)
- Ideal closed container principle not applicable
  - Shield needs to be opened and closed for insertion of DUT
  - Required space on ATE loadboard for routing of tester resources to contactor pads (see next slide)
  - Hole on top for airstream in case of temperature testing
  - No direct touching of MuMetal parts to avoid mechanical stress
- No magnetic active parts within shield
  - Check material of socket screws and guide pins
  - Use of nickel free ROL contacts (ECO-1) from JTI
  - Avoid nickel, iron and steel; choose brass, aluminum or Torlon instead

ATE Loadboard Design

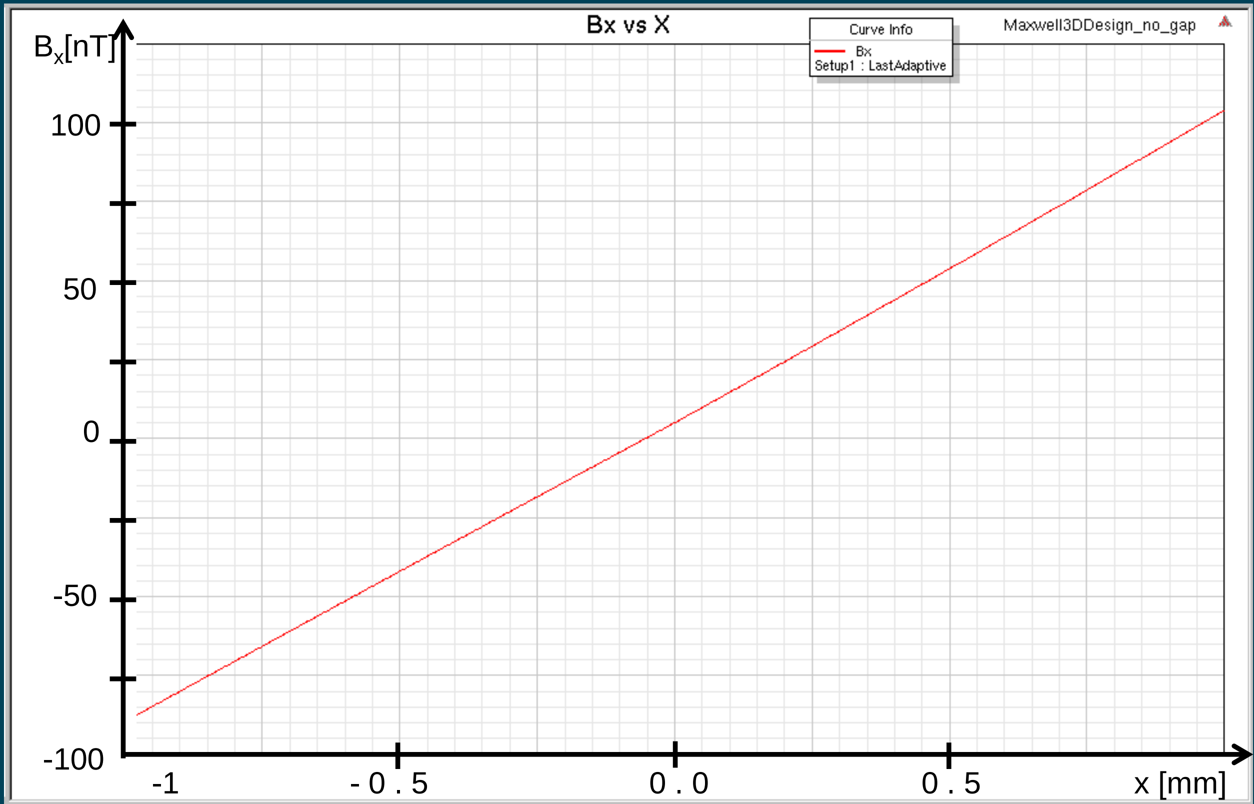
- First simulations identified excessive leakage through gap in shield at the ATE loadboard (~5mm thick)
- Solved by milling a 3.2mm channel for contactor shield
- Remaining space of 1.6mm for ATE signal routing



