

Gallium Semiconductor

Delivering Next Generation Performance & Efficiency

Aug 2023



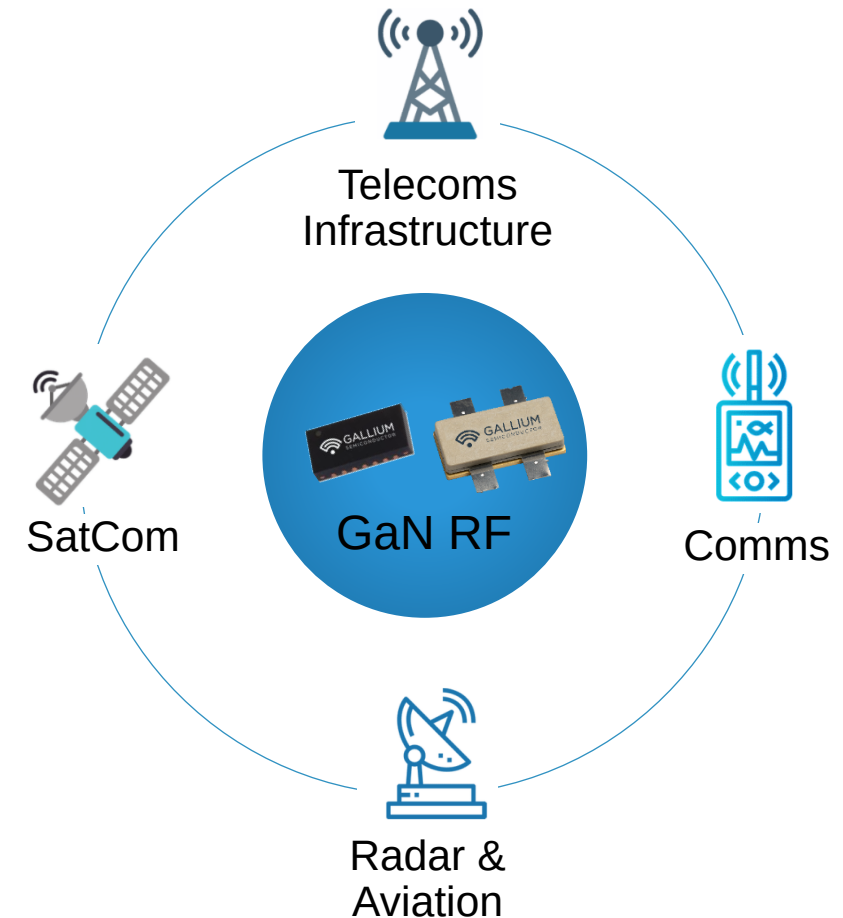
About Us

Gallium Semiconductor designs and manufactures Gallium Nitride (GaN) and Gallium Arsenide (GaAs) based RF semiconductor products to cost effectively deliver the **highest performance and reliability** for **5G Communication Networks** as well as **Aerospace, Radar, Industrial, Scientific and Medical** applications.

We are a **global company** with team members throughout Asia, and Europe.

Our team is comprised of distinguished RF semiconductor experts with **decades** of engineering, operations and management experience.

We have a **proven track record** of success in developing and supplying high performance semiconductors for RF, microwave and related applications in cellular communications, satellite and defence-related markets.



Exponential Growth

Strategic Investments,
Operational Expertise,
RF Design Excellence,



2021,
Founded by
Gaas Lab.
Headquartered
in Singapore.



May 2022 ,
Opened RnD
Facility in
Nijmegen, The
Netherlands.



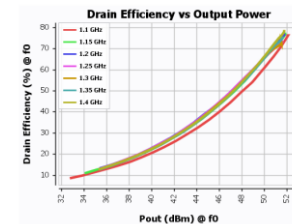
Sept 2022,
Presented
1st Generation
Products at EuMW
in Milano , Italy



Feb 2023,
Unveiled the
Dedicated
Manufacturing
Facility in Laguna,
Philippines.



June 2023,
Presenting the
2nd Generation
High Efficiency
Radar products at
IMS in San Diego,
USA



- L/S band 150W
- 71% Efficiency

Delivering Next Generation Performance & Efficiency



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Global Operations – Headquarters in Singapore



R&D Center
Nijmegen, Netherlands



Sales
Seoul, Korea



Sales & Applications
Shanghai, China



Assembly & Test
Laguna, Philippines



HQ
Singapore



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Core Competencies

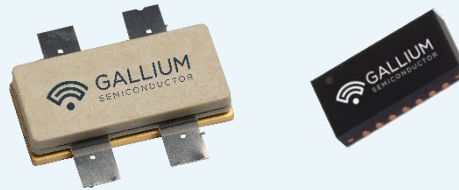
Device Engineering

- GaN RF Device Design and Fab
- Device and PA Characterization
- Electro-Thermal Modeling
- GaN Epi & Process R&D



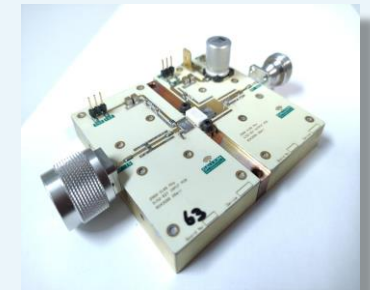
Packaging Design

- Advanced RF Packaging solution
- Solid High-Volume Operation
- Dedicated Back-End Test/Assembly
- Partners in Asia, and Europe



Full Application Support

- Models and Evaluation Boards
- Application Notes
- Reference Design Support



Performance + Reliability + Service + Cost = Customer Satisfaction

Package Portfolio

Plastic Package



DFN 3x6



DFN 6.5x7



Air Cavity Plastic Package



ACP-462 2L



ACP-800 2L



ACP-800 4L

Air Cavity Ceramic Package



NI-200



NI-360



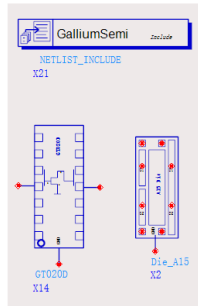
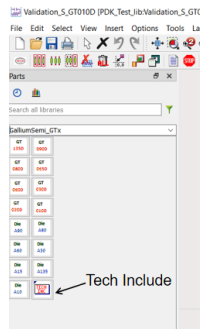
NI-650 4L



