

Radiation Hardened Discrete Products & Hybrids Roadmap

Microsemi Space Forum Russia – November 2013

Al Ortega
Product Line Manager, HiRel Group



Product Strategy & Roadmap

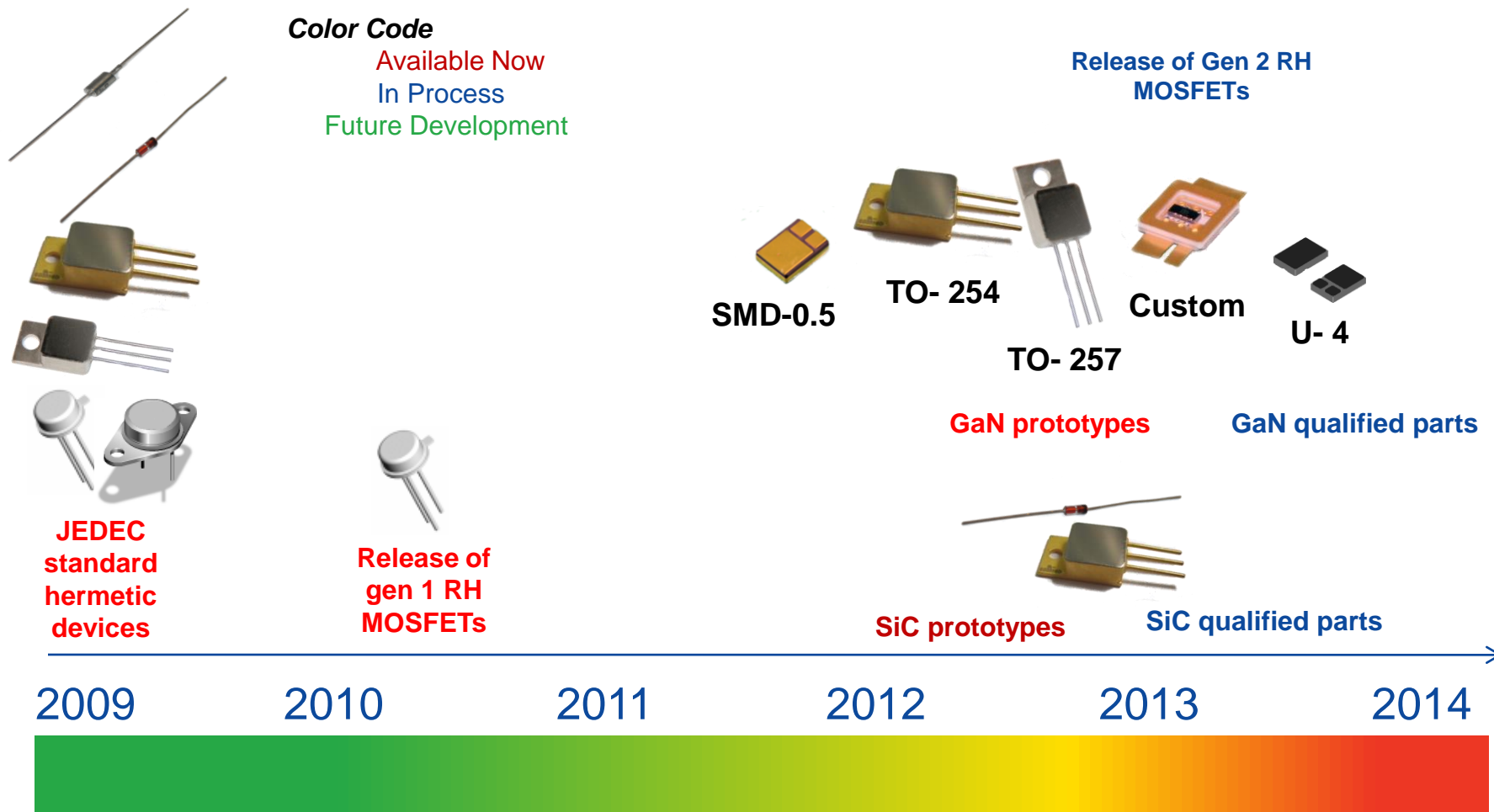
DISCRETE PRODUCTS

Color Code

Available Now

In Process

Future Development



Product Strategy & Roadmap

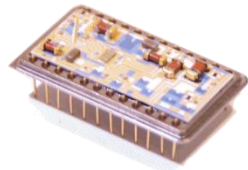
HYBRID PRODUCTS

Color Code

Available Now

In Process

Future Development



Custom Hybrid products



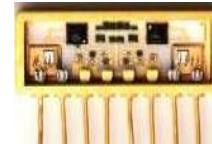
Silicon based Linear regulators



Si based single POL's 3A or 5A



Si based Quad hybrid POL

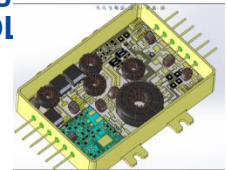


Solid State Relays

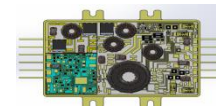


SOI Process Integrated high efficiency POL Controllers

Hi Efficiency Hybrid POL



High Efficiency RH Isolated DC-DC Hybrid using GaN



Hip50 Hardened Isolated Power Series

SiC qualified parts Bridge Rectifiers

1990-2009

2010

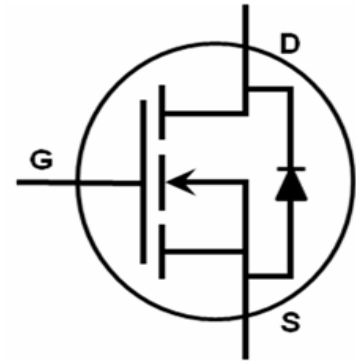
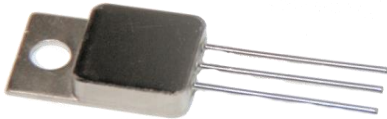
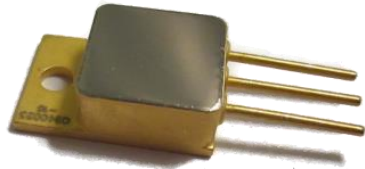
2011

2012

2013

2014

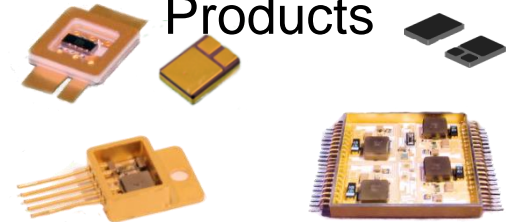
2015



Radiation Hardened MOSFETs

Gen1 MSC Rad Hard MOSFETs
60V to 200V
IR Gen IV Direct Cross

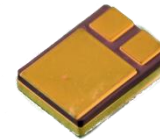
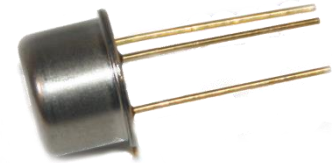
RAD Hard and Hybrid
Products



RH1 Radiation Hardened MOSFETs

- RH1 radiation-hardened MOSFET complete
 - Voltage range from 60 V – 200 V
 - 24 new part numbers / 9 base device types
 - N and P channel
 - Five package types
 - Through hole and surface mount
 - TID to 300Krad & SEE hardening

- Second source IR Gen4 products
- Cross-References available
- New Gen 1 “Die” availabilities



TO-254



| Microsemi / QPL Part Number | CH | BVDSS MIN | VGS MAX | RDS(on) MAX | ID MAX | PD MAX | Max TID Rating (K RAD) | Slash Sheet |
|--------------------------------|----|--------------|------------|----------------|--------|--------|------------------------------|----------------|
| | | V | V | mΩ | A | W | | |
| JANSR2N7268 | N | 100 | ±20 | 65 | 34 | 150 | 100 | /603 |
| JANSF2N7268 | N | 100 | ±20 | 65 | 34 | 150 | 300 | /603 |
| JANSR2N7269 | N | 200 | ±20 | 100 | 26 | 150 | 100 | /603 |
| JANSF2N7269 | N | 200 | ±20 | 100 | 26 | 150 | 300 | /603 |

RH1 RAD HARD MOSFET Portfolio

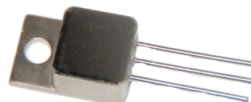
TO-39 Hermetic Package (TO-205AF)



TO-39 = 8.5 mm CAN; 12.2 mm min LL

| Microsemi / QPL Part Number | CH | BVDSS MIN | VGS MAX | RDS(on) MAX | ID MAX | PD MAX | Max TID Rating (K RAD) | Slash Sheet |
|--------------------------------|----|--------------|---------|----------------|--------|--------|------------------------------|----------------|
| | | V | V | mΩ | A | W | | |
| JANSR2N7389 | P | -100 | ±20 | 300 | 6.5 | 25 | 100 | /630 |
| JANSF2N7389 | P | -100 | ±20 | 300 | 6.5 | 25 | 300 | /630 |
| JANSR2N7261 | N | 100 | ±20 | 180 | 8.0 | 25 | 100 | /601 |
| JANSF2N7261 | N | 100 | ±20 | 180 | 8.0 | 25 | 300 | /601 |
| JANSR2N7262 | N | 200 | ±20 | 350 | 5.5 | 25 | 100 | /601 |
| JANSF2N7262 | N | 200 | ±20 | 350 | 5.5 | 25 | 300 | /601 |

