

RF & Microwave Capability & Roadmap

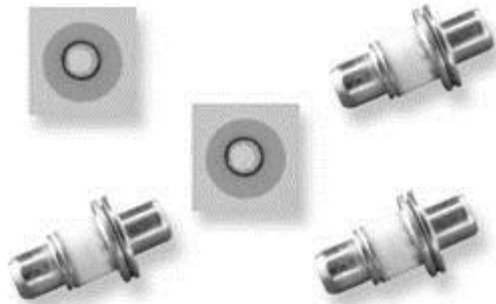
Microsemi Space Forum Russia – November 2013

Pete Blanchard,
Senior Field Applications Engineer, RF Integrated Solutions Group



RF Integrated Solutions Space Heritage

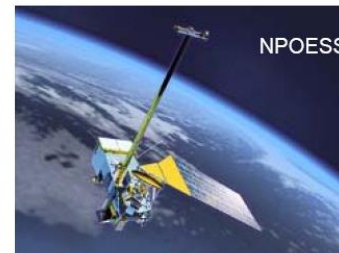
- RF & microwave products
 - Si PIN, SRD, and varactor diodes
 - GaAs PIN and varactor diodes
 - Si bipolar power transistors



RF Integrated Solutions Space Heritage

■ Applications

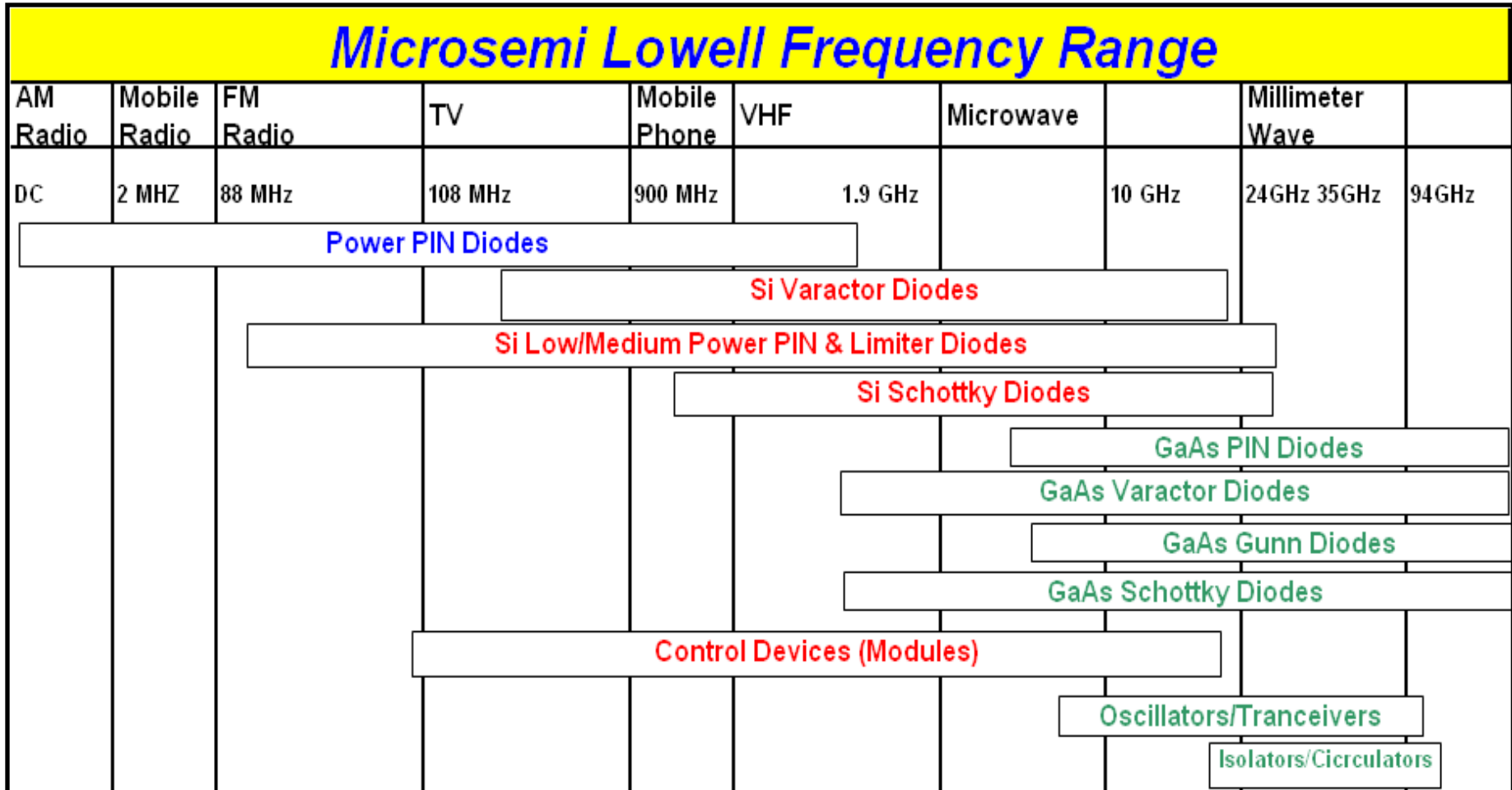
- RF switching and attenuation
- Communication data links
- Conversion / Modulation
- Surveillance / tracking
- Telemetry / guidance
- Receiver protection
- Imaging / profiling
- Meteorological
- Broadcast
- Scientific
- Military
- Tuning
- GPS