We Aim at Providing High Quality Collateral's

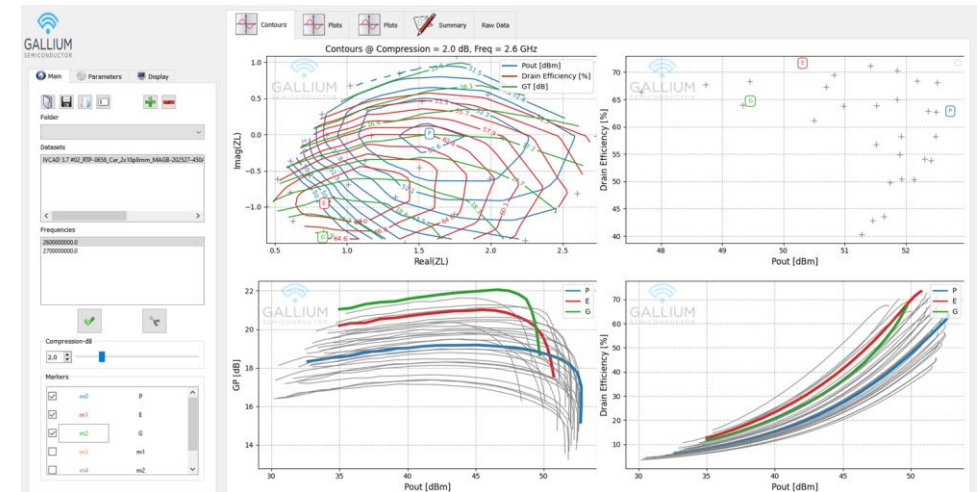
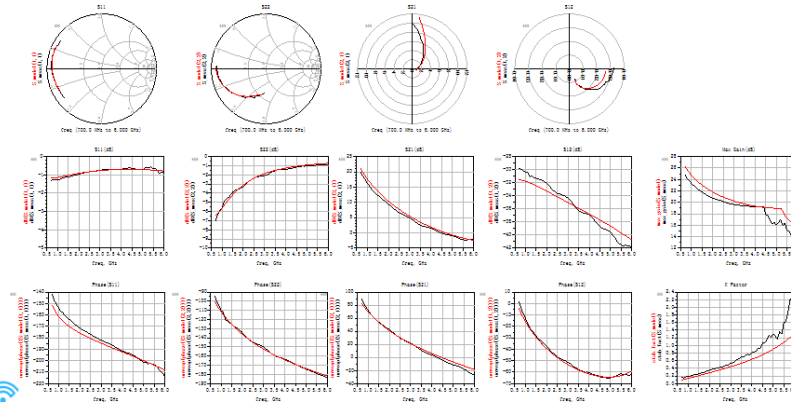
1. Broadband S-Parameters vs Vds
2. Loadpull Reports
3. Electrical Models (ADS and MWO)
4. Demo-boards

How to use the models in ADS



- Place one *Tech Include* Instance in the schematic
- Place Product or Die Model

GT030D, Vds=50V, Idq= 30mA



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Aug 22, 2023



GaN Bare Dies



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GaN Bare Die Part # decoder

GDX065

065: Power P3dB in W

C: upto 8 GHz
X: upto 12 GHz
J: upto 14 GHz
K: upto 18GHz

T: Transistor
D: Die
A: MMIC Amplifier
I: IMFET

GaN Bare Die in Production

Discrete Bare Die upto C band , 50V



5.500 X 0.900 mm Die

Discrete Bare Die up to C band , 50V

Part Number	Frequency (MHz)	Psat (W)	Linear Gain (dB) _[1]	Dr. Efficiency (%) _[1]	Drain Supply (V)	Die Size (mm)
GD010	DC to 8000	10 _[1]	20 _[1]	61 _[1]	50	0.90 x 0.75
GD020	DC to 7000	20 _[1]	21 _[1]	63 _[1]	50	1.26 x 0.75
GD030	DC to 6000	30 _[1]	21 _[1]	64 _[1]	50	1.63 x 0.75
GD060	DC to 3700	60 _[1]	21 _[1]	64 _[1]	50	2.35 x 0.75
GD080	DC to 3700	80 _[1]	21 _[1]	66 _[1]	50	2.74 x 0.82
GD090	DC to 3700	90 _[1]	22 _[1]	67 _[1]	50	3.08 x 0.75
GD135	DC to 3200	135 _[1]	19 _[1]	66 _[1]	50	3.48 x 0.80
GD160	DC to 3200	160 _[1]	19 _[1]	65 _[1]	50	3.50 x 0.90
GD200	DC to 2700	200 _[2]	15 _[2]	65 _[2]	50	3.50 x 0.90
GD250	DC to 2700	250 _[2]	15 _[2]	64 _[2]	50	5.50 x 0.90

New

New

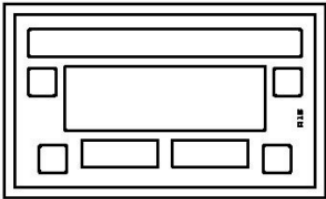
[1] specifications from the datasheet, typical performance at V_{ds}=50V measured from packaged device in a Loadpull test fixture at 3 GHz.

[2] specifications from the datasheet, typical performance at V_{ds}=50V measured from packaged device in a Loadpull test fixture at 2,5 GHz.

For CW applications, refer to datasheet for thermal and reliability information.

GaN Bare Die in Sampling

Discrete Bare Die upto Ku band , 28V



1.26 x 0.75 mm Die

Discrete Bare Die up to Ku band, 28V						
Part Number	Frequency (MHz)	Psat (W)	Linear Gain (dB) _[1]	Dr. Efficiency (%) _[1]	Drain Supply (V)	Die Size (mm)
GDJ007	DC to 14000	7 _[2]	22 _[2]	65 _[2]	28	0.60 x 1.050
GDJ011	DC to 14000	12 _[1]	21 _[1]	66 _[1]	28	0.61 x 2.18
GDK002	DC to 18000	1.6 _[2]	22 _[2]	65 _[2]	28	0.61 x 1.05
GDK005	DC to 18000	5 _[2]	22 _[2]	65 _[2]	28	0.61 x 2.18
GDK003	DC to 18000	2.4 _[2]	22 _[2]	65 _[2]	28	0.56 x 1.05

[1] specifications from the datasheet, typical performance at Vds=28V measured from packaged device in a Loadpull test fixture at 3 GHz.

[2] target performance based on simulations

For CW applications, refer to datasheet for thermal and reliability information.

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Discrete Wideband GaN Amplifiers



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GaN Part # decoder in DFN package

G T 065 D

D: DFN

065: Power P3dB in W

T: Transistor

D: Die

A: MMIC Amplifier

I: IMFET

Discrete Wideband GaN Amplifiers in DFN package



14 Pin 6x3 mm DFN Package

Discrete Wideband GaN Amplifiers in DFN package

Part Number	Frequency (MHz)	Psat (W) _[1]	Linear Gain (dB) _[1]	Dr. Efficiency (%) _[1]	Drain Supply (V)	Package (mm)	
GT010D	DC to 8000	15	19	62	50	DFN14 6 x 3	Production
GT012D	DC to 12000	12	21	66	28	DFN14 6 x 3	Sampling
GT020D	DC to 7000	30	19	64	50	DFN14 6 x 3	Production
GT030D	DC to 6000	50	21	65	50	DFN14 6 x 3	Production
GT065D	DC to 3700	80	21,9	66	50	DFN14 6 x 3	Production
GT090D	DC to 3700	120	21,6	66	50	DFN14 6 x 3	Production
GT135D	DC to 3200	150	19	64	50	DFN14 6 x 3	Sampling

[1] specifications from the datasheet, typical performance at V_{ds}=50V measured from packaged device in a Loadpull test fixture at 3GHz.
For CW applications, refer to datasheet for thermal and reliability information.