TO-257AA Hermetic Package



TO-257 = L 16.7 X W 10.7 X H 5.2mm

| Microsemi / QPL Part Number | CH | BVDSS MIN | VGS MAX | RDS(on) MAX | ID MAX | PD MAX | Max TID Rating (K RAD) | Slash Sheet |
|--------------------------------|----|--------------|------------|----------------|--------|--------|------------------------------|----------------|
| | | V | V | mΩ | A | W | | |
| JANSM2N7382 | P | -100 | ±20 | 300 | 11.0 | 75 | 3 | /615 |
| JANSF2N7382 | P | -100 | ±20 | 300 | 11.0 | 75 | 10 | /615 |
| JANSR2N7382 | P | -100 | ±20 | 300 | 11.0 | 75 | 100 | /615 |
| JANSF2N7382 | P | -100 | ±20 | 300 | 11.0 | 75 | 300 | /615 |
| JANSR2N7380 | N | 100 | ±20 | 180 | 14.4 | 75 | 100 | /614 |
| JANSF2N7380 | N | 100 | ±20 | 180 | 14.4 | 75 | 300 | /614 |
| JANSR2N7381 | N | 200 | ±20 | 400 | 9.4 | 75 | 100 | /614 |
| JANSF2N7381 | N | 200 | ±20 | 400 | 9.4 | 75 | 300 | /614 |

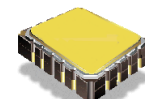
RH1 Radiation Hardened MOSFET Portfolio



SMD1 Hermetic Package (TO-267AB Surface Mount)

SMD1 = L 16 X W 11.5 X H 3.6 mm

| Microsemi / QPL Part Number | CH | BVDSS MIN | VGS MAX | RDS(on) MAX | ID MAX | PD MAX | Max TID Rating (K RAD) | Slash Sheet |
|--------------------------------|----|--------------|---------|----------------|--------|--------|------------------------------|----------------|
| | | V | V | mΩ | A | W | | |
| JANSR2N7268U | N | 100 | ±20 | 65 | 34.0 | 150 | 100 | /603 |
| JANSF2N7268U | N | 100 | ±20 | 65 | 34.0 | 150 | 300 | /603 |
| JANSR2N7269U | N | 200 | ±20 | 100 | 26.0 | 150 | 100 | /603 |
| JANSF2N7269U | N | 200 | ±20 | 100 | 26.0 | 150 | 300 | /603 |



18-PIN LCC Hermetic Package (Surface Mount)

18 PIN LCC = L 9.1 X W 7.5 X H 2.9 mm

| Microsemi / QPL Part Number | CH | BVDSS MIN | VGS MAX | RDS(on)) MAX | ID MAX | PD MAX | Max TID Rating (K RAD) | Slash Sheet |
|--------------------------------|----|--------------|------------|------------------|--------|--------|------------------------------|----------------|
| | | V | V | mΩ | A | W | | |
| JANSR2N7389U | P | -100 | ±20 | 300 | 6.5 | 25 | 100 | /630 |
| JANSF2N7389U | P | -100 | ±20 | 300 | 6.5 | 25 | 300 | /630 |
| JANSR2N7261U | N | 100 | ±20 | 180 | 8.0 | 25 | 100 | /601 |
| JANSF2N7261U | N | 100 | ±20 | 180 | 8.0 | 25 | 300 | /601 |
| JANSR2N7262U | N | 200 | ±20 | 350 | 5.5 | 25 | 100 | /601 |
| JANSF2N7262U | N | 200 | ±20 | 350 | 5.5 | 25 | 300 | /601 |

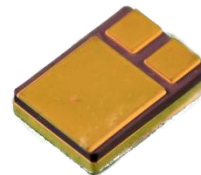
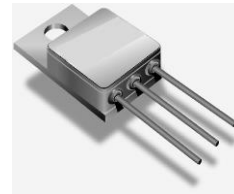
JANHC and JANKC Die Qualification Extension

- RH1 Die availabilities
 - JANHC and JANKC die qualification extensions have been allocated by DLA to our Gen-1 die product offerings
 - Reference number VQE-13-025437 and control number 037833 have been assigned by DLA to this approval which was effective 19 November 2012
 - Portfolio of devices includes all packaged variants of N-channel, P-channel 100 volt and 200 volt die to JANSF level

| Part numbers | 36D number | JANSF approval letter number | JANSF test report number |
|--------------------------------|------------|------------------------------|--------------------------|
| JANHCBF/ JANKCBF2N7382, 2N7389 | 36D-129 | VQE-09-018474 | 19500-2632-09 |
| JANHCBF/ JANKCBF2N7261, 2N7380 | 36D-130 | VQE-10-020198 | 19500-2876-10 |
| JANHCBF/ JANKCBF2N7262, 2N7381 | 36D-131 | VQE-10-020199 | 19500-2877-10 |
| JANHCBF/ JANKCBF2N7268 | 36D-132 | VQE-10-020198 | 19500-2876-10 |
| JANHCBF/ JANKCBF2N7269 | 36D-133 | VQE-10-020199 | 19500-2877-10 |

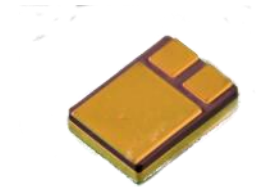
Product Roadmap: Next-generation Radiation Hardened MOSFETs

- Microsemi RH2 radiation-hardened MOSFETs are now in end stages of prototype evaluations (100V)(Q3-2013)
- 200V (IMOS Process) expect rev2 prototypes (Q3-2013)
- Development plans
 - Voltage range from 30 V – 250 V
 - Size 3 and size 6 die
 - Ultra low $R_{ds(on)}$
 - Lower Q_g
 - Improved single-event hardening
 - Equivalent to R6 from IR
 - IR cross-reference available
 - 60 new part numbers

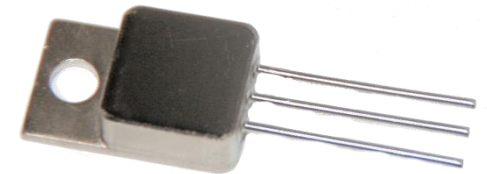


RH2 MOSFET Development

- RH2= IR R6, N- Channel size 3 Die
- Two Processes: HMOS (Garden Grove)
IMOS (Bend)
- 30V HMOS Process
 - Fab Development at GG
 - TO- 257, SMD0.5, TO- 39
 - JANSR2N7479U3, Qual: Q2, 2014
- 60V, HMOS
 - Engineering Design Units: November '13
 - TO- 257, SMD0.5, TO- 39
 - JANSR2N7587U3 /746, Qual: Q1 2014



**U3 = L 10.1 X W
7.5 X H 3.2 mm**



TO-257



TO-39

RH2 MOSFET Development

- RH2= IR R6, N- Channel size 3 Die
- Two Processes: HMOS (Garden Grove)
IMOS (Bend)
- 150V size 3 die. (IMOS)
 - Engineering Design Units: November '13
 - JANSR2N7589U3 /746, Qual: Q1 2014
 - (HMOS, IMOS)
- 200V size 3 die. (IMOS)
 - Engineering Design Units: November '13
 - JANSR2N7591U3 /746, Qual: Mid 2014
 - New IMOS Process



**U3 = L 10.1 X W
7.5 X H 3.2 mm**

Phase 1 RH2 portfolio- N- Channel, Sz 3



| <u>Bvdss</u> V | <u>RDS(on)</u> Ω | <u>Channel</u> | <u>JEDEC</u> <u>Number</u> | <u>Industry Equivalent</u> | <u>RH2 Base MSC p/n</u> | <u>Package</u> | <u>Slash</u> <u>Sheet</u> |
|-------------------|----------------------------|----------------|-------------------------------|----------------------------|-------------------------|----------------|------------------------------|
| 30 | 0.02 | N | 2N7479U3 | IRHNJ57Z30 | MRH03N22U3 | SMD-0.5 | 703 |
| 30 | 0.03 | N | 2N7482T3 | IRHY57Z30CM | MRH03N18T3 | TO-257AA | 702 |
| 60 | 0.08 | N | 2N7495U5 | IRHE57034 | MRH06N12U5 | LCC-18 | 700 |
| 60 | 0.048 | N | 2N7492T2 | IRHF57034 | MRH06N12T2 | TO-39 | 701 |
| 60 | 0.03 | N | 2N7480U3 | IRHNJ57034 | MRH06N22U3 | SMD-0.5 | 703 |
| 60 | 0.04 | N | 2N7483T3 | IRHY57034CM | MRH06N18T3 | TO-257AA | 702 |
| 100 | 0.11 | N | 2N7496U5 | IRHE57130 | MRH10N10U5 | LCC-18 | 700 |
| 100 | 0.08 | N | 2N7493T2 | IRHF57130 | MRH10N??T2 | TO-39 | 701 |
| 100 | 0.042 | N | 2N7587U3 | IRHNJ67130 | MRH10N22U3 | SMD-0.5 | 746 |
| 130 | 0.13 | N | 2N7500U5 | IRHE57133SE | MRH13N09U5 | LCC-18 | 707 |
| 130 | 0.1 | N | 2N7497T2 | IRHF57133SE | MRH13N09T2 | TO-39 | 706 |
| 130 | 0.08 | N | 2N7485U3 | IRHNJ57133SE | MRH13N19U3 | SMD-0.5 | 704 |
| 150 | 0.088 | N | 2N7589U3 | IRHNJ67134 | MRH15N19U3 | SMD-0.5 | 746 |
| 200 | 0.13 | N | 2N7591U3 | IRHNJ67230 | MRH20N22U3 | SMD-0.5 | 746 |
| 200 | 0.13 | N | | IRHF67230 | MRH20N12T2 | TO- 39 | |
| 200 | 0.13 | N | | IRHYB67230CM | MRH20N12T3 | TO-257 | |
| 250 | 0.42 | N | 2N7499T2 | IRHF57234SE | MRH25N09T2 | TO-39 | 706 |
| 250 | 0.21 | N | 2N7593U3 | IRHNJ67234 | MRH25N22U3 | SMD-0.5 | 746 |
| 250 | 0.22 | N | 2N7494T3 | IRHYS67234CM | MRH25N12T3 | TO-257AA | 755 |



