

AMPLEON

The background features a close-up, slightly blurred image of a printed circuit board (PCB) with several integrated circuits (chips) mounted on it. A large, dark blue diagonal shape cuts across the right side of the image, containing white text. The overall color palette is dominated by blues and greys.

Q2 2022

PIP II Workshop

Tom Dekker

Director of Marketing – American

Tom.dekker@ampleon.com

Agenda

- Ampleon Highlights
- Power FET Market
- Managing Longevity
- Products for Particle Accelerators

Ampleon at a Glance

Designing and manufacturing RF Power products for over 50 years

Our Company

- Worldwide presence (HQ in Nijmegen, Netherlands)
- 1,600 employees, >30 nationalities in 15 sites
- Sales, Application and R&D on 3 continents
- Own manufacturing facility with reliable supply chain
- Partnering with leading external manufacturers
- Financially solid

Our Technology and Know-How

- Market-leading RF Power know-how
- **Broad LDMOS and GaN technology portfolio**
- Comprehensive package line-up
- Scientific ecosystem with universities / institutes
- **Industry's best product consistency**

Our Business

Ampleon is globally

- **Top 3 RF power supplier** for wireless infrastructure cellular base stations
- **#1 RF power supplier** for Broadcast, Commercial DME / TACAS systems, Industrial RF supplies, Scientific, Medical and Heating systems

Our Customers and Partners

- All global cellular base station, RF broadcast, MRI, air navigation, non-cellular communications, defense and industrial RF Generation OEMs
- Pioneers in green energy generation and solid-state based appliances
- Distribution partners within customer proximity

We are globally creating optimal value for our customers



Nijmegen, Netherlands



1,600 employees in 15 sites

- **R&D:**
Nijmegen (Netherlands) and
Toulouse (France)
- **Manufacturing:**
Cabuyao (Philippines)
- **Application Support & Sales**
14 locations around the globe
- **Distribution:**
Distribution partners within
customer proximity

Market for Power FETs above 5W

- **> \$2 Billion**
 - **Small market size compared to Power, Digital, Optical Solid State**
 - **50% is Telecom**
 - **50% is sub-banded into various niche markets**
 - Industrial, instrumentation, Scientific, Medical, Mil/Aero, Satcom...
 - Particle Acceleration is niche segment
 - **Complex & dynamic mixture of LDMOS, GaN-SiC, GaAs technologies**
 - Process upgrades in GaN-SiC HEMT (on-going)
 - Competitive forces (>10+ GaN foundries, 3-4 will win)
 - High-Power RF is not a fabrication factor filler
 - Logistical migration does play a role in longevity
 - **Solid State continues to erode Tubes (Mil/Aero, Comm'l Radar)**
 - **Tubes value hard to beat for certain applications**

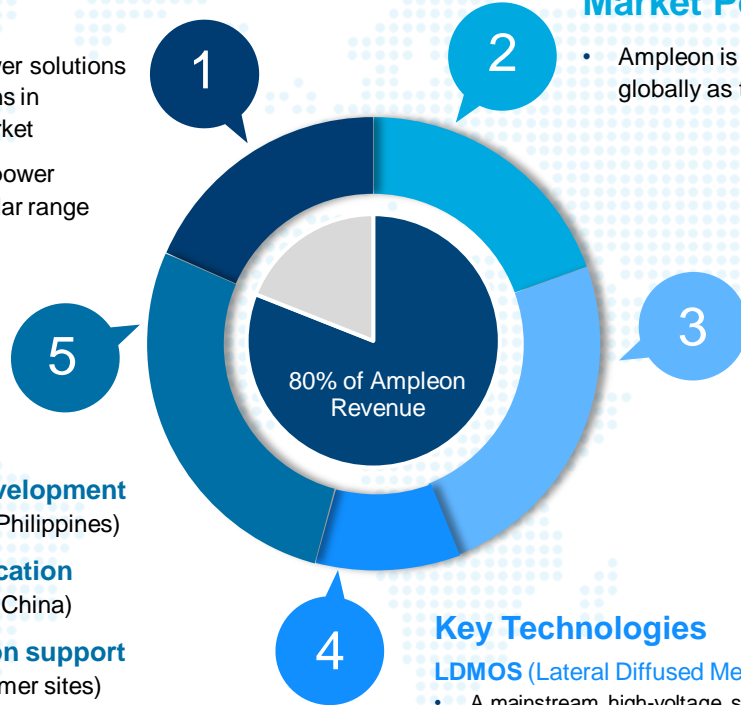
Mobile Broadband (MBB - Telecom)

End Market

- Radio Frequency (RF) power solutions for 4G and 5G base stations in Wireless infrastructure market
- The total addressable RF power market size is in billion-dollar range

R&D

- **Technology development** (Netherlands and Philippines)
- **Design & Application** (Netherlands, US, China)
- **Field Application support** (global, incl. customer sites)



Market Position

- Ampleon is in **Top 3 RF power supplier** globally as the LDMOS market leader

Market Segments

Small cell base stations

- High efficiency integrated LDMOS amplifiers up to 20 W

mMIMO base stations (16T to 64T)

- Integrated LDMOS and GaN amplifier solutions up to 120 W

Macro base stations (2T to 8T)

- LDMOS and GaN RF amplifiers up to 900 W

Key Technologies

LDMOS (Lateral Diffused Metal Oxide Semiconductor)

- A mainstream high-voltage silicon technology for RF power amplifiers

GaN (Gallium-Nitride on a silicon-carbide (SiC) substrate)