Completed Product Reliability Qual for 50V GaN Power Amplifier in DFN 3 x 6 mm

GALLIUM SEMICONDUCTOR Product Reliability Qualification Report	
Product Reliability Qualification Report for GaN Power Amplifier in DFN 3x6	
Doc Number / Revision	PQR0002, Rev. 1.0
Release Date	July 10, 2023

Test Item and Conditions	Test Methodology	Sample Size	Test Result
High-Temperature Operating Life Test (HTOL) Tj=200°C, 1000hrs	JESD22-A108	45units/lot x 3 lots	Pass
Preconditioning (PC) MSL 1	JESD22-A113	50units/lot x 3 lots	Pass
Temperature Cycling (TC) -65°C - 150 °C, 500 Cycles	JESD22-A104	25units/lot x 3 lots	Pass
Unbiased Highly Accelerated Stress Testing (uHAST) 85%RH / 130 °C, 33.3 psia, 96hrs	JESD22-A118	25units/lot x 3 lots	Pass
High Temperature Reverse Bias (HTRB) 85%RH, Tc=150°C, Drain bias 100V	JESD22-A108	15units/lot x 3 lots	Pass
Solderability Test 8hrs steam aging, 245°C, dip & look	J-STD-002	3 units	Pass
ESD - Human Body Model (HBM), 250V, Class 1A	ANSI/ESDA/JEDEC JS-001	3 units	Pass
ESD - Charged Device Model (CDM), 1500V, Class C3	ANSI/ESDA/JEDEC JS-002	3 units	Pass

Doc Number / Revision	PQR0002, Rev. 1.0
Release Date	July 10, 2023

Discrete Wideband GaN Amplifiers in ACC package



NI-200



NI-360



NI-650 4L

Discrete Wideband GaN Amplifiers in ACC package

Part Number	Frequency (MHz)	Psat (W) _[1]	Linear Gain (dB) _[1]	Dr. Efficiency (%) _[1]	Drain Supply (V)	Package (mm)	
GTH0-0080015S	DC to 8000	17	20	62	50	NI-200	Sampling
GTH0-0070030S	DC to 7000	35	20	67	50	NI-200	Sampling
GTH0-0060050S	DC to 6000	50	19	66	50	NI-360	Sampling
GTH0-0037110S	DC to 3700	120	19	67	50	NI-360	Sampling
GTH0-0032150S	DC to 3200	173	13	66	50	NI-360	Sampling
GTH0-0032180P	DC to 3200	190	19	67	50	NI-650	Sampling

[1] specifications from the datasheet, typical performance at V_{ds}=50V measured from packaged device in a Loadpull test fixture at 3GHz.
For CW applications, refer to datasheet for thermal and reliability information.

August 22, 2023



Pulsed Radar Amplifiers

Part # decoder

GTH2r-1214250S

S: Single Ended
P: Symmetrical PushPull
A: Asymmetrical Doherty

250: Power P3dB in W

Freq band: e.g. 1200-1400MHz

t: telecom
s: satcom
r: radar / avionics / pulsed
e : ISM / CW
g: general purpose / broadband

0: 1st generation
2: 2nd generation

H: 50V
M: 28V
L: 12V
T: Transistor

D: Die
A: Amplifier
A: Amplifier MMIC



L-band and S-band Pulsed Radar Amplifiers



6 Pin 6.5x7 mm DFN Package

ACP-462 2L



ACP-800 4L

L-band and S-band Pulsed Radar Amplifiers

Part Number	Frequency (MHz)	Psat (W)	Linear Gain (dB)	Dr. Efficiency (%)	Drain Supply (V)	Package (mm)
GTH2r-1014150S	1000 to 1400	150	18 _[1]	75 _[1]	50	DFN6.5 x 7 mm
GTH2r-1214500P	1200 to 1400	500	18 _[2]	66 _[2]	50	ACP-800-4L
GTH2r-0912500P	960 to 1215	500	18 _[2]	66 _[2]	50	ACP-800-4L
GTH2r-1010700P	1030 to 1090	700	20 _[2]	70 _[2]	50	ACP-800-4L
GTH2r-2731125S	2700 to 3100	125	15 _[1]	63 _[1]	50	ACP-462
GTH2r-2731150S	2700 to 3100	150	17 _[1]	67 _[1]	50	DFN6.5 x 7 mm
GTH2r-2731250S	2700 to 3100	250	15.5 _[1]	64 _[1]	50	ACP-800-4L
GTH2r-2731500P	2700 to 3100	500	17 _[2]	65 _[2]	50	ACP-800-4L
GTH2r-2933150S	2900 to 3300	150	16 _[1]	63 _[1]	50	DFN6.5 x 7 mm
GTH2r-3135125S	3100 to 3500	125	15 _[1]	56 _[1]	50	ACP-462
GTH2r-3135250S	3100 to 3500	250	16 _[2]	65 _[2]	50	ACP-800-4L
GTH2r-3135500P	3100 to 3500	500	16 _[2]	65 _[2]	50	ACP-800-4L

Sampling

Sampling

Samples in Q4, 2023

Samples in Q4, 2023

Sampling

Sampling

Sampling

Sampling

Sampling

Sampling

Sampling

Sampling

[1] specifications from the datasheet, typical performance at Vds=50V measured from packaged device in a fixed tuned test fixture using a pulsed signal 100us, 10%.

[2] target performance based on simulations

For CW applications, refer to datasheet for thermal and reliability information.



C-band and X-band Pulsed Radar Amplifiers



LGA, 5 x 6 mm

LGA, 10 x 12 mm

C-band and X-band Pulsed Radar Amplifiers						
Part Number	Frequency (MHz)	Psat (W) _[2]	Linear Gain (dB) _[2]	Dr. Efficiency (%) _[2]	Drain Supply (V)	Package (mm)
GAM2r-5060050S	5000 to 6000	50	20	47	40	LGA , 10 x 12 mm
GAM2r-0610015S	6000 to 10000	15	13	45	40	LGA, 5 x 6 mm
GAM2r-9199050S	9100 to 9900	50	14	51	40	LGA , 5 x 6 mm
GAM2r-9199100S	9100 to 9900	100	22	42	40	LGA , 10 x 12 mm

[1] specifications from the datasheet, typical performance at Vds=40V measured from packaged device in a test fixture.

[2] target performance based on simulations

For CW applications, refer to datasheet for thermal and reliability information.