TO-257



TO-39

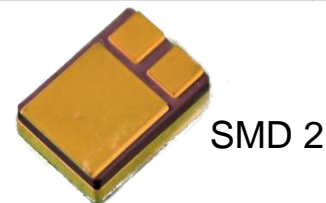


LCC18



Phase 2 RH2 portfolio, N- Ch, Sz 6

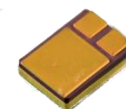
| <u>Bvdss</u> <u>V</u> | <u>RDS(on)</u> <u>Ω</u> | <u>Channel</u> | <u>JEDEC</u> <u>Number</u> | <u>Industry Equivalent</u> | <u>RH2 Base MSC p/n</u> | <u>Package</u> | <u>Slash</u> <u>Sheet</u> |
|--------------------------|----------------------------|----------------|-------------------------------|----------------------------|-------------------------|----------------|------------------------------|
| 30 | 0.0045 | N | 2N7478T1 | IRHMS57Z60 | MRH03N45T1 | TO-254AA | 697 |
| 30 | 0.0035 | N | 2N7467U2 | IRHNA57Z60 | MRH03N45U2 | SMD-2 | 683 |
| 60 | 0.0066 | N | 2N7470T1 | IRHMS57064 | MRH06N45T1 | TO-254AA | 698 |
| 60 | 0.0056 | N | 2N7468U2 | IRHNA57064 | MRH06N56U1 | SMD-2 | 673 |
| 100 | 0.011 | N | 2N7580T1 | IRHMS67160 | MRH10N45T1 | TO-254 | 753 |
| 100 | 0.01 | N | 2N7579U2 | IRHNA67160 | MRH10N56U2 | SMD-2 | 760 |
| 130 | 0.0135 | N | 2N7472U2 | IRHNA57163SE | MRH13N56U1 | SMD-2 | 684 |
| 150 | 0.019 | N | 2N7582T1 | IRHMS67164 | MRH15N45T1 | TO-254 | 753 |
| 150 | 0.018 | N | 2N7581U2 | IRHNA67164 | MRH15N56U1 | SMD-2 | 760 |
| 200 | 0.029 | N | 2N7584T1 | IRHMS67260 | MRH20N45T1 | TO-254 | 753 |
| 200 | 0.028 | N | 2N7583U2 | IRHNA67260 | MRH20N56U1 | SMD-2 | 760 |
| 250 | 0.041 | N | 2N7586T1 | IRHMS67264 | MRH25N45T1 | TO-254 | 753 |
| 250 | 0.04 | N | 2N7585U2 | IRHNA67264 | MRH25N56U1 | SMD-2 | 760 |



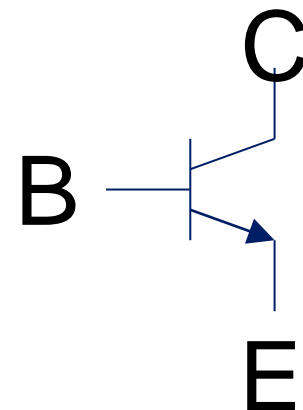
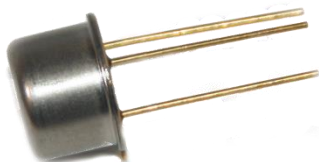
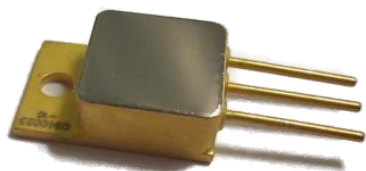
RH2 Radiation Hardened MOSFET Portfolio

SMD-0.5 Hermetic Package (TO-276AB Surface Mount)

| Microsemi / QPL Part Number | CH | BVDSS MIN | VGS MAX | RDS(on) MAX | ID MAX | PD MAX | Max TID Rating (K RAD) | Slash Sheet |
|--------------------------------|----|--------------|---------|----------------|--------|--------|------------------------------|----------------|
| | | V | V | m? | A | W | | |
| JANSR2N7479U3 | N | 30 | ±20 | 20 | 22.0 | 75 | 100 | /703 |
| JANSF2N7479U3 | N | 30 | ±20 | 20 | 22.0 | 75 | 300 | /703 |
| JANSR2N7480U3 | N | 60 | ±20 | 30 | 22.0 | 75 | 100 | /703 |
| JANSF2N7480U3 | N | 60 | ±20 | 30 | 22.0 | 75 | 300 | /703 |
| JANSR2N7587U3 | N | 100 | ±20 | 42 | 22.0 | 75 | 100 | /746 |
| JANSF2N7587U3 | N | 100 | ±20 | 42 | 22.0 | 75 | 300 | /746 |
| JANSR2N7589U3 | N | 150 | ±20 | 88 | 19.0 | 75 | 100 | /746 |
| JANSF2N7589U3 | N | 150 | ±20 | 88 | 19.0 | 75 | 300 | /746 |
| JANSR2N7591U3 | N | 200 | ±20 | 130 | 16.0 | 75 | 100 | /746 |
| JANSF2N7591U3 | N | 200 | ±20 | 130 | 16.0 | 75 | 300 | /746 |
| JANSR2N7593U3 | N | 250 | ±20 | 210 | 12.4 | 75 | 100 | /746 |
| JANSF2N7593U3 | N | 250 | ±20 | 210 | 12.4 | 75 | 300 | /746 |
| JANSR2N7519U3 | P | -30 | ±20 | 70 | 22.0 | 75 | 100 | /732 |
| JANSF2N7519U3 | P | -30 | ±20 | 70 | 22.0 | 75 | 300 | /732 |
| JANSR2N7520U3 | P | -60 | ±20 | 85 | 21.0 | 75 | 100 | /732 |
| JANSF2N7520U3 | P | -60 | ±20 | 85 | 21.0 | 75 | 300 | /732 |
| JANSR2N7545U3 | P | -100 | ±20 | 205 | 12.5 | 75 | 100 | /712 |
| JANSF2N7545U3 | P | -100 | ±20 | 205 | 12.5 | 75 | 300 | /712 |
| TBD | P | -150 | ±20 | TBD | TBD | 75 | 100 | TBD |
| TBD | P | -150 | ±20 | TBD | TBD | 75 | 300 | TBD |
| JANSR2N7546U3 | P | -200 | ±20 | 505 | 8.0 | 75 | 100 | /712 |
| JANSF2N7546U3 | P | -200 | ±20 | 505 | 8.0 | 75 | 300 | /712 |
| TBD | P | -250 | ±20 | TBD | TBD | 75 | 100 | TBD |
| TBD | P | -250 | ±20 | TBD | TBD | 75 | 300 | TBD |