RF Integrated Solutions – Diode Products

Si & GaAs

RFIS Diode Products Overview



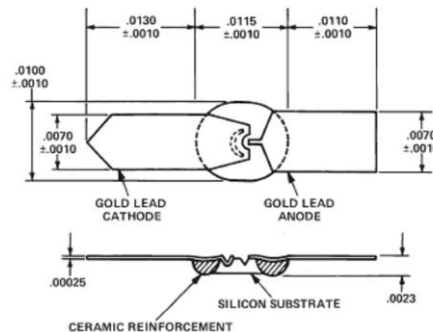
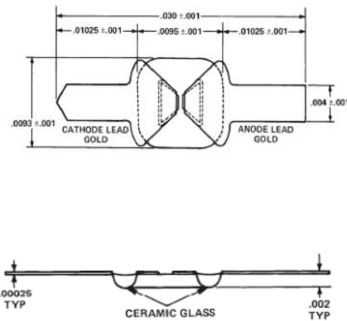
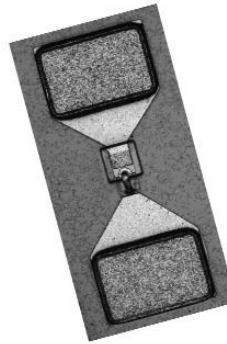
RFIS Diode Products Overview

- Silicon and GaAs diodes – Schottky, PIN, varactor
- Diodes available as die or packaged
- Package options include:
 - Microwave (higher freq) – ceramic, MMSM, stripline
 - Surface mount – MMSM, EPSM, MELF, GigaMite, SOT-23, thru-hole
- Diode based control components – switches, limiters, detectors
- Catalog and custom devices, components, & transceivers
- Military, commercial, semi-cap and ISM markets
- MIL-STD-750, MIL-STD-883, MIL-PRF-19500, Hi-Rel screening available, element evaluation sample testing for space qualification

RFIS Diode Products Overview

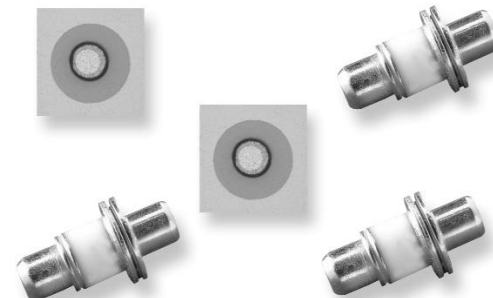
■ Silicon Diodes

- PINs
- Schottkys
- Varactors
- Limiter
- Multiplier
- Noise
- SPST Switch Element



■ GaAs Diodes

- PINs
- Schottkys
- Varactors
- Gunn
- Impatt



RFIS Diode Products Space Applications

- Switches
- Limiters
- Attenuators
- Detectors
- Phase Shifters
- Tunable Filters
- VCOs
- Mixers
- Up and Down Converters
- Phased Array Antennas
- Antenna Tuning Units
- T/R Switches