GAM2r-9199050S

50W X band fully-matched GaN Module



LGA, 5 x 6 mm

Development

– Features:

- 2nd Gen GaN on SiC HEMT module
- 50W pulsed at 40V output power, 9.1 to 9.9 GHz
- >50% saturated drain efficiency (P2dB)
- RoHS* compliant and MSL-3
- Package 5 x 6 LGA

– Sales Information:

- EAR99
- Customer engineering samples available in Q4, 2023
- Advanced data sheet available
- Electrical Model (ADS) TBD, (MWO) TBD.
- Operating from 40V (typical)

– Target Markets and Applications:

- 50W X-band Amplifier
- Xband radar and satellite communications
- Weather Radar
- Avionics

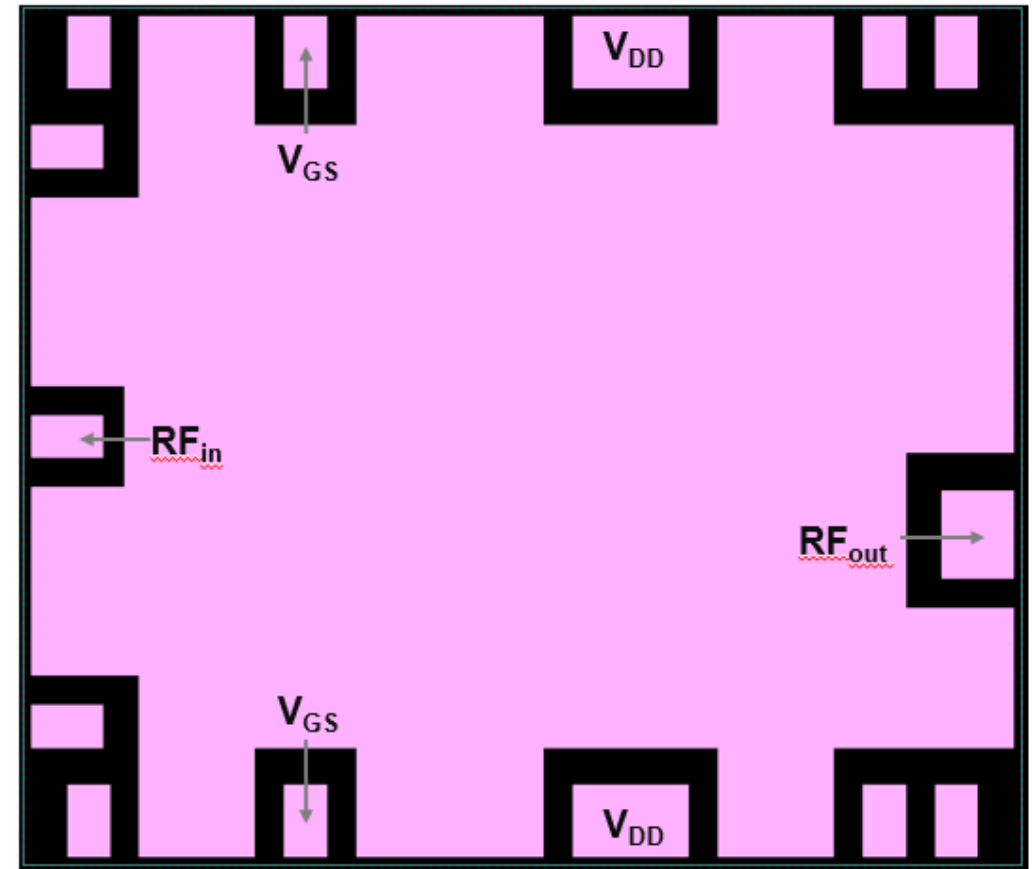
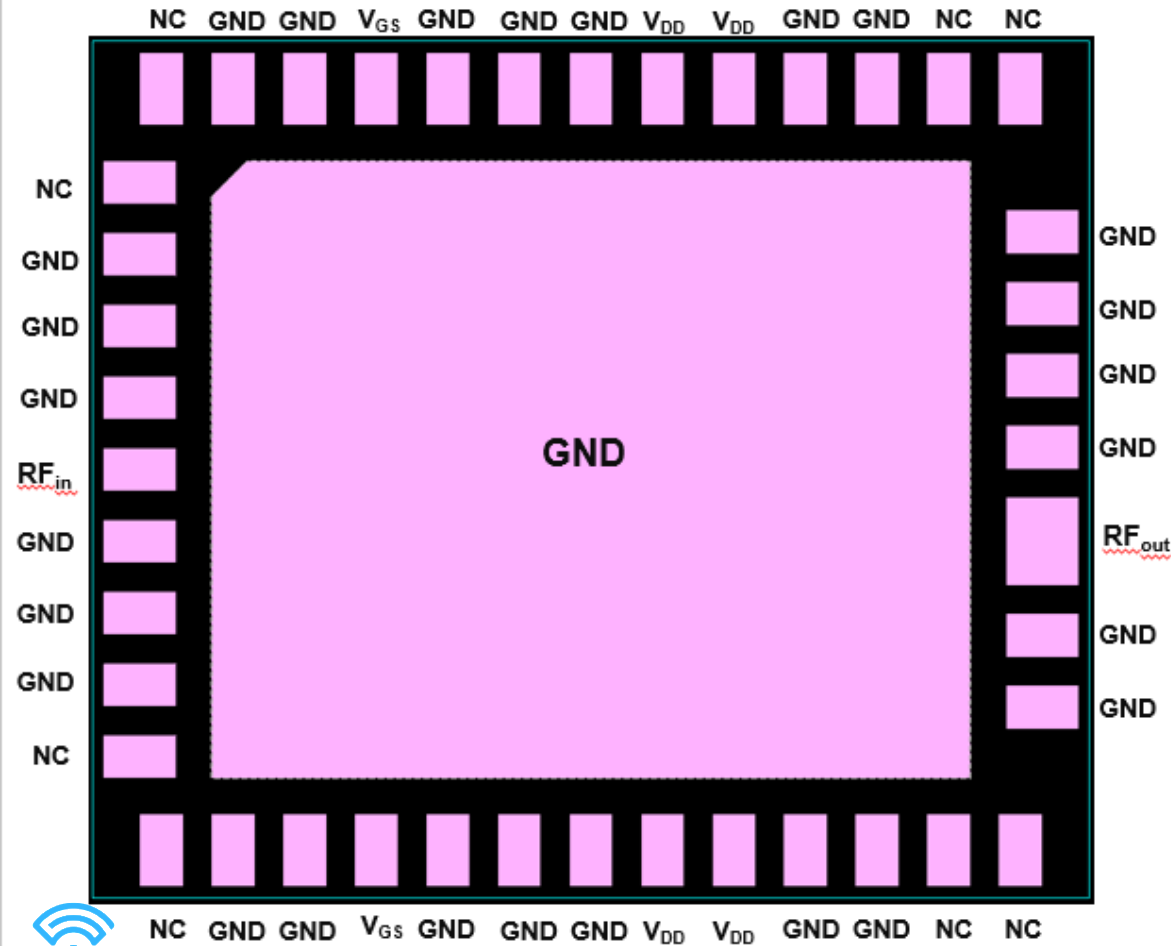
Parameters	Simulation Results
Operation Frequency	9.1 – 9.9 GHz
Drain Voltage (V_{DS})	40 V
Small Signal Gain (S_{21})	> 14 dB
Input RL (S_{11})	< -18 dB
Output Power (P_{out})	> 47 dBm (50 W)
Drain Efficiency (DE)	> 55 %
Power Gain (G_T)	> 11 dB
Max. Channel Temp. (T_{ch})	< 150 °C
Area	5 mm x 6 mm



GAM2r-9199050S

50W X band fully-matched 1-stage GaN Module

Development



GAM2r-9199100S

100W 2-stage X band fully-matched GaN Module



LGA, 10 x 12 mm

Development

– Features:

- 2nd Gen GaN on SiC HEMT module
- 100W pulsed at 40V output power, 9.1 to 9.9 GHz
- 40% saturated drain efficiency (P2dB)
- RoHS* compliant and MSL-3
- Package 12mm x 10mm LGA

– Sales Information:

- EAR99
- Customer engineering samples available in Q4, 2023
- Advanced data sheet available
- Electrical Model (ADS) TBD, (MWO) TBD.
- Operating from 40V (typical)

– Target Markets and Applications:

- 100W X-band Amplifier
- X band radar and satellite communications
- Weather Radar / Avionics
- ISM



Parameters	Project Goals
Operation Frequency	9.1 – 9.9 GHz
Drain Voltage (V_{DS})	40 V
Operation mode	10 %
Small Signal Gain (S_{21})	
Gain Flatness inband	<0.5 dB
Input RL (S_{11})	< -10 dB
Output Power (P_{out})	> 50 dBm (100 W)
Drain Efficiency (DE)	> 40 %
Power Gain (G_T)	> 24 dB
Max. Channel Temp. (T_{ch})	< 225 °C
Area	12 mm x 10 mm

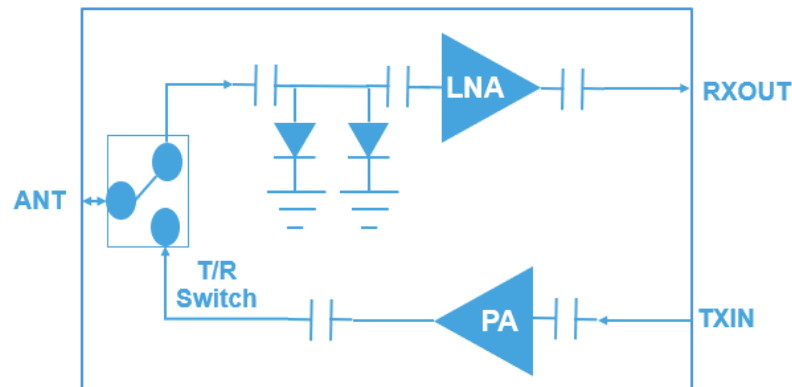
GX010 X-band FEM, samples planned in end Q1, 2024

GX010

7.9 – 11 GHz, 10W TR FEM

FEATURES

- Operating Frequency Range: 7.9 – 11 GHz
- RX Noise Figure: 2.2 dB
- RX Linear Gain: 25 dB
- RX Saturated Power: 14 dBm
- RX Output TOI: 22dBm
- TX Large Signal Gain: 20 dB
- TX Saturated Power: 40 dBm Pulsed
- TX Power Added Efficiency: 30% at $P_{in} = 18$ dBm
- Antenna Port Power Survivability: 40 dBm Pulsed
- Integrated Rx Limiter
- 7 x 5 x 1.44 mm plastic SMT package



Confidential

24

GX010 X-band FEM, samples planned in end Q1, 2024

RF ELECTRICAL SPECIFICATIONS, TRANSMIT:

Parameter	Min.	Typ.	Max.	Units	Conditions
Operating Frequency Range	8		12	GHz	
TX Small Signal Gain		30		dB	CW
TX Large Signal (Pin = 20 dBm)		20		dB	Pulsed V _D
TX Input Return Loss		12		dB	CW
Output Return Loss		5		dB	CW
Output Power (Pin = 20 dBm)		40		dBm	Pulsed V _D
Power Added Efficiency (Pin = 18 dBm)		30		%	Pulsed V _D
Harmonic suppression, 2nd		20		dBc	Pin = 20 dBm 8 – 9 GHz
Harmonic suppression, 2nd		30		dBc	Pin = 20 dBm 9-12 GHz
Harmonic suppression, 3rd		50		dBc	Pin = 20 dBm
Gate Leakage Current	-4			mA	TXVD = 40V, TXVG = -10 V
Switching time		30		nS	
TX Gain temp Coeff		-0.09		dB/°C	

Test conditions, unless otherwise noted: T = +25 °C, VD = 24 V, Pulse Width = 100 us, Duty Cycle = 10% , RXSW = 0 V, TXSW = -28 V, LNA off. Data deembedded to device reference plane.

RF ELECTRICAL SPECIFICATIONS, RECEIVE:

Parameter	Min.	Typ.	Max.	Units	Conditions
Operating Frequency Range	8		12	GHz	
RX Noise Figure		2.2		dB	
RX Small Signal Gain		25		dB	CW
RX Large Signal (Pin = TBD dBm)		14		dBm	Pulsed V _D
RX Output TOI		22		dBm	CW
RX Input Return Loss		8		dB	CW
RX Output Return Loss		10		dB	RX mode, CW
TX port to RX port Isolation		30		dB	

Test conditions, unless otherwise noted: T = +25 °C, RXVD = 1.8 V, RXIDQ = 90 mA, RXSW = -28 V, TXSW = 0 V, PA off. Data deembedded to device reference plane.



High Efficiency 150 W Transistor for L- band

GTH2r-1014150S

- Best-in-class efficiency
- 150 W pulsed output power
- GEN2 GaN Technology,
- DFN Plastic Package , 6.5 x 7 mm

GTH2r-1014150S @ 50V, Pulse Width 100us, Duty Cycle = 10%

Frequency	1.0 to 1.4	GHz
Output Power (P _{sat})	>150	W
Dr. Efficiency	75	%
Power Gain	15	dB



RF Matching size 30 x 20 mm

August 22, 2023



ISM CW Amplifiers

S band ISM CW Amplifier, 2450 MHz



ACP-800 4L



ACP-1600 4L

S band ISM CW Amplifier, 2450 MHz						
Part Number	Frequency (MHz)	Psat (W)	Linear Gain (dB)	Dr. Efficiency (%)	Drain Supply (V)	Package (mm)
GTH2e-2425300P	2400 to 2500	300	18 _[1]	73 _[1]	50	ACP-800-4L
GTH2e-2425600P	2400 to 2500	600	17 _[2]	73 _[2]	50	ACP-1600-4L

Sampling
Samples in Q1, 2024

[1] specifications from the datasheet, typical performance at Vds=50V measured from packaged device in a fixed tuned test fixture at 2.45 GHz

[2] target performance based on simulations

For CW applications, refer to datasheet for thermal and reliability information.