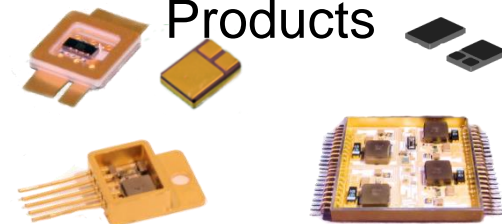
**U3 = L 10.1 X W
7.5 X H 3.2 mm**



Radiation Hardened BiPolar Junction Transistors

New JANSR RadHard Slash Sheets
TID Characterization
ELDRS Characterization

RAD Hard and Hybrid
Products

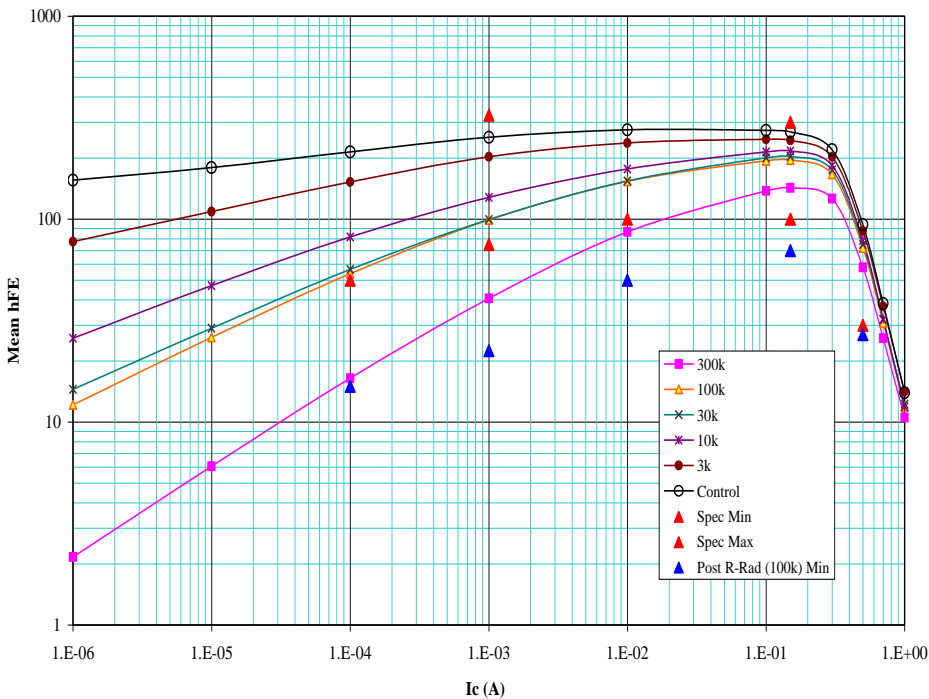


BJT Technology Does Matter

OLD TECHNOLOGY



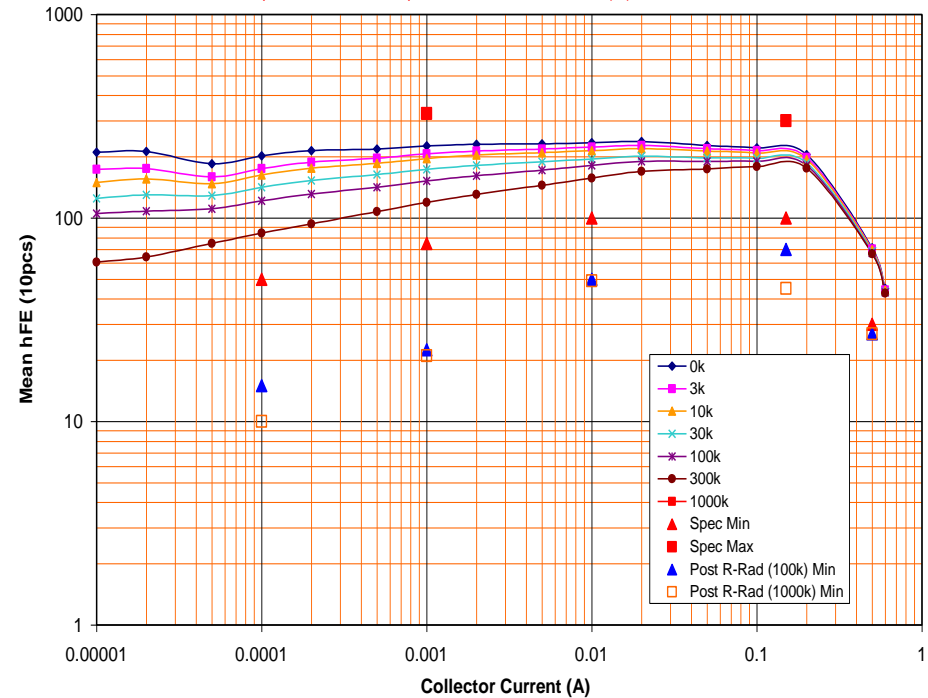
Lot 1775-18 Standard Nitric



NEW LEVEL 2 DIE TECHNOLOGY

Level 2 IPG 2N2222A

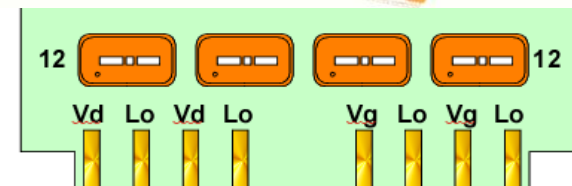
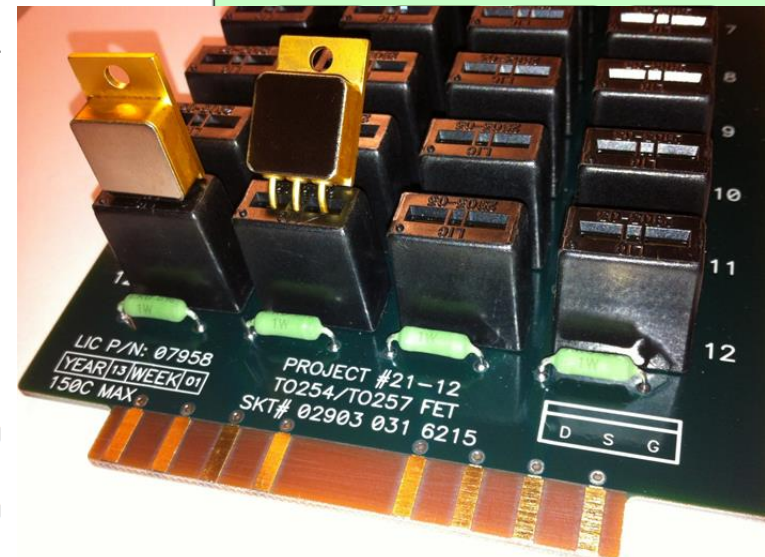
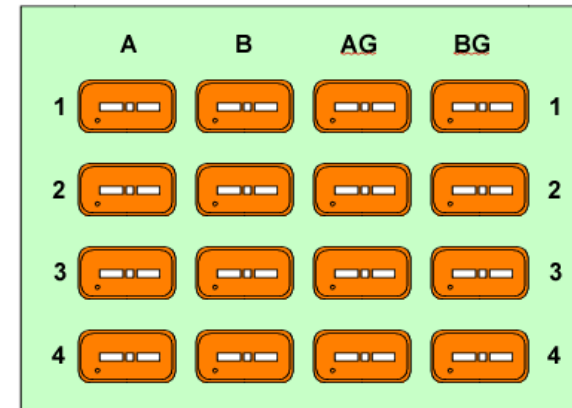
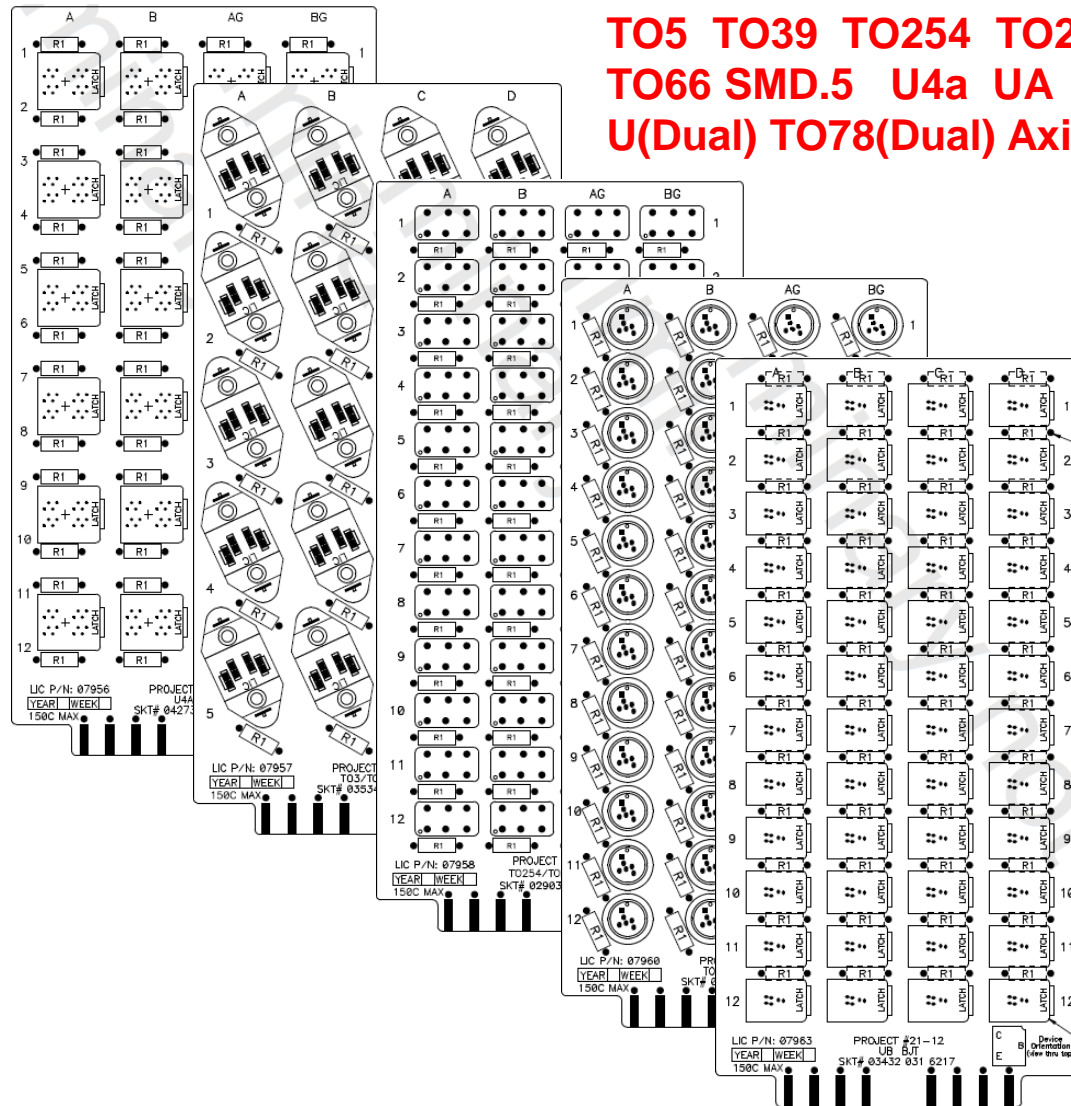
Special Photomask, Special Case, Special Circumstances, Special Considerations



ELDRS Testing on Bipolars

- Dose rate: .01 Rad(s)/ sec. (10 mrads)
- Historical Test facility: Umass- Lowell
 - Co- 60 Source
 - TID, Proton, ELDRS
 - DLA Certified Facility
 - **NEW JL SHEPHERD CO-60 irradiator being installed in Lawrence Microsemi HRG facilities**
- BiPolar Products tested to date - reports available
 - 2N2222A
 - 2N2907A
 - 2N3700
 - 2N2369
- Custom radiation testing

Irradiator Test Boards for Every Occasion:



Microsemi HRG Radiation Testing Roadmap

COMMISSIONING OF FULL IRRADIATION SYSTEM

May 2013

ELDRS 100mRAD/s Data Reporting on JANS Lots

Beginning May 2013 and Thereafter

TID VERSUS ELDRS 100mRAD/s LOT CERTIFICATION

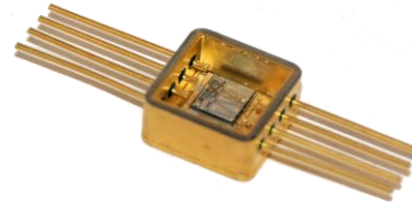
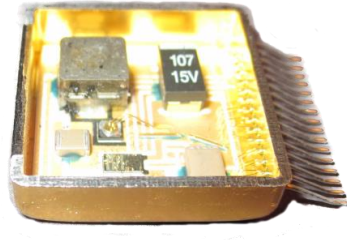
September 2013

ELDRS 100mRAD/s VERSUS 10mRAD/s CERTIFICATION

April 2014

ELDRS 100mRAD/s DATA ON EVERY JANS LOT

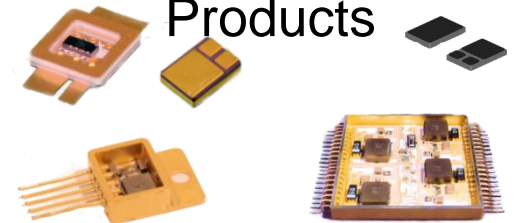
Standard Operating Procedure



Microsemi Hybrid Facilities

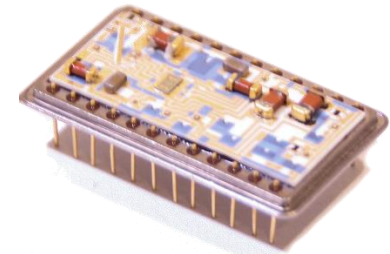
Linear & POL products

RAD Hard and Hybrid Products



Updated Fabrication & Certification

- Microsemi Hybrid Group
 - 30+ Years (TSI/HPG Microsemi)
- DLA MIL-PRF-38534 Facilities
 - Class H & K approved
 - QML End of line process Non TRB
 - RHA plans approved by DLA
- Product Heritage
 - Utilization of Microsemi RH Die wherever possible
- Standard Non-isolated products
- Standard Isolated products in development