Heritage/Current RFIS Diodes Space Programs

Satellite / Program					
Amazonas 3	Echostar XI	Galileo	Nimiq 6	Viasat	ISDLA-1
Anik G1	Echostar XIV	GPS Block III	QuetzSat	Wildblue 1	ISDLA-2
ARGON	Echostar XV	Hispasat 1E	Satmex 6	XM-5	NBNC0-1A
Asiasat 5	Echostar XVI	ICO G1	SES Sirius 5	ABS-2	NBNC0-1B
Asiasat 7	Echostar XVII	Intelsat 14	Sirius FM-5	Asiasat 6	Optus-10
DirecTV-7S	Galaxy 16	Intelsat 17	Telstar 14R	Asiasat 8	Sirius 6
DirecTV-8	Galaxy 18	Intelsat 19	TerreStar 1	DirecTV-14	Thor 7
DirecTV-9S	Galaxy 19	Intelsat 20	Thor 7	Echostar XVIII	Jupiter 2



RF Integrated Solutions – Transistor Products

Si, SiC, GaN on SiC

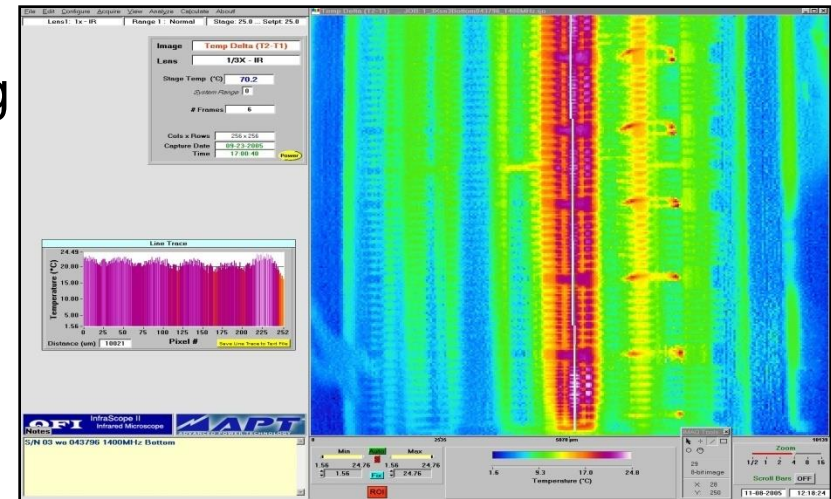
RFIS Discrete Transistor Products Overview

- HF to C-band today, X & Ku band under development
- Si bipolar – HF to S-band, Pulsed/CW, Class A/AB/C, $V_{cc} < 52V$
- SiC SIT – VHF & UHF, pulsed class AB, $V_{dd} = 100-125V$
- GaN on SiC HEMT, class AB, $V_{dd} = 45-65V$
 - L band through C-Band today, pulsed & CW
 - X & Ku band under development, pulsed & CW
 - Broadband CW under development
- VHF to UHF – $< 1W$ to $2200W$
- L-Band – Up to $1100W$
- S-Band – Up to $500W$
- C-Band – Up to $100W$



RFIS Discrete Transistor Products Overview

- Si bipolar proven device technology for space applications
 - Rugged, robust, radiation hard
 - Proper choice of package considering properties of materials, physical strength, electrical & thermal properties
 - Robustness assured by device processing, piece part selection, single metal configuration, and electrical testing
 - Hermetically sealed gold plated metal ceramic packages & all gold bond wire and wafer metallization
 - IR scan for thermal resistance measurements under RF conditions
 - 100% DC and RF electrical testing
 - MIL-STD-19500 JAN-S flow screening
 - Customer tailored device screening
 - ISO9001 registered



RFIS Space Power Transistor Applications

- Power Amplifiers – CW and Pulsed
- Communication data links
- Surveillance / tracking
- Telemetry / guidance
- Ground penetrating
- Imaging / profiling
- Scatterometers
- Meteorological
- Broadcast
- Scientific
- Military
- Clocks
- GPS