GTH2e-2425300P

300W 2.4-2.5GHz ACP Pre-matched GaN Transistor



Sampling

– Features:

- 2nd Gen GaN on SiC HEMT depletion mode transistor
- 300W CW at 50V output power, 2.4 to 2.5GHz
- 75% Pulsed CW saturated drain efficiency (P2dB) at 2.47GHz
- 73% CW saturated drain efficiency (P2dB) at 2.47GHz
- 70% CW saturated drain efficiency (P2dB) at 2.4 to 2.5 GHz
- RoHS* compliant and MSL-1

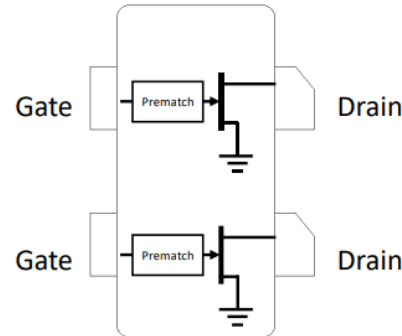
– Sales Information:

- EAR99
- Customer engineering samples available.
- Advanced data sheet available
- GTH2e-2425300P, 10-12 weeks lead time.
- GTH2e-2425300P -EVB-1, 8-12 weeks lead time. (2.47GHz)
- GTH2e-2425300P -EVB-2, 8-12 weeks lead time. (2.4 to 2.5 GHz)
- Operating from 50V (typical)

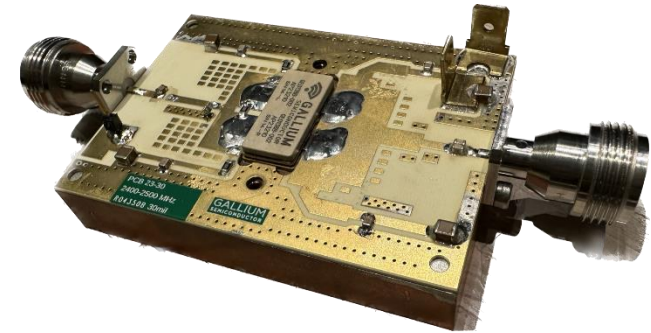
– Target Markets and Applications:

- ISM, RF Energy, CW Applications

Functional Schematic



Evaluation Board



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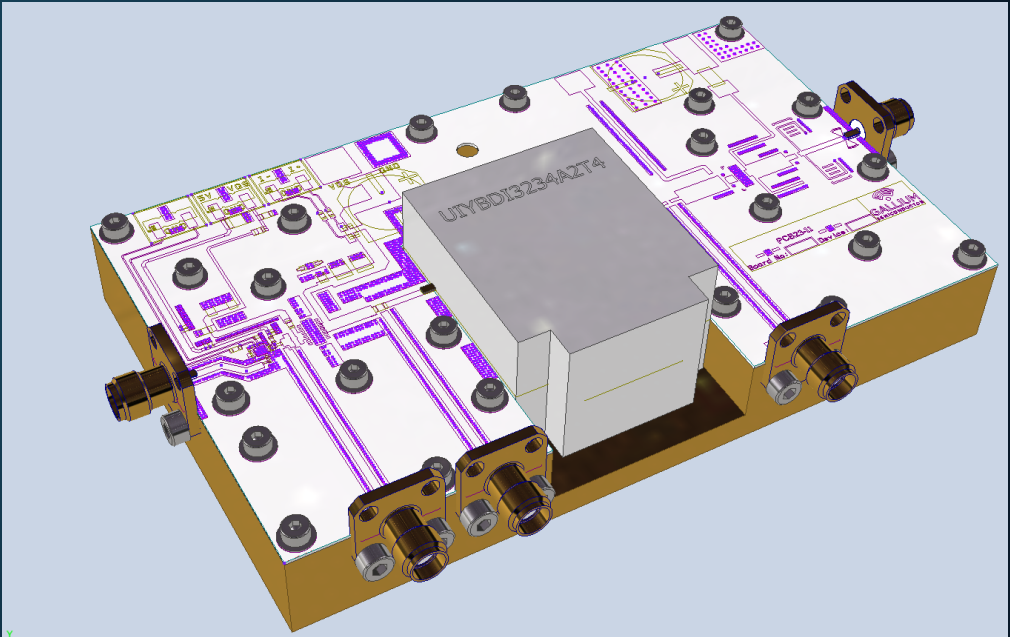
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Broadband High Performance Amplifier Line-up



GA203 + GT010D + GT030D

- Demo optimized for Broadband Operation
- 30 W pulsed output power
- GEN1 GaN Technology

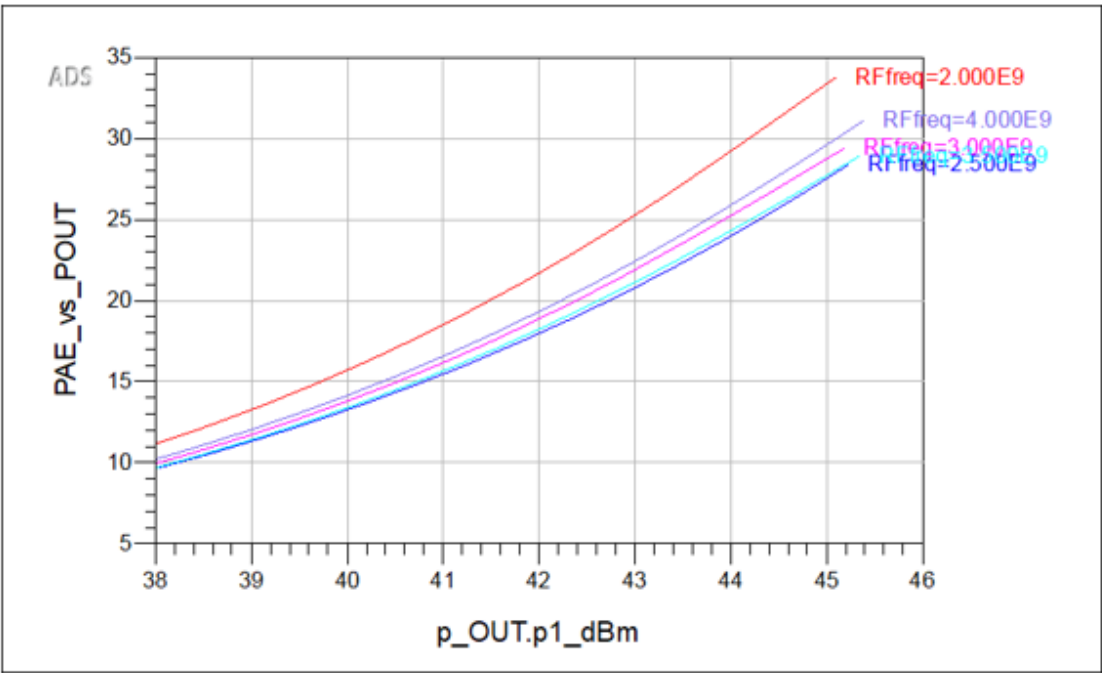
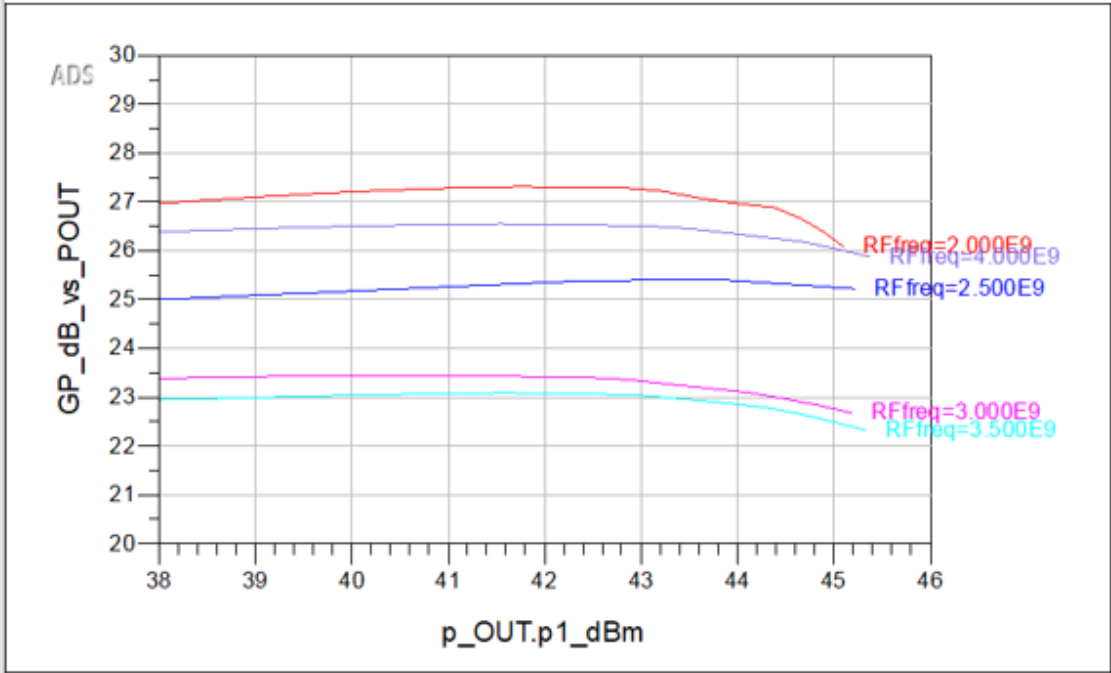