MICROSEMI HRG Hybrid Facilities

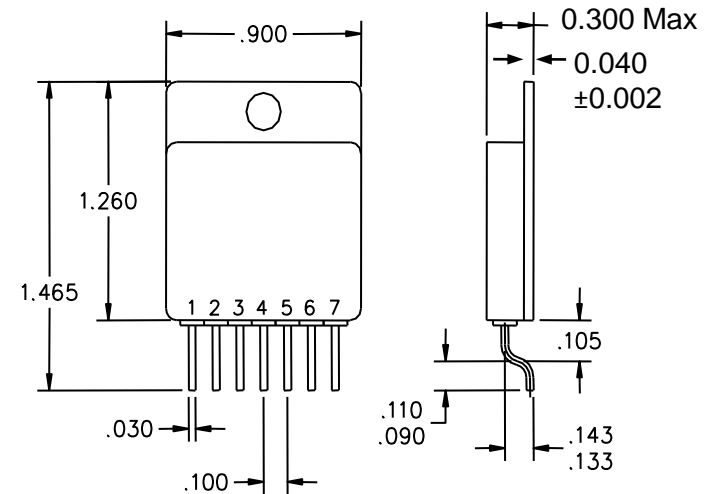
NEW MIL-PRF-38534 Class K facility to be set- up in Lawrence!

- \$1.5 Million Dollar NEW facility development investment (Class 10K)
- All existing personnel, equipment and processes shall re-locate from current Danvers Massachusetts facility to Microsemi HRG divisional headquarters by June 1, 2013 (17 Mile Move)
- “Rad-Hard Power Hybrid Center of Excellence for Microsemi”
- Additional Cap-ex underway to further enhance operational excellence
- Engineering capacity & personnel have been increased to support growth experienced within our current power hybrid business

Investments are part of Microsemi long term business strategy to support Domestic & International space communities radiation reliability requirements of high level integrated power Hybrid technologies.

ULDO Linear Regulator MHL8701/5

- The MHL 87XX Series are space qualified, ultra low dropout linear regulators designed for military and space flight applications. Assembled in a hermetic package, this series provides an ultra low drop out voltage of 400mV @ 2A. They are optimized for operation at +5V input or +3.3V input.
- Enhanced SEE performance, SET < 5% of Vout
- Thermal shutdown @ 150 °C
- Output Voltage: +1.26V to +4.5V
- Post Rad Output Voltage accuracy +/-6%
- Rad- Tolerant to 300 Krad HDR TID
- Rad- Tolerant to 100 Krad Eldrs .01 rads(si)/sec
- LET= 85 MeV (Au ions) No Latch-up
- Fixed & Adjustable output voltages
- 7 Pin Power SIP



Some linear regulators on the market for Space applications have inadequate Single- Event performance due to poor filtering on the output of the part. Designers typically need to add additional protection on the output of linears to improve the SEE performance of the system. With the MHL8701/5 the filter is included in the package. This product has an on- board L-C filter to improve the SEE response of the system to 82 MeV.

Point of Load Switchers- MHP-8564

The MHP series are non-isolated Point of Load switching regulators for high reliability Military and Space distributed power applications. Fully integrated, these include a buck controller, inductor, and input / output capacitors combined in a single package.

MHL 8564 operates from an input voltage of +4.5V to +5.5V providing step down power conversion to output voltages as low as 0.5V or lower

- 150 Krad TID, 75K Eldrs 0.1 rad(si)/sec
- Adjustable or Fixed Output Voltage
- External Sync Option 580Khz-1000Khz
- Free Run nominal @ 500Khz
- Soft Start
- Up to 4.5A Output Current
- Remote Sense option
- Output current limit
- Efficiencies up to 87% @ 3.3Vout
- Line regulation +/-0.5% - Load +/- 1.0% @ 1.21 Voutput @ 1-3A
- Compact package: 0.195 cu-in
- Parallel configurations allow higher currents.

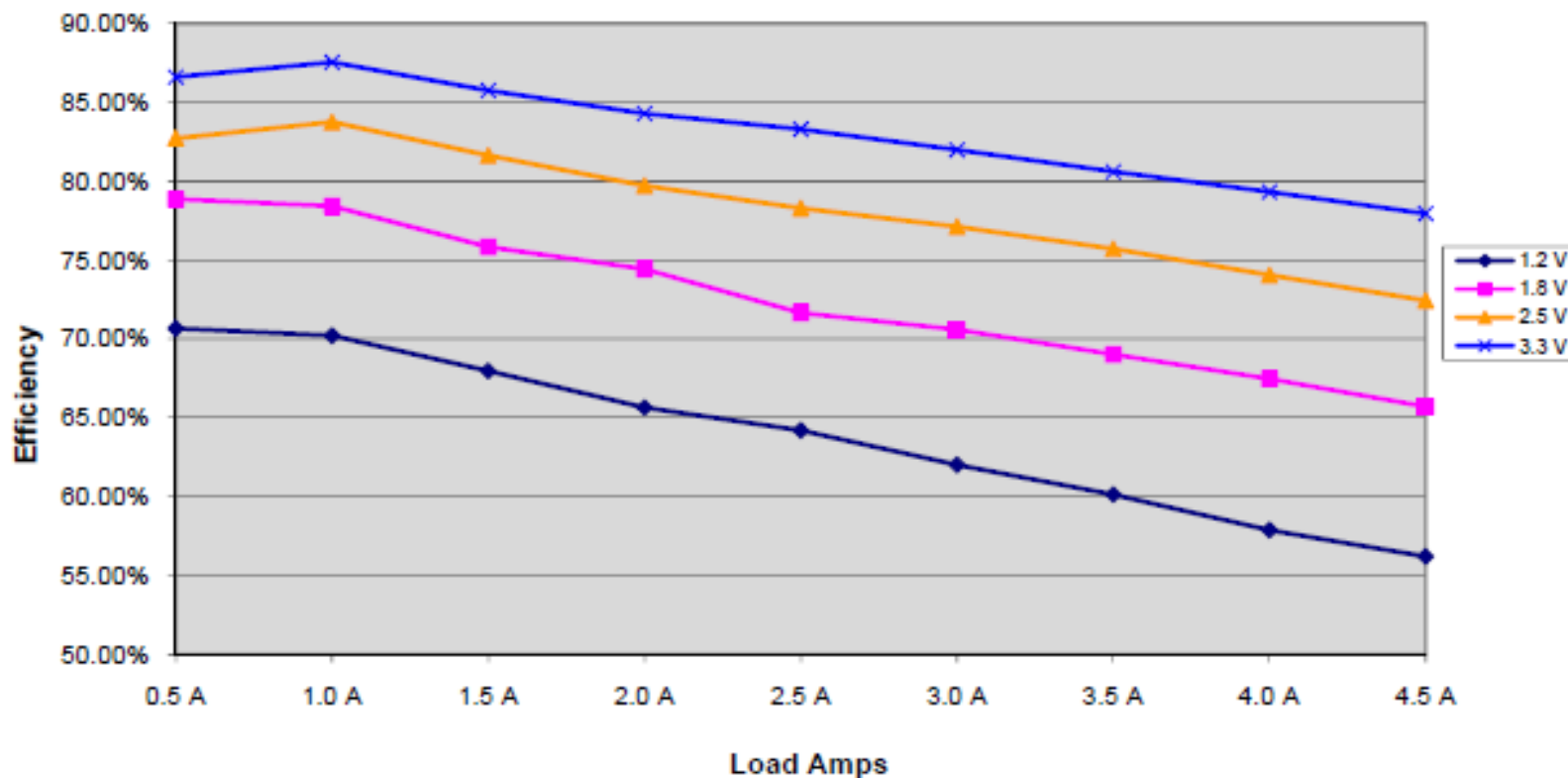
16-PIN Flat pack = L 35.3 X W 36 X H 9.8 mm

This part has more functions vs. the 8565. In addition to the standard shutdown pin, the part has extra connections for managing compensation and frequency synching. It also has the Remote Sense option to provide more accurate output voltages over long runs in the circuit. A most useful option for this part is the ability to parallel outputs with synch circuit



8564 Efficiency Curves

Figure 12 – Typical Efficiency Curves ($V_{in} = 5V$)

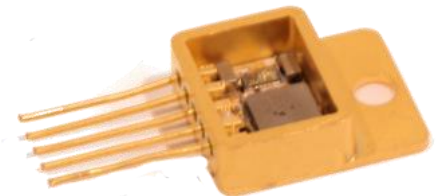


MHP-8565 Point of Load

MHP Point of loads are fully integrated, these include a buck controller, inductor, and input / output capacitors combined in a single package. They operate from an input voltage of +4.5V to +5.5V .providing step down power conversion to output voltages as low as 1.2V @ full current rating or as low as 0.5V (with reduction in current rating).

Operating features include output voltage adjust, output current limit, enable, external synchronization and soft start. Some models can also be setup in a parallel configuration to increase output current capability.