RFIS Si Bipolar Space Heritage/Current

Platform	Application	Freq Band
GPS III*	Navigation & Communication	UHF
Classified govt satellite	Space based infra-red system (SBIR)	S
GPS III	Frequency standard clock in navigation system	L
Galileo Constellation*	Maser Clock	UHF
Satellite (JPL)*	Power amp for on board radar- soil moisture measurements	L
Meteorological Satellite*	Data Transmission	S
P142 classified govt. satellite*	Power amp line up for communication	UHF
Galileo Constellation*	Navigation and communication, clock signal	UHF
Aquarius Satellite*	SSPA on scatterometer for measuring sea water salinity	L

* Multiple RF power transistors



Wide Band Gap

SiC & GaN on SiC

Wide Band Gap Material Property Advantages

Material Property	Si	SiC	GaN
Band Gap (eV) 3 Times Silicon	1.1 3X	3.2	3.5
Critical Field (10^6 V/cm) Ten Times Silicon	0.3 10X	3	3.3
Thermal Conductivity (Watt/cm ² -K) 3 Times Silicon	1.5 3X	4.9	>1.5

Capability

High operating temperature

High breakdown voltage, higher power output, higher impedance

Higher Power Per part

System Benefit

- Increase reliability
- High operating temperature

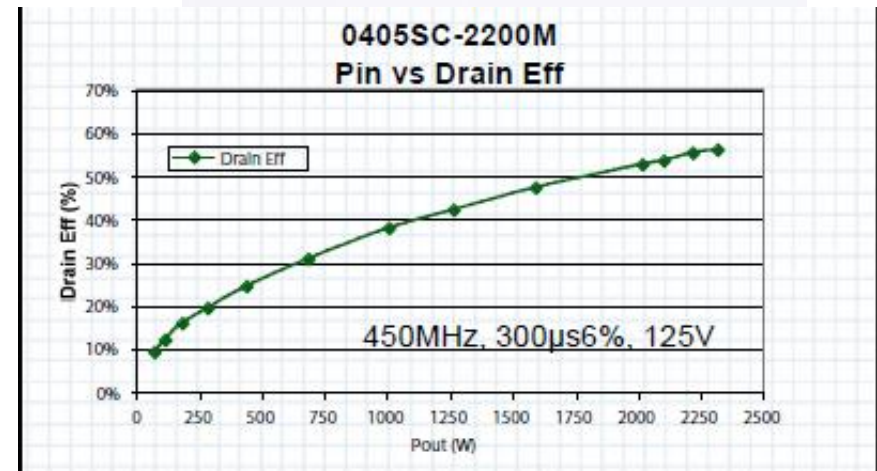
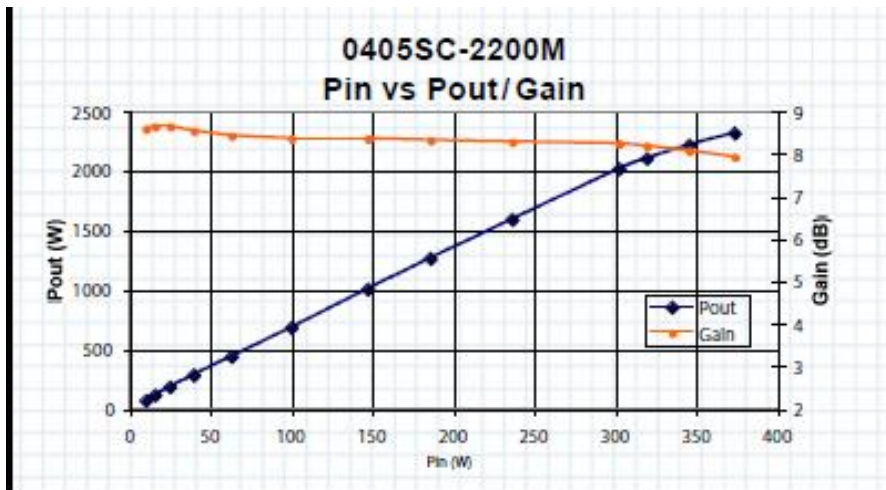
- Higher power
- Wider bandwidth amplifier