Demo size 116 x 70 mm

GA203 + GT010D + GT030D @ 50V, Pulse Width 100us, Duty Cycle = 10%		
Frequency	2 to 4	GHz
Line-up Output Power (Psat)	> 30	W
Line-up Dr. Efficiency	> 20	%
Line-up Power Gain	> 30	dB



GT010D + GT030D Broadband Line-up Simulation

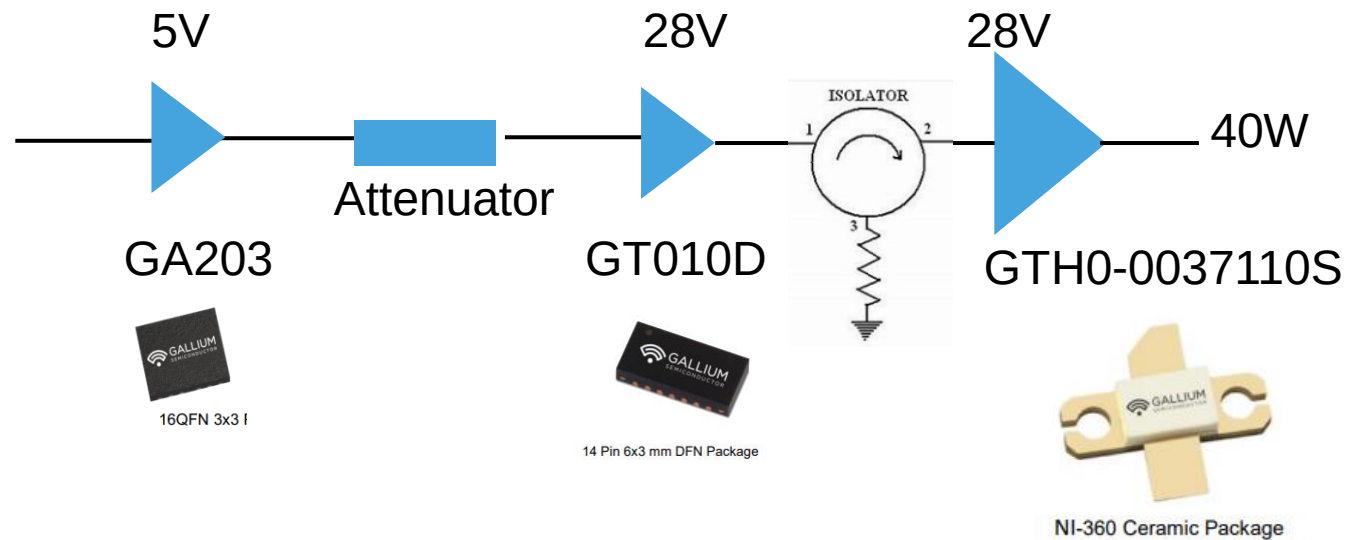
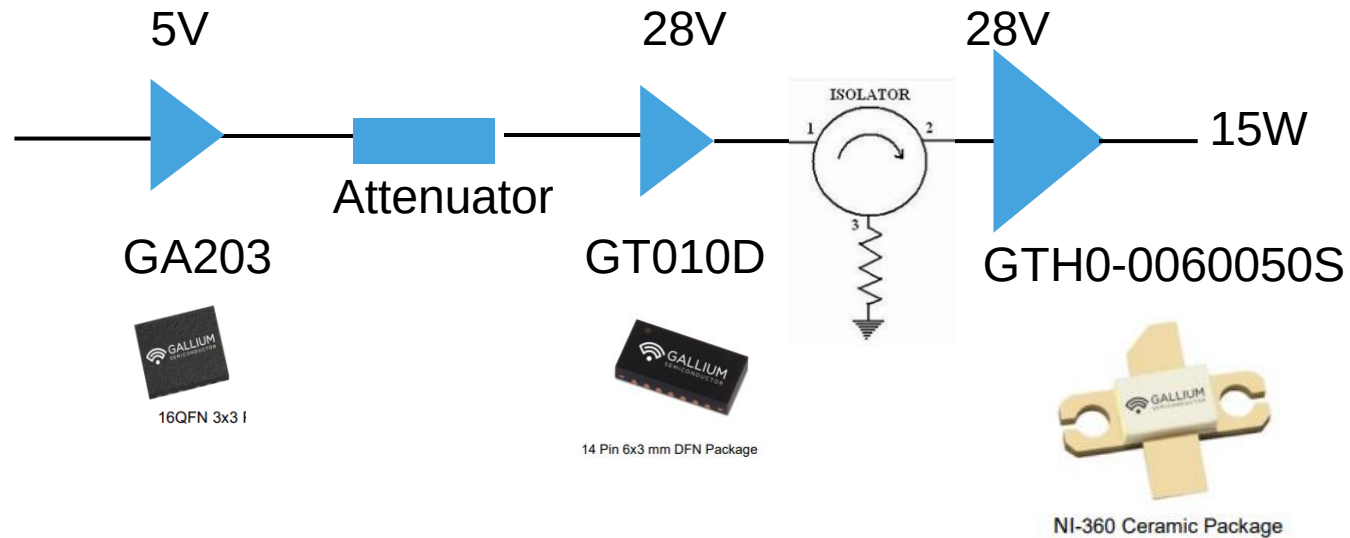