- Rad- Tolerant > 150 Krad HDR TID
- Rad- Tolerant to 75 Krad Eldrs .01 rads(si)/sec
- Up to 3.5A Output Current
- Efficiencies up to 87%
- Low Thermal resistance assembly
 - $R_{\theta j-c} = 2.5^{\circ} \text{ C/W}$

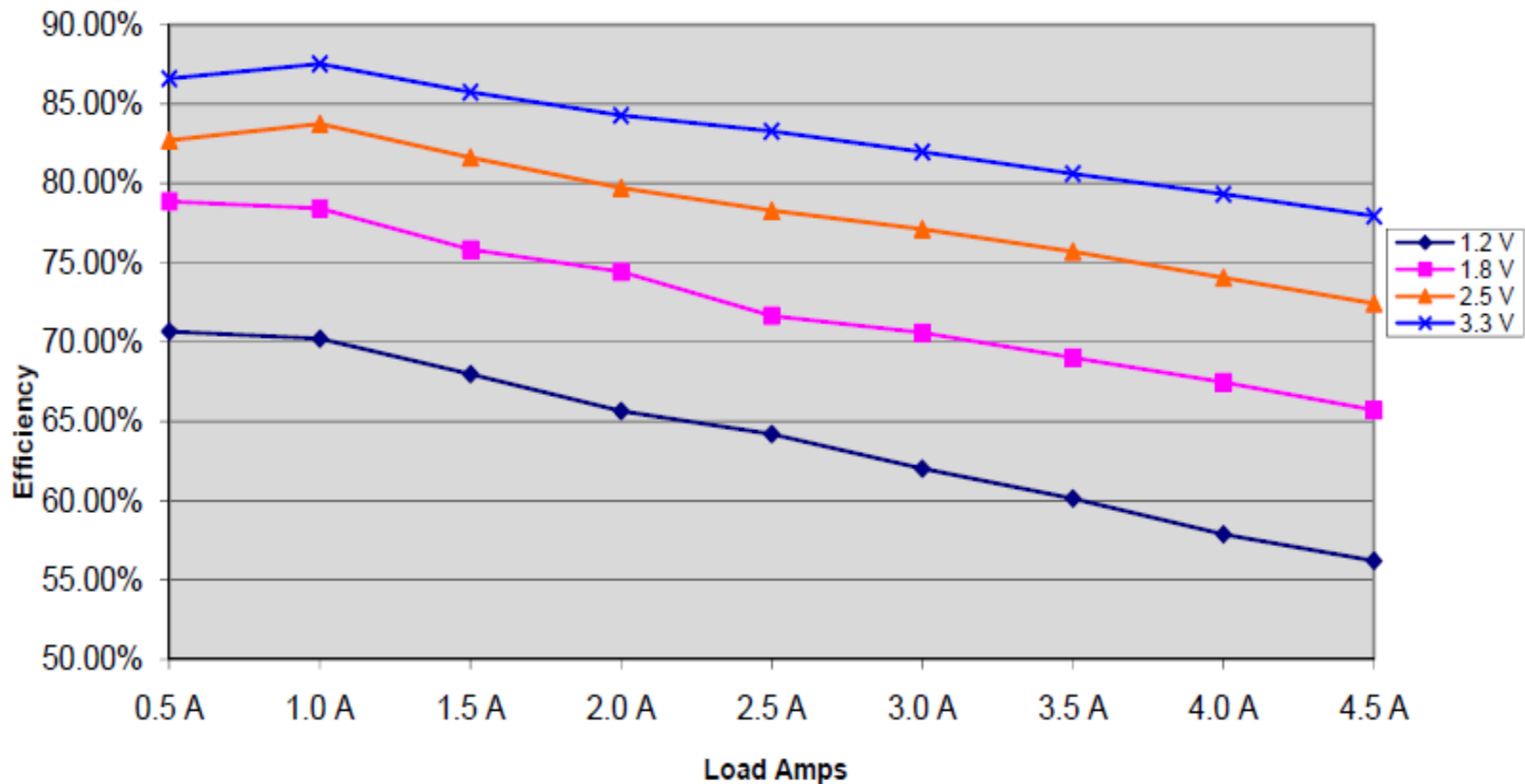


MO-078 = L 27 X W 32 X H 8 mm

This product was designed for ease-of- use and quick design turn- around. These POL's are optimized for +5V input systems. It is configured to provide a wide range of adjustable output voltages as low as 1.21V using a single resistor. The low thermal resistance cannot be matched by any competitor of similar class. Better efficiencies and a product that dissipates less power.

Typical Efficiency Curves

Figure 7– Typical Efficiency Curves ($V_{in} = 5V$)

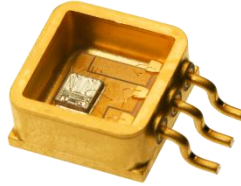


Product Heritage



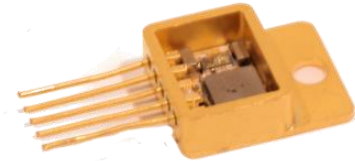
8601

Classified programs
CHIRP



117

Multiple programs



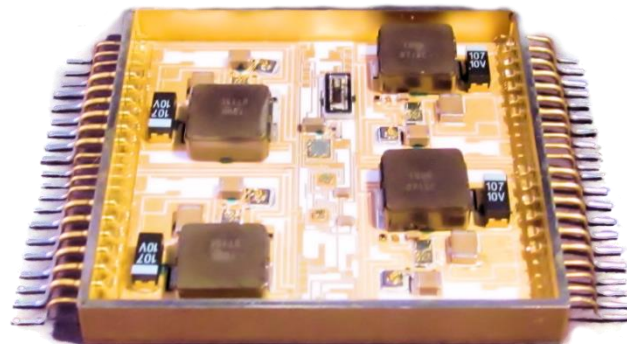
8565A

CHIRP
Multiple



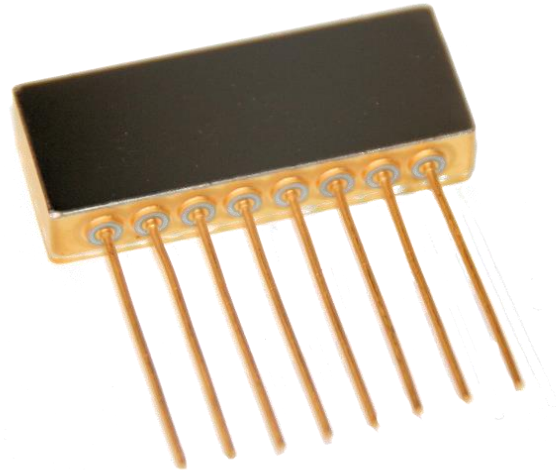
CHIRP

8564S



8566

Flying on ISS

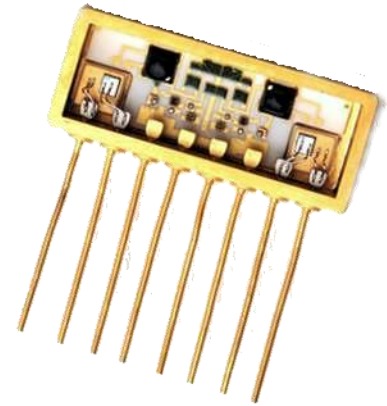


Electromechanical and Solid- State Relays

Rad- Hard, 60V to 200V
5/10/20A

Solid-State Relay Roadmap

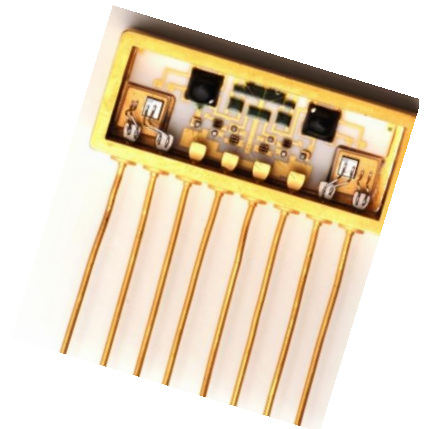
- MIL-PRF- 38534
- 5A & 10A Max Current
- Class H & K Screening levels
- Surface Mount & Thru- Hole packages
- Normally open or Normally closed operation

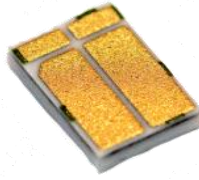


| Part # | Description | Rated Switch Voltage | Package / Config. |
|---------|----------------|----------------------|------------------------------|
| MHS1005 | Dual, 5A Relay | 100V | 8- Pin SIP/ SMT & Thru- Hole |
| MHS2005 | Dual, 5A Relay | 200V | 8- Pin SIP/ SMT & Thru- Hole |
| MHS1010 | Dual, 10A | 100V | 8- Pin SIP/ SMT & Thru- Hole |
| MHS2010 | Dual, 10A | 200V | 8- Pin SIP/ SMT & Thru- Hole |

Solid- State Relays-

- MHS Series are immune to shock and vibration (having no moving parts) and the additional benefit having no contact bounce unlike electromechanical relays
- 100V, 200V Operation
- Accepts Logic Level inputs, (+3.0V- +5.5V)
- 1000V Isolation
- Internal Switch rated at $T_j = 150^{\circ}\text{C}$
- TID >300Krad; SET = 85 Mev





U4A

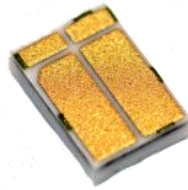
Gallium Nitride Products, MiGaN™

40V to 200V

Top Level Introduction – Early Introduction information only

Gallium Nitride (GaN)

- Microsemi GaN products are designed for use in Space and Military applications
 - Therefore, will be considered as 'ITAR' until a 'Commodity Jurisdiction' is determined
- Our GaN products will meet extensive radiation and efficiencies as defined in the market
- The product line is new and under development