- Reduce part size
- Minimize cooling requirements

2200W Single Ended UHF SiC SIT 125V

0405SC-2200M

125V, 406-450MHz, 300 μ s, 6%



SiC Power Transistor Devices

SiC RF Power Device Family



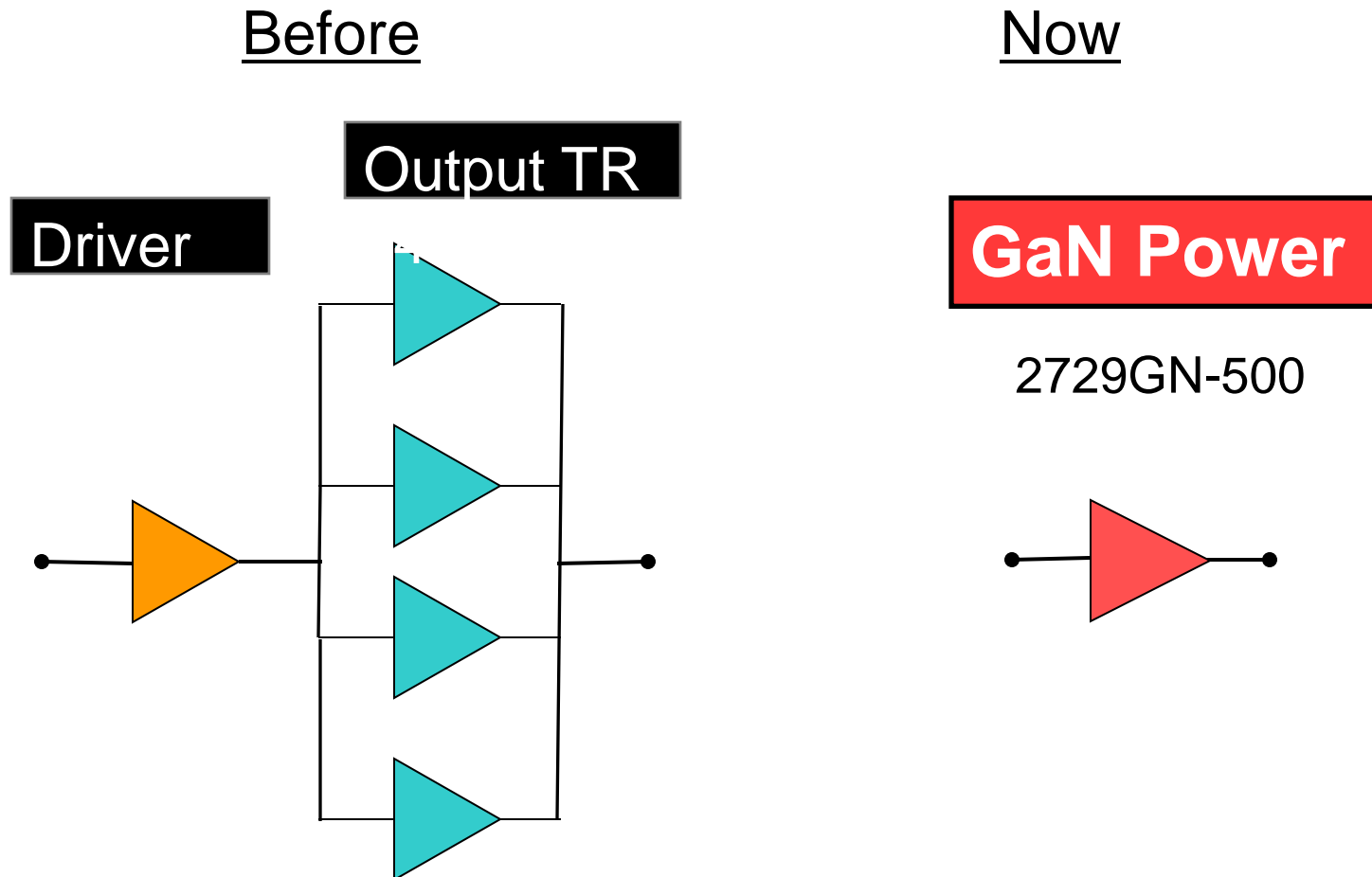
	0150SC-1250M	0405SC-100M	0405SC-500M	0405SC-1000M	0405SC-1500M	0405SC-2200M	1214SC-500M	0912SC-500M
Band	VHF	UHF	UHF	UHF	UHF	UHF	L-Band	Avionics
Freq:	150 MHz	406-450 MHz	406-450 MHz	406-450 MHz	406-450 MHz	406-450 MHz	1200-1400 MHz	960-1215 MHz
Power Out:	1250 W	100 W	500 W	1000 W	1500 W	2200 W	500 W	500 W
Power Gain:	9.5 dB	10 dB	10 dB	8.5 dB	8 dB	8 dB	8 dB	8 dB
Pulse Width:	300 μ s	300 μ s	300 μ s	300 μ s	300 μ s	300 μ s	300 μ s	300 μ s
Duty Cycle:	10%	10%	10%	10%	6%	6%	10%	20%
VSWR-T:	10:1	10:1	10:1	10:1	10:1	10:1	10:1	10:1
Efficiency:	60%	50%	50%	55%	55%	55%	50%	50%
Bias:	125V	125V	125V	125V	125V	125V	125V	100V
Case:	ST-FET	KT-FET	KT-FET	ST-FET	ST-FET	TW-FET	ST-FET	ST-FET
Metallization:	all AU	all AU	all AU	all AU	all AU	all AU	all AU	all AU