3D FEM Simulation for Handler Kit



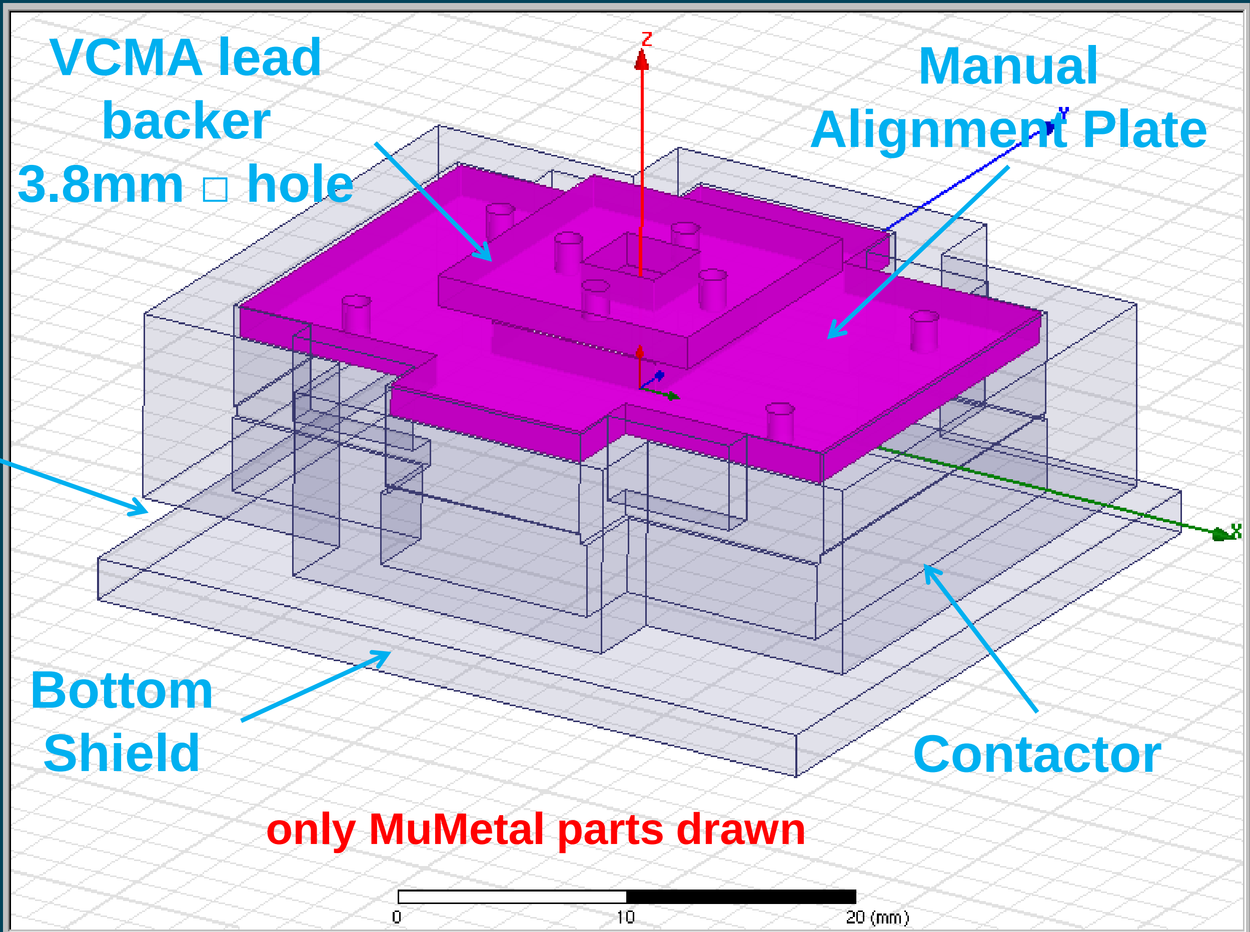
3D FEM Result Handler: B_x within DUT



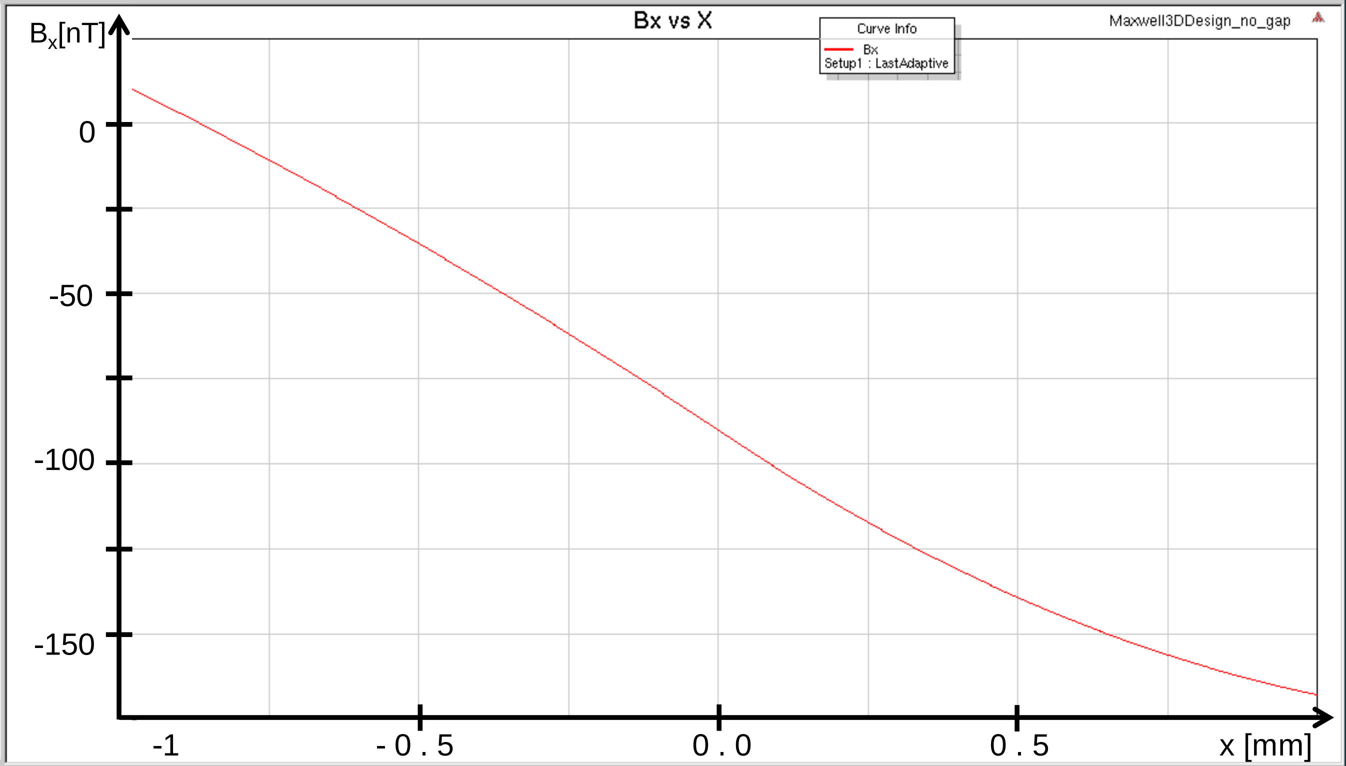
$-90nT < B_X < 100nT$

3D FEM Simulation for Manual Parts

PCB not drawn, 1.6mm gap here