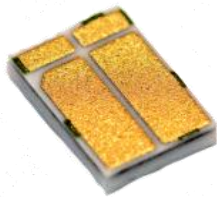
GaN vs. RH Si- Part

| <u>PART NO.</u> | <u>VOLTAGE</u> <u>V_{ds}</u> | <u>CURRENT</u> | <u>PEAK</u> | <u>RDS(ON) (mΩ)</u> | <u>Qg (nC)</u> | <u>FOM =</u> <u>Qg * Rds(on)</u> | <u>DIM (mils)</u> | <u>EST Size</u> |
|-----------------|---|----------------|-------------|---------------------|----------------|-------------------------------------|------------------------------|-----------------|
| MGN2015 | 40V | 33A | 150A | 4 | 11.6 | 46.4 | .162x .065 (4.05 x 1.625) | 2 |
| IRHNA57Z60 | 30V | 45 | 300 | 4 | 200 | 800 | .257 sq. (6.4sq) | 6 |
| MGN2005 | 60V | 25A | 100A | 7 | 10 | 70 | .162x .065 (4.05 x 1.625) | 2 |
| IRHNA57064 | 60V | 75 | 300 | 6 | 160 | 960 | .257 sq. (6.4sq) | 6 |
| MGN2001 | 100V | 25A | 100A | 7 | 10.5 | 73.5 | .162x .065 (4.05 x 1.625) | 2 |
| IRHNA67160 | 100V | 56 | 224 | 10 | 170 | 1700 | .257 sq. (6.4sq) | 6 |
| MGN2010 | 200V | 12A | 40A | 25 | 7.5 | 187.5 | .141 x .065 (3.5 x 1.625) | 1.5 |
| IRHNA67260 | 200V | 56 | 224 | 29 | 240 | 6960 | .257 sq. (6.4sq) | 6 |

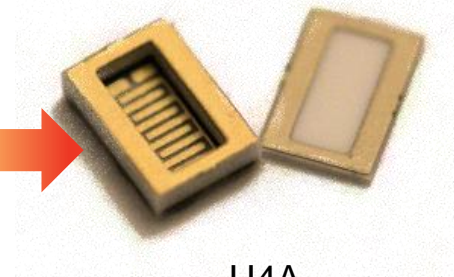
**Dramatic improvement in
Qg & FOM vs. V_{ds}!**

1st Gen GaN product line (preliminary)

| <u>PART NO.</u> | <u>VOLTAGE</u> | <u>CURRENT</u> | <u>PEAK</u> | <u>RDS(ON) (mΩ)</u> | <u>Qg (nC)</u> | <u>FOM- Qg * Rds(on)</u> |
|-----------------|----------------|----------------|-------------|---------------------|----------------|------------------------------|
| MGN2915U4A | 40V | 33A | 150A | 4 | 11.6 | 46.4 |
| MGN2914U4A | 40V | 10A | 40A | 16 | 3 | 48 |
| MGN2905U4A | 60V | 25A | 100A | 7 | 10 | 70 |
| MGN2909U4A | 60V | 6A | 25A | 30 | 2.4 | 72 |
| MGN2901U4A | 100V | 25A | 100A | 7 | 10.5 | 73.5 |
| MGN2907U4A | 100V | 6A | 25A | 30 | 2.7 | 81 |
| MGN2911U4A | 150V | 12A | 40A | 25 | 6.7 | 167.5 |
| MGN2913U4A | 150V | 3A | 12A | 100 | 1.7 | 170 |
| MGN2910U4A | 200V | 12A | 40A | 25 | 7.5 | 187.5 |
| MGN2912U4A | 200V | 3A | 12A | 100 | 1.9 | 190 |