Available Q4 2010

- ✓ High breakdown voltage allows the benefits of high voltage operation > 100 Volts
- ✓ Vertical structure not dependant on dielectric field strength
- ✓ Vertical Structure = High Power Density
- ✓ SIT operation in Class AB → Wide dynamic range
- ✓ SIT device extremely rugged
- ✓ SIT has high breakdown to Vdd Ratio

GaN Devices Improve Size, Weight & Power

- One GaN replaces Five Si BJT transistors



GaN Technology Advantages

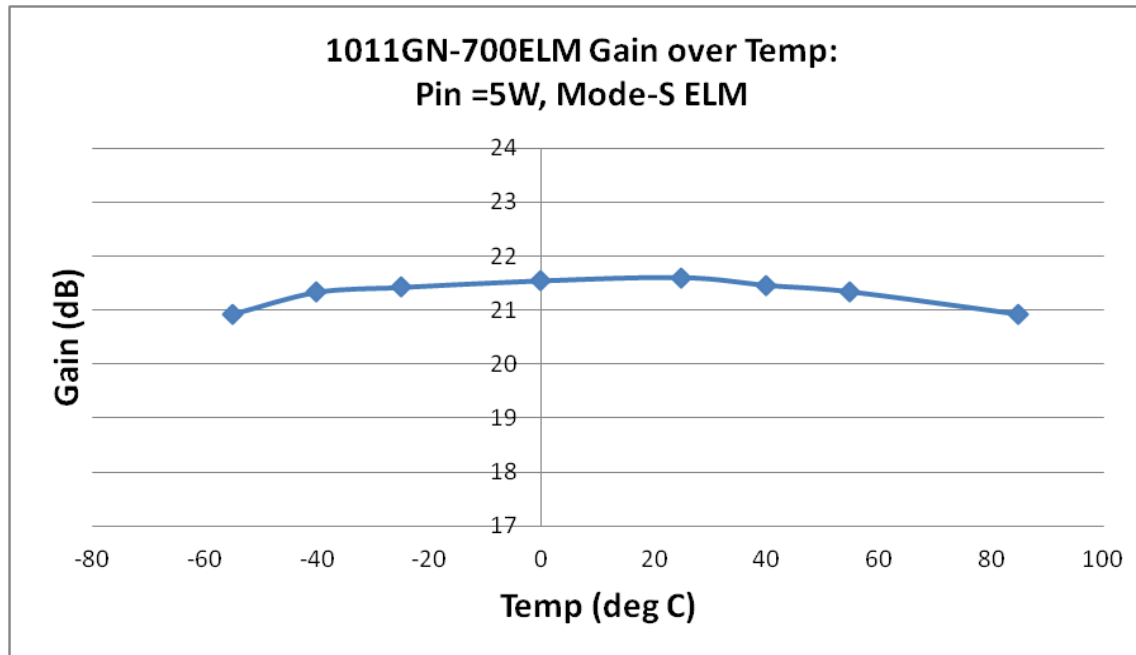
- Highest power per transistor than other solid state solutions - Si BJT, LDMOS, GaAs
- Highest power density – smallest transistor size
- Ability to cover higher frequency
- Excellent Temperature stability
- Better Efficiency
- Broad Band Application