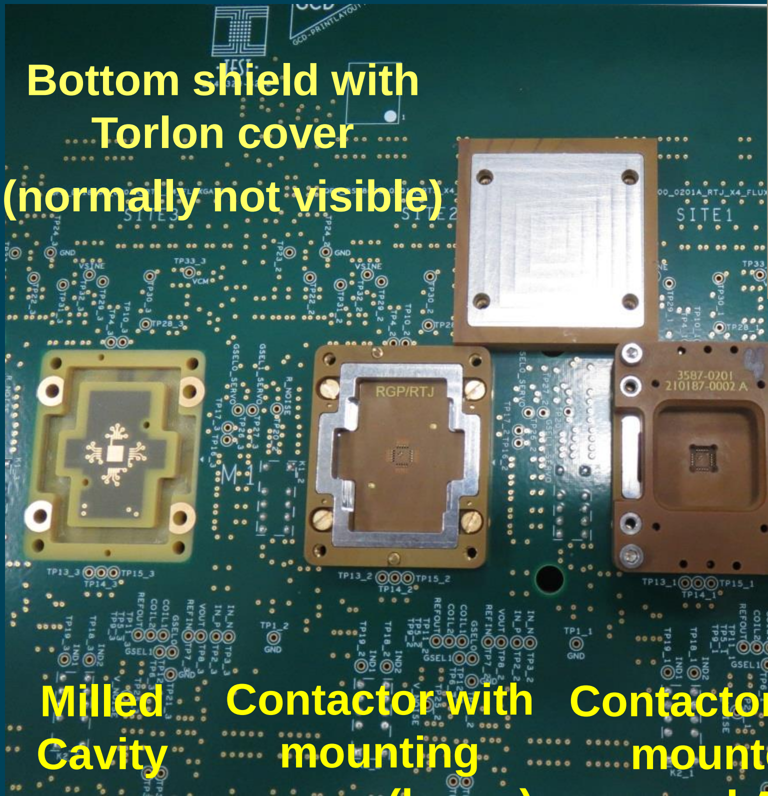


3D FEM Result Manual: B_x within DUT

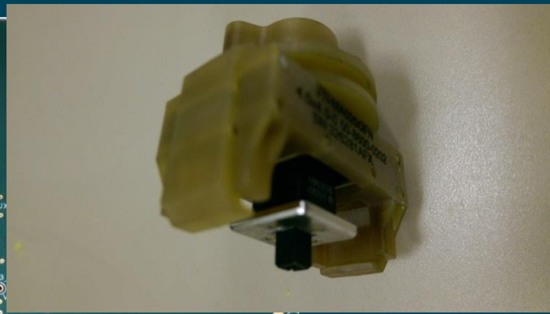


$-170nT < B_x < 15nT$

Shielding Solution for Manual Test



Bottom shield with Torlon cover (normally not visible)