Broadband Amplifier Line-up Solutions at 28V

		Pre-Driver	Driver	Final
1.2-1.7 GHz 15W	GA203	GT010D	GTH0-0060050S	
1.2-1.7 GHz 40W			GTH0-0037110S	
2.4-2.5 GHz 15W	GA203	GT010D	GTH0-0060050S	
2.4-2.5 GHz 40W			GTH0-0037110S	

- For each Band, Pre-Driver and Driver using same device and PCB, different BOM to cover 15 & 40W
- Final stage: Each band, both power share same PCB, different BOM
- Total PCB Size ~100mm x 50mm + isolator between final and driver

15 W and 40 W Line-up Solutions



GTH0-0032110S, 50W Broadband from 0.5 to 2.5 GHz

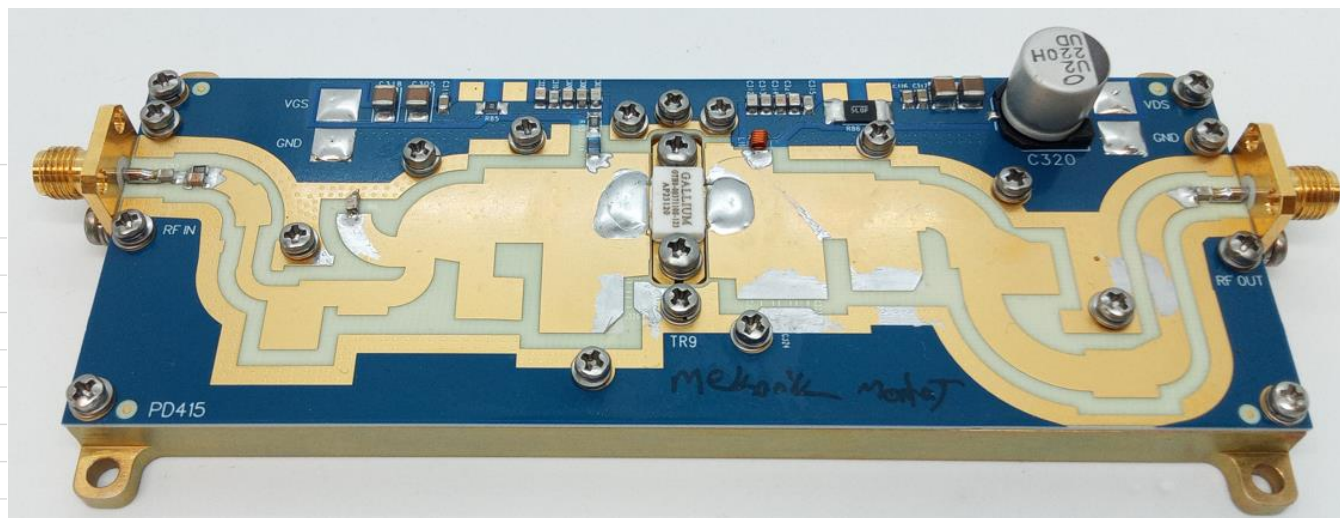
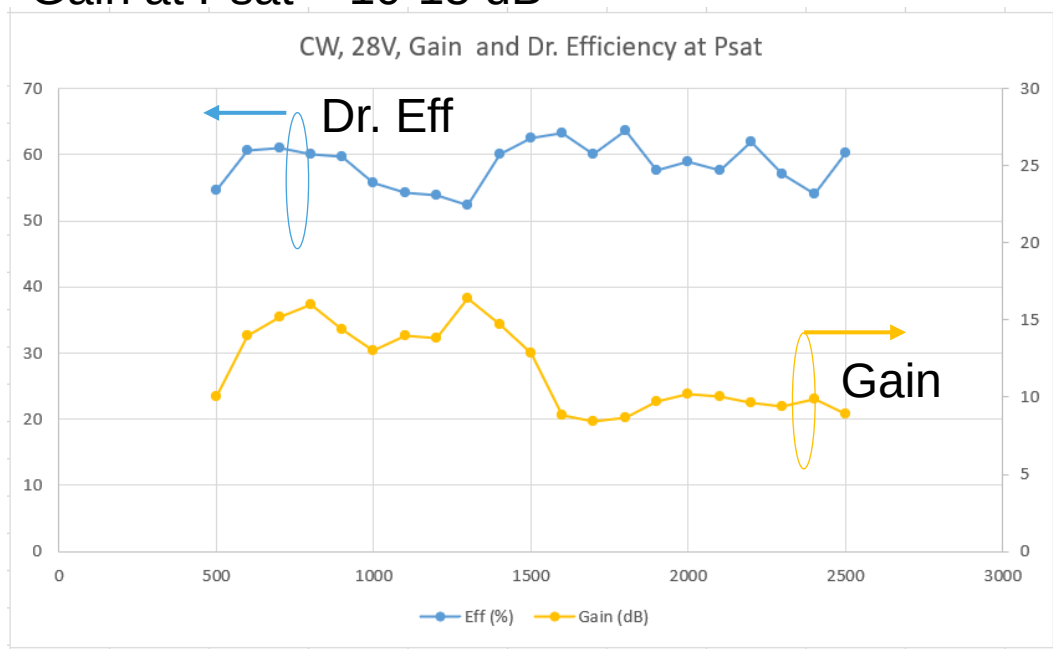
Measured CW Performance

Vds at 28V

Psat ~ 40-60W,

DE at Psat ~ 55-60%

Gain at Psat ~ 10-15 dB



Cross Reference GaN-SiC DFN/ QFN 50V

Rating P3dB	Freq	GS	Qorvo	Wolfspeed
15W	DC-6GHz	GT010D DFN 3x6	QPD01009 QFN 3x3	CGHV27015S DFN3x4
30W	DC-6GHz	GT020D DFN 3x6	QPD0020 QFN 4x3	CGHV27030S DFN3x4
50W	DC-6GHz	GT030D DFN 3x6	QPD0030 QFN 4x3	
80W	DC-3.7GHz	GT065D DFN 3x6	QPD0050 QFN 6x7	
100W	DC-3.7GHz	GT080D DFN 3x6	QPD0060 QFN 6x7	
110W	DC-3.7GHz	GT090D DFN 3x6		
150W	DC-3.2GHz	GT135D DFN 3x6	QPD1013 QFN 6x7	
60W	DC-2.7GHz	GT065D DFN 3x6		CGHV27060MP SMT 4x6
60W	2.7-3.8GHz	GT065D DFN 3x6		CGHV35060MP SMT 4x6



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Cross Reference GaN-SiC ACC 50V, Pulsed

Rating P3dB	Freq	GS	Qorvo	Wolfspeed
15W	DC-6GHz	GTH0-008015S NI-200		
30W	DC-3.7GHz	GTH0-0037080S (28V) NI-200		CGH40045F NI-200
45W	DC-6GHz	GTH0-0006050S NI-200		CGHV40030 NI-200
50W	DC-6GHz	GTH0-0006050S NI-200		
80W	DC-3.7GHz	GTH0-0037080S NI-360		CGHV59070 NI-200
110W	DC-3.7GHz	GTH0-0036110S NI-360		CGHV40100 NI-200
150W	DC-3.2GHz	GTH0-0032150S NI-360		





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