GaN Temperature Stability Advantage Example

Less Than 1dB Gain and Power Variation from -55° to +85° C

Temp (°C)	Pin (W)	Pout (W)	Gp (dB)	Δ Gain
-55	5	621	20.9	-0.7
+25	5	720	21.6	0
+85	5	621	20.9	-0.7

- Heavy Mode-S ELM pulsing
- High Power >700W
- High Gain > 21 dB
- Excellent Efficiency > 70%



24+ New 2013 50V GaN Power Transistors

Model Number	Freq (MHz)	Pout (W)	Gain Typ (dB)	Efficiency Typ (%)	Pulse Width (us)	Duty Cycle (%)	Vdd (V)	Case
1011GN-1000V	1030	1000	17.5	55	10	1	50	55KR
MDSGN-750ELMV	1030/1090	750	17.2	68	ELM	6.4	50	55KR
DME-GN-700V	1025-1150	700	19	60	20	6	50	55KR
0912GN-20V	960-1215	20	17	55	128	10	50	55KR
0912GN-100LV	960-1215	100	16	55	3000	30	50	55KR
0912GN-300V	960-1215	300	16.8	55	128	10	50	55KR
0912GN-650V	960-1215	650	17.6	55	128	10	50	55KR
1214GN-20V	1200-1400	20	17	50	300	10	50	55KR
1214GN-100LV	1200-1400	100	16	55	3000	30	50	55KR
1214GN-180LV	1200-1400	180	16.6	52	3000	30	50	55KR
1214GN-280LV	1215-1400	280	16.7	60	200	20	50	55KR
1214GN-550V	1215-1400	550	16.6	55	300	10	50	55KR
2729GN-150V	2700-2900	150	11.76	50	100	10	50	55QP
2729GN-270V	2700-2900	270	12.7	55	100	10	50	55QP
2729GN-500V	2700-2900	500	11.4	50	100	10	50	55KR
2731GN-20V	2700-3100	20	16	46	200	10	50	55QP
2731GN-100LV	2700-3100	100	11	50	3000	30	50	55QP
2731GN-110V	2700-3100	110	11.4	50	200	10	50	55QP
2731GN-220V	2700-3100	220	11.4	50	200	10	50	55QP
2731GN-450V	2700-3100	450	11	46	200	10	50	55KR
3135GN-20V	3100-3500	20	13	45	300	10	50	55QP
3135GN-110V	3100-3500	110	10.8	42	300	10	50	55QP
3135GN-200V	3100-3500	200	11	40	300	10	50	55QP
3135GN-400V	3100-3500	400	10.5	42	300	10	50	55KR

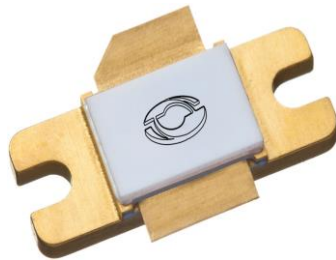
New Long Pulse 1214GN – 600VHE (High Efficiency)

1200 – 1400MHz, 300us, 10% , +50V

- 1.2 – 1.4 GHz
- High Output Power >600W
- High Gain > 17.5 dB typ
- Excellent Efficiency > 60%

Typical Performance

Freq(GHz)	Pin (W)	Pout (W)	Id (A)	RL (dB)	Eff(%)	G (dB)	Droop (dB)
1.2	11.2	656	2.20	-10.0	63%	17.67	0.5
1.3	11.2	644	2.06	-8.8	66%	17.59	0.4
1.4	11.2	647	1.94	-15.0	70%	17.61	0.3