VCMA with lead backer

Milled Cavity

Contactor with mounting screws (brass)

Contactor with mounted manual ALPL

JTI Manual Test Parts

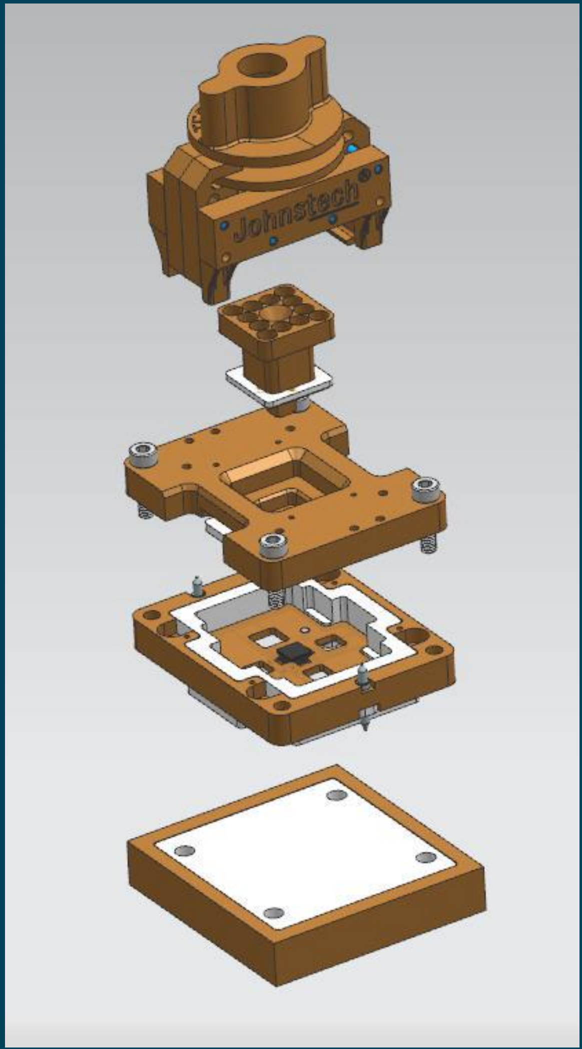
VCMA with lead backer
(manual test only)

Manual Alignment Plate
(manual test only)