- Driving signal bandwidth, power density & efficiency in RF power

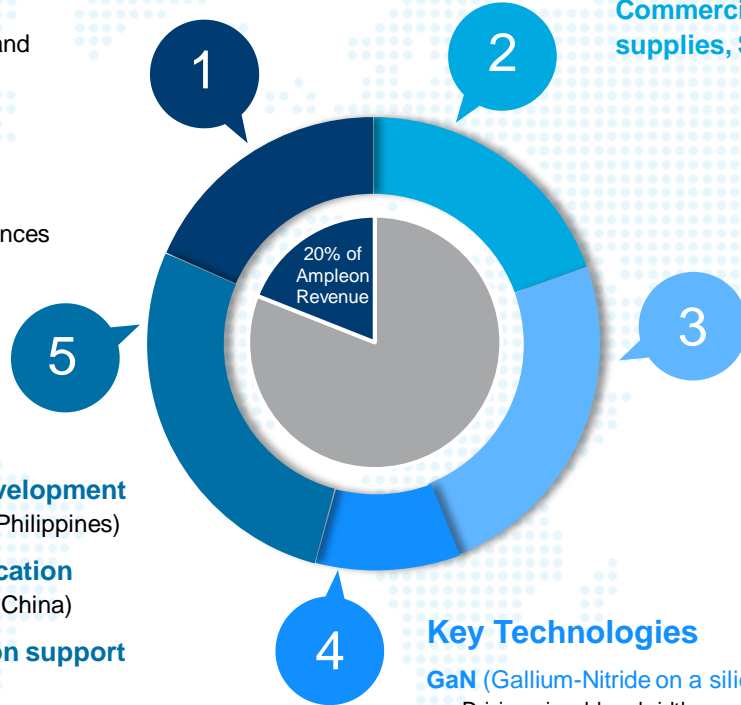
Multi-Market (MM) Wide Variety

End Markets

- High precision semiconductor and microelectronics processing
- Industrial processing
- Air / naval / ground navigation
- UHF / FM and VHF Broadcast
- Non-Cellular Communication
- Domestic & professional appliances
- Scientific research
- High precision medical
- Green energy generation
- Defense equipment

R&D

- **Technology development** (Netherlands and Philippines)
- **Design & Application** (Netherlands, US, China)
- **Field Application support** (global)



Market Position

- Ampleon is in **#1 RF power supplier in Broadcast, Commercial DME / TACAS systems, Industrial RF supplies, Scientific, Medical and Heating** globally

Market Segments

- Broadcast (UHF D-TV, FM / VHF Radio)
- Non-cellular communications: Land mobile radio (LMR), Public safety networks..
- Air / naval navigation: Air Traffic Control (ATC), Naval radars, Distance measuring equipment (DME), Traffic Alert and Collision Avoidance (TACAS) systems
- Military radars, Identification friend or foe (IFF) radars
- Military Communications, Electronic countermeasure (ECM), Electronic warfare (EW)
- Plasma generators (13M .. 2.45G)
- CO2 Laser drivers
- Healthcare (MRI, RF ablation..)
- Scientific: Particle accelerators
- Instrumentation
- Industrial heating
- Cooking and Defrosting

Key Technologies

GaN (Gallium-Nitride on a silicon-carbide (SiC) substrate)

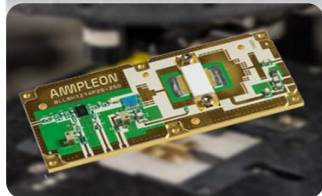
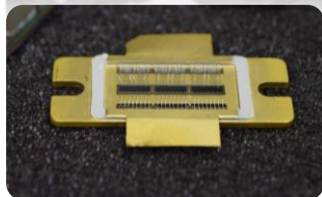
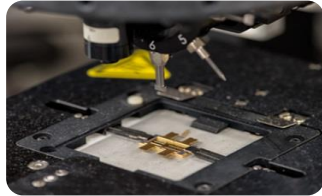
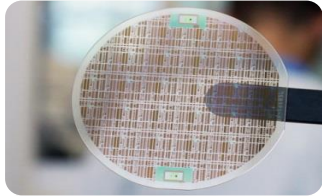
- Driving signal bandwidth, power density & efficiency in RF power

LDMOS (Lateral Diffused Metal Oxide Semiconductor)

- A mainstream high-voltage silicon technology for RF power amplifiers

Multi-Market (MM) offers Radio Frequency (RF) Power Solutions addressing non-Telecom related Segments

Technologies from Wafers to Application Boards



Multi-Market offers a wide range of LDMOS and GaN solutions targeting broadcast, industrial, scientific, medical, heating, non-cellular communication as well as aerospace and defense applications.

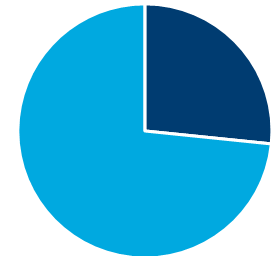
Regional & New Product Share of Revenues

By Region



■ AMEC ■ APAC ■ EMEA ■ GC

By Product Category



■ New ■ Mature

Ampleon's Multi-Market New Wafer Fab Locations

New Wafer Fab Industrial Footprint

LDMOS
10 MHz to 3.8 GHz



Phasing out / Legacy



Recent, New

- Gen9, Gen10, Gen11 32V LDMOS
- Gen9 HV 50V LDMOS
- Gen9 LV 13.6V LDMOS
- ART65 65V Extremely Rugged LDMOS
- ART50 50V Extremely Rugged LDMOS



GaN
10 MHz to 15 GHz



Phasing out / Legacy



New

- NP25-x 0.25um 28V GaN on SiC HEMT
- NP45-x 0.45um 50V GaN on SiC HEMT
- 28V GaAs IPD
- 50V GaAs IPD



Longevity

2 Business Units at Ampleon

Telecom

Unique PNs optimized for Freq Bands, 8dB BO

Life Cycle 3-5 years (Typical)

Business model mostly signature devices to a specific customer requirement

**