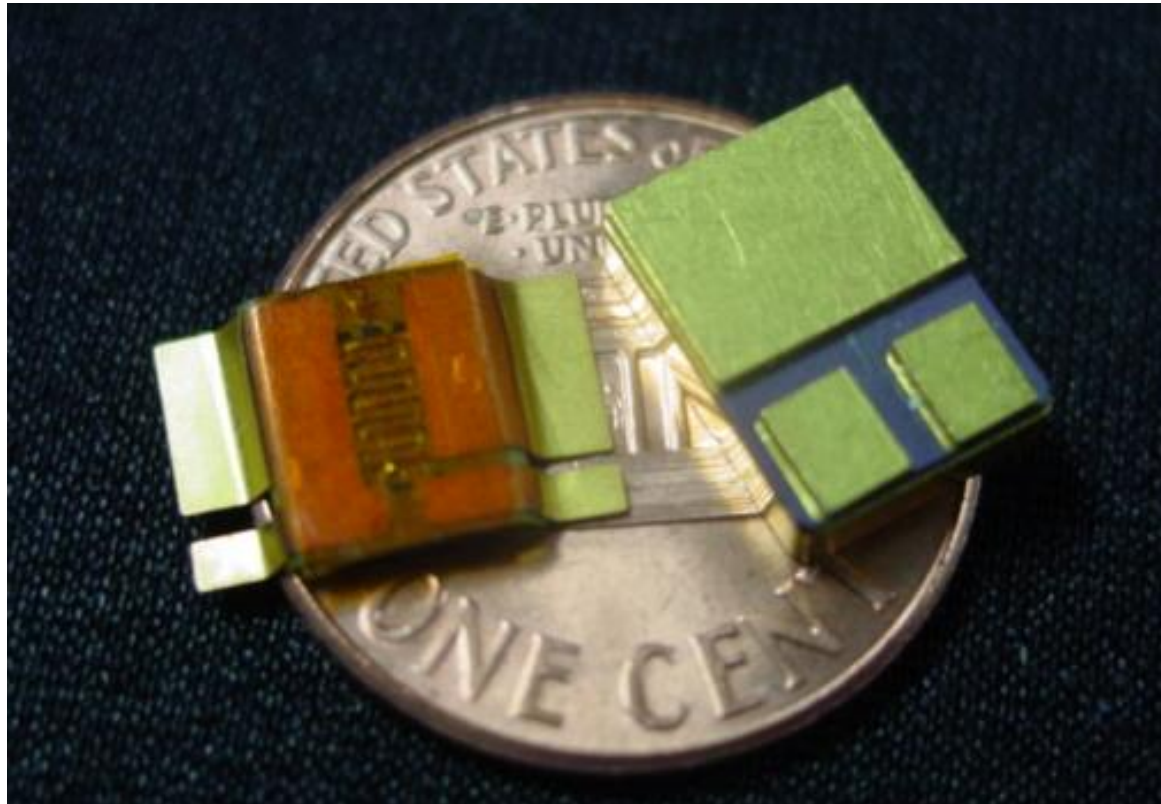


U4A

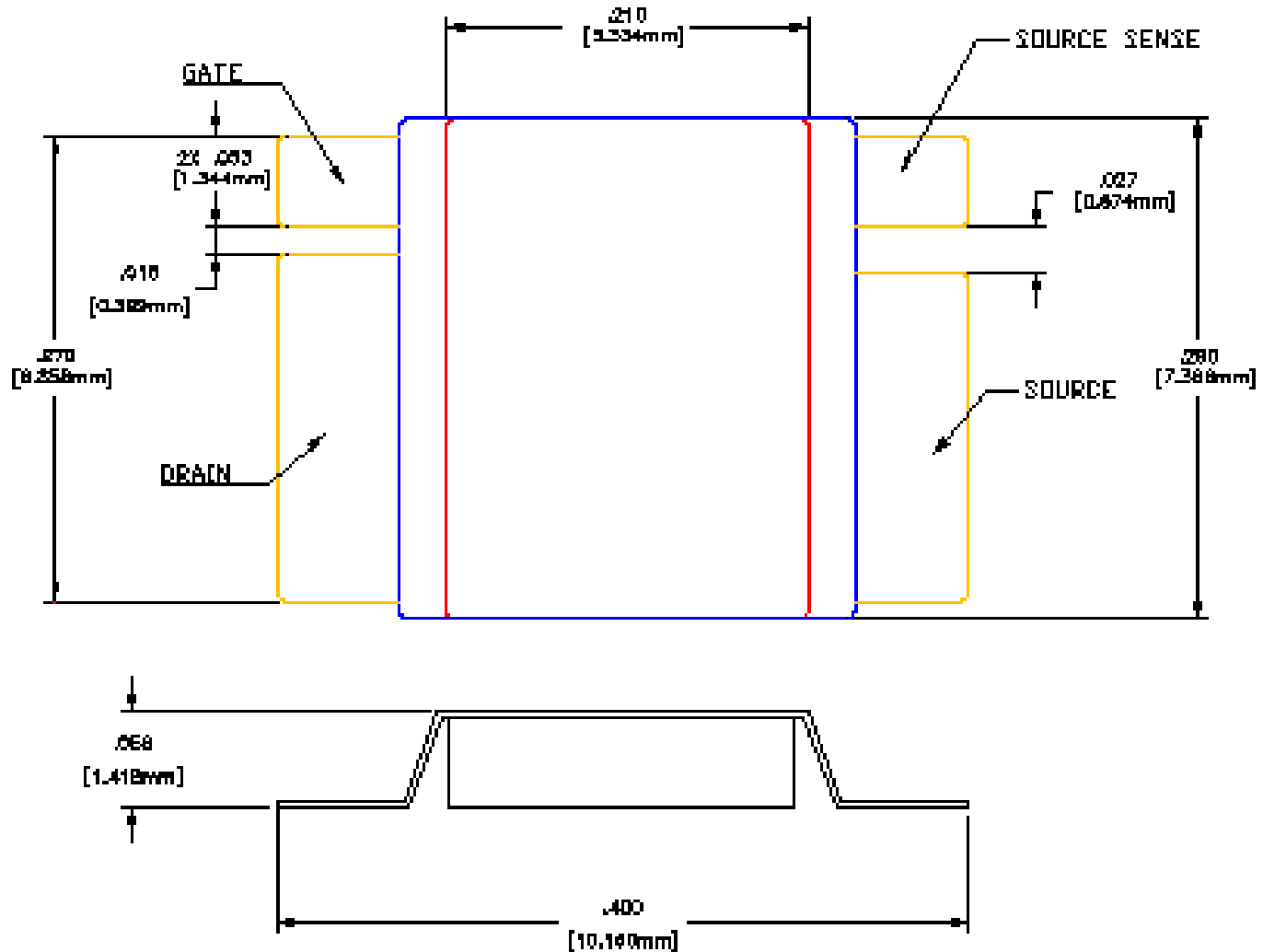


U4A

GaN Flex



GaN Flex Dimensions

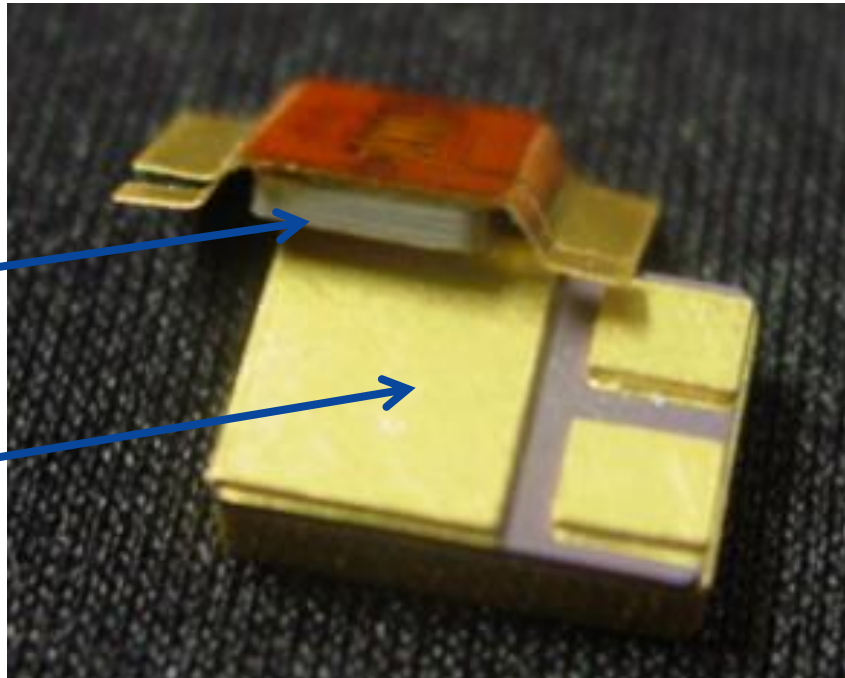


Advantages

- No wirebonds
- Low inductance
- Low thermal resistance
 - Heat transfer through the backside of die
- Low package electrical resistance
 - Less than 0.5 mΩ

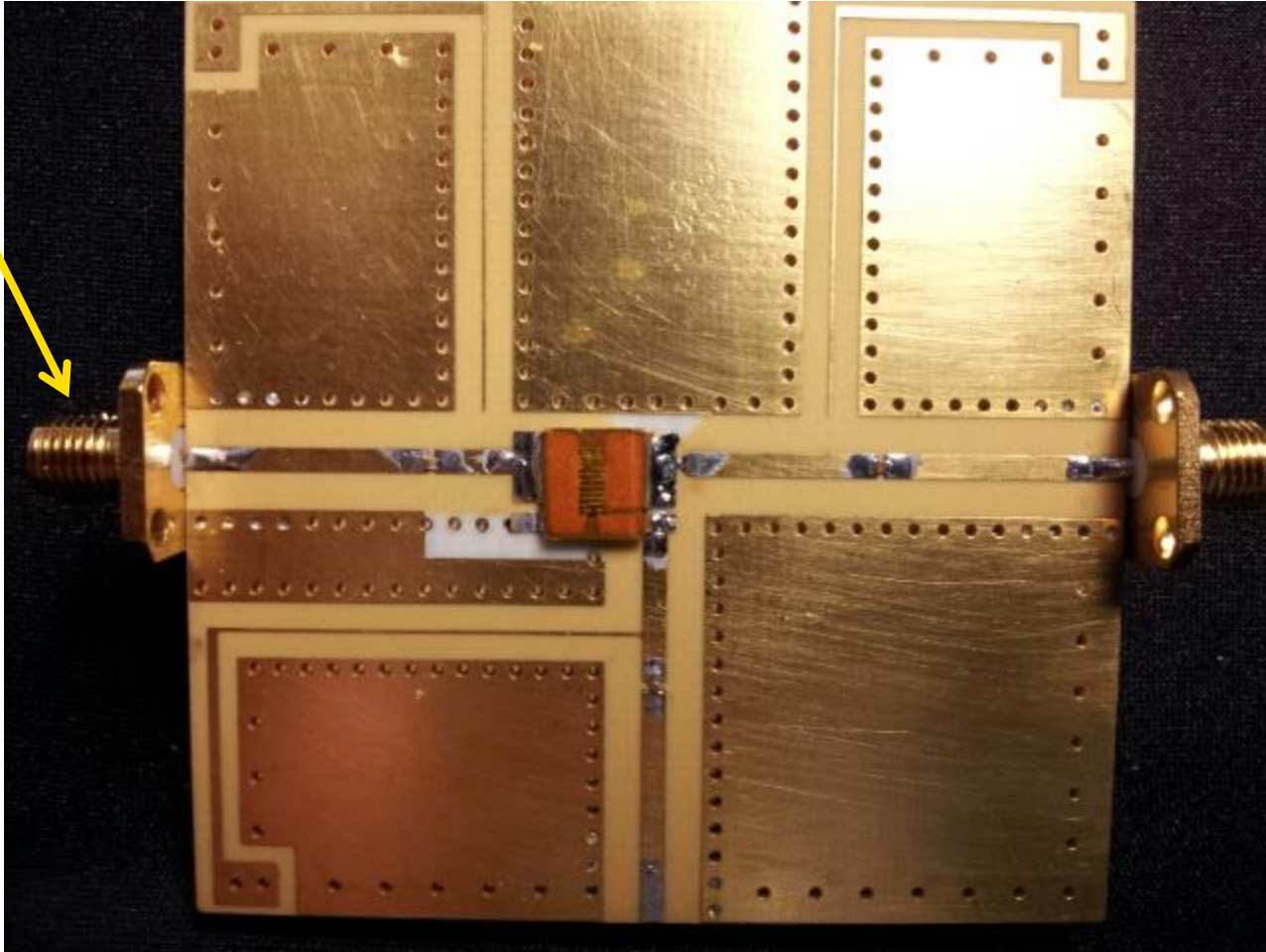
Thermal path

SMD 0.5



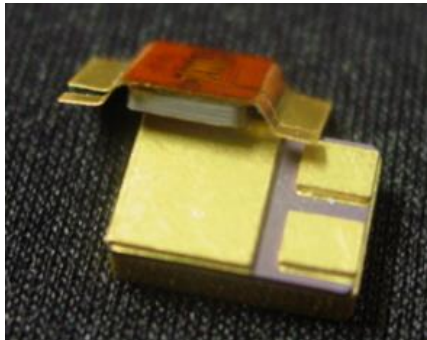
GaN Flex RF Testing Set-up

50 mΩ feed thru



1st Gen GaN Flex Product line (preliminary)

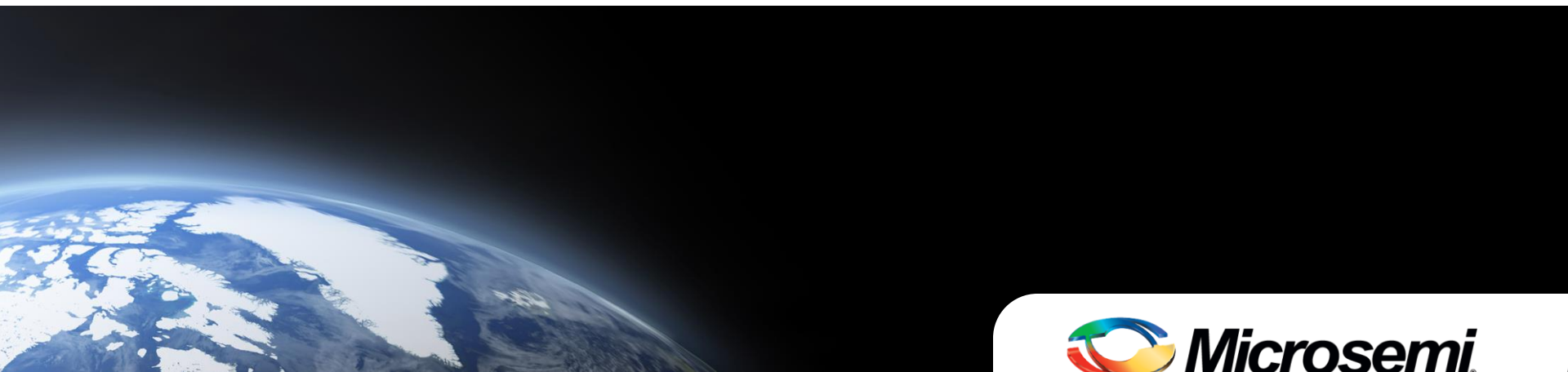
| <u>PART NO.</u> | <u>VOLTAGE</u> | <u>CURRENT</u> | <u>PEAK</u> | <u>RDS(ON) (mΩ)</u> | <u>Expected Sample Date</u> |
|-----------------|----------------|----------------|-------------|---------------------|-----------------------------|
| MGN2915FLX | 40V | 33A | 150A | 4 | Sept'13 |
| MGN2914FLX | 40V | 10A | 40A | 16 | TBD |
| MGN2905FLX | 60V | 25A | 100A | 7 | TBD |
| MGN2909FLX | 60V | 6A | 25A | 30 | TBD |
| MGN2901FLX | 100V | 25A | 100A | 7 | Sept '13 |
| MGN2907FLX | 100V | 6A | 25A | 30 | Sept '13 |
| MGN2911FLX | 150V | 12A | 40A | 25 | TBD |
| MGN2913FLX | 150V | 3A | 12A | 100 | TBD |
| MGN2910FLX | 200V | 12A | 40A | 25 | TBD |
| MGN2912FLX | 200V | 3A | 12A | 100 | TBD |



Preliminary Information

Features/ Properties Summary

- Normalized $R_{ds(on)}$ is lower than Si: 1.47 vs. 1.7
- Natural Logic- Level drive
 - +5V gate drive- fully enhanced at +4.5V to +5V
 - $V_{gsmax} = 6.0V!!!$
- Small die size will result in much smaller packages
 - High frequency operation increase power density
- Radiation resistant HiRel products in Development
 - Heavy Ion testing showing very good performance
 - TID, ELDRS characterization
- Extremely low parasitic capacitance U4A package
 - Cuts switching losses significantly
 - Extremely low gate charge



Thank You