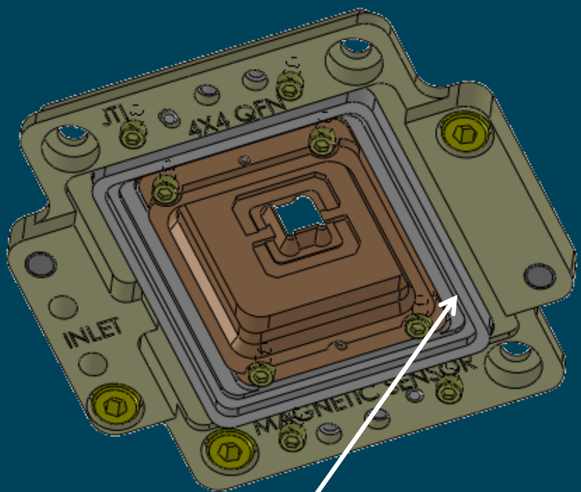
Contactor
(used for handler and manual test)

Bottom Shield
(used for handler and manual test)

(Brown: Torlon / White: MuMetal)

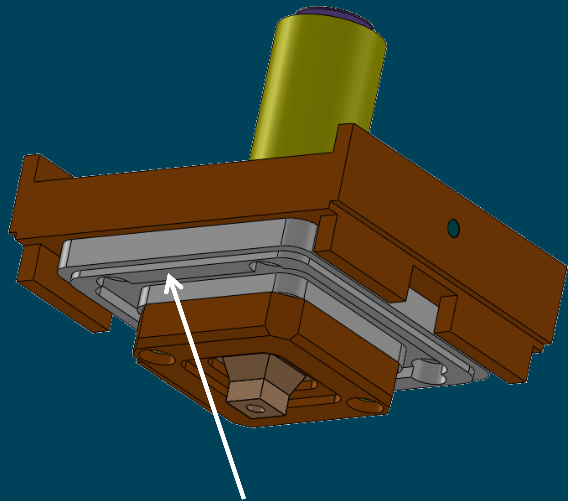


Delta Matrix Handler Kit



Handler Alignment Plate

Grey: MuMetal

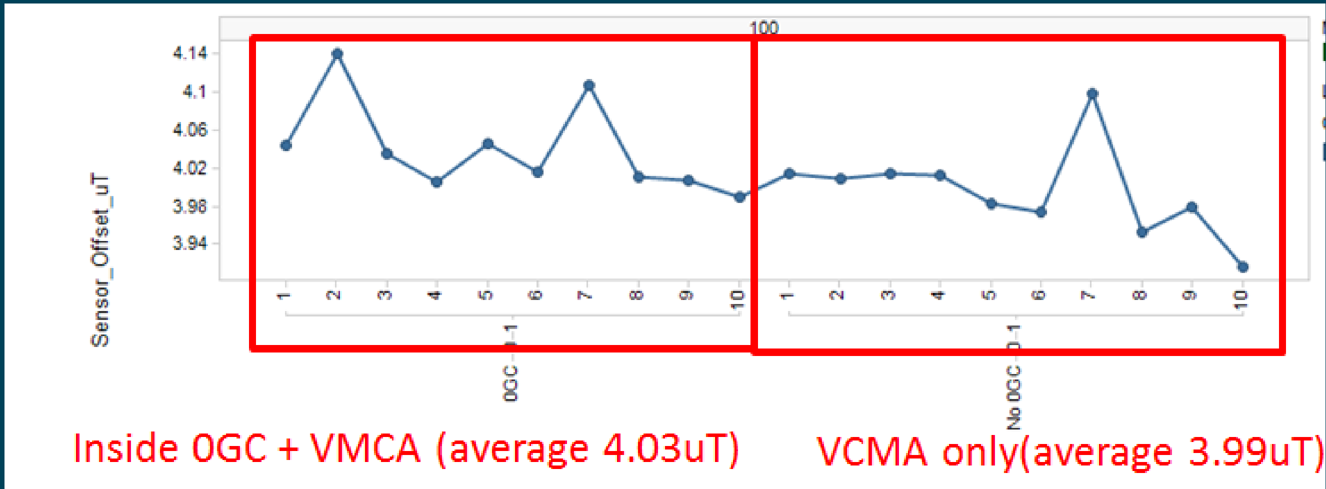


Handler Nest

Grey: MuMetal

Magnetic Shielding Performance

- Insert DRV421 chip in shielded manual test fixture and execute offset measurement ten times with lab equipment
- Put the setup into three layer zero gauss chamber 0GC and re-measure offset



<u>Result:</u> The delta between the two measurements of 40nT lies well within the predicted range of ±100nT!

Magnetic Shielding and PCB Plating

- First magnetic offset correlation revealed side-by-side differences of several µT
- NiAu-plating of ATE loadboard identified as root cause
- Problem solved by new loadboards with ENEPIG plating
  - ENEPIG = Electroless Nickel / Electroless Palladium / Immersion Gold
  - 7-13% Phosphorus content blocks the magnetic effects of Nickel
- ENEPIG offers the advantage of increased life-time compared to NiAu
- However cost of ENEPIG-plating is higher than NiAu-plating

Risk Management (1)

- Using an unshielded instead of a shielded contactor or alignment plate
  - Blocked by keyed guide-pins
- No bottom shield mounted on load-board
  - Detected by load-board diagnostics
- Running the device with a standard handler-nest instead of the shielded version
  - No mechanical keying possible
  - Use correlation lockout with golden devices
- Using ferromagnetic (XL-2) instead of non-magnetic ROL contacts (ECO-1) in contactor
  - Store ROL contacts in separate boxes with different colors
  - Use correlation lockout with golden devices

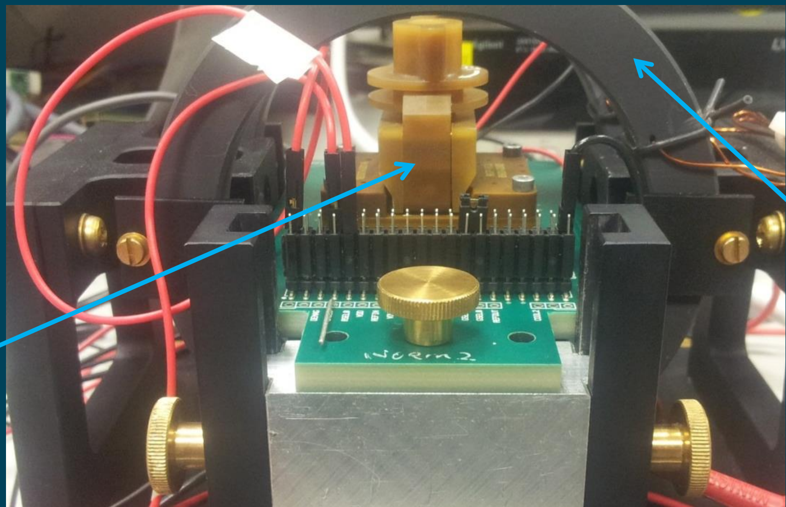
Risk Management (2)

- Reduction of the shielding effect due to mechanical stress of the MuMetal parts
  - Use correlation lockout with golden devices
- Magnetize the shield with high B-fields in the vicinity of the test-cell. Develop a method for degaussing in case magnetizing occurs from low B-fields.
  - Execute experiments to find critical size for B-fields to magnetize the shield (see next two slides)

Magnetizing Experiments (1)

- Magnetic offset of 10 parts DRV421 is measured
- The shielded manual socket is exposed to a B-field of 10mT generated by a Helmholtz coil
- Magnetic offset of same parts was re-measured without change

Shielded Socket



Helmholtz Coil

Magnetizing Experiments (2)

- Determine the magnetic field required to saturate MuMetal by forcing magnetic fields stepwise up to 2T
- Equipment of University of Jena, Germany
- Result:
  The magnetic offset measured after exposure to B-field of 2T did not change

Summary

- The magnetically shielded test-cell is realized based on existing equipment and was successfully transferred to production site
- Additional parts (contactor and handler kit) for QFN are available from Johnstech and Cohu
- Danger of reduced shield performance caused by external magnetic fields could be dispelled
- Nickel needs to be compensated in PCB plating
- Correlation lockout needed to cover risks that could not be addressed by mechanical design