✓ Power Matters
✓ 50V Matters

New Long Pulse 1214GN – 300LV

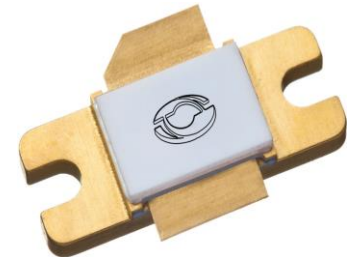
1200 – 1400MHz, 3ms, 30%, +50V

Prototype Performance

Freq (GHz)	Pin (W)	Pout (W)	Gp (dB)	Effi (%)
1.2	7.9	349	16.4	64
1.3	7.9	346	16.4	60
1.4	7.9	327	16.2	64

- 1.2 – 1.4 GHz
- High Output Power >300W
- High Gain > 16 dB
- Excellent Efficiency > 60%

✓ Power Matters
✓ 50V Matters
✓ Long Pulse Matters



From Heritage to New Technologies

The challenges & benefits

Adopting New Technologies

- Development cycle can exceed 4 years before purchase of flight units
- From flight units purchase to launch can be another 3-5 years
- Requires solid long term engineering and production commitment by Microsemi
- Engage closely with space payload/satellite platform manufacturer(s) to collaborate on the consideration for use in space new technologies
- With all Microsemi divisions having products for space, participate in the industry trade shows/forums/conferences together to offer greatest benefit to the market and our customers offering many products vertically
- Seek to develop/acquire the best new technologies for new space products
- Overcome Recession/Sequestration and other funding issues

Phase 1 – up to 4 years

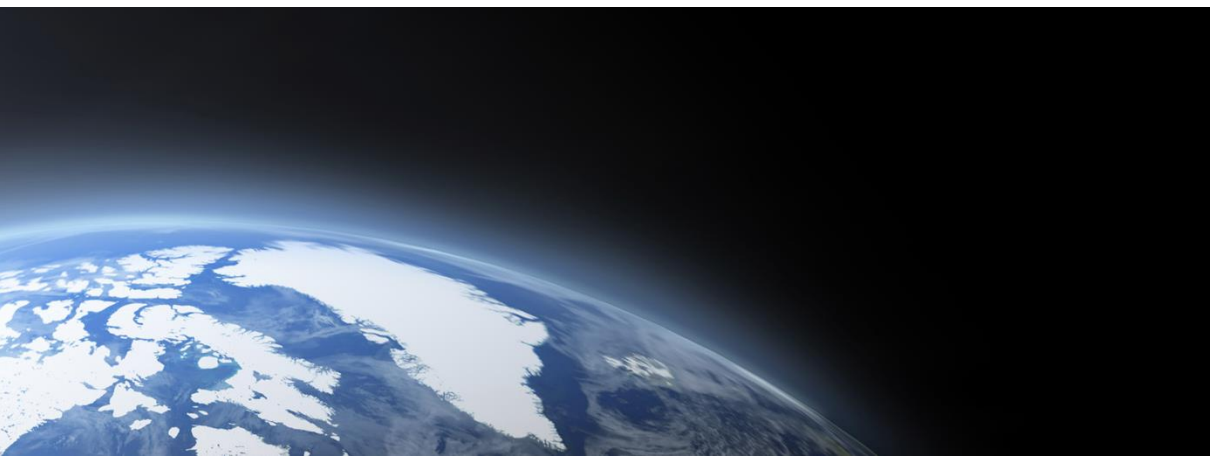
Design Start
Prototype Delivery
Test and Evaluation
Purchase Flight Units

Phase 2 – 3-5 years

Sub systems assembly
Test and Evaluation
Spacecraft Integration
Launch set mount and test

Adopting New Technologies

- Collaboration allows improved development cycle time
- Microsemi broad space products portfolio can reduce supplier count costs
- Microsemi commitment to leading edge space products technologies will increase performance and decrease development and operating costs
- Overcome Recession/Sequestration and other funding
- Where Power Matters, we can together outfit high-performance satellites and payloads to be more safe, secure, and reliable



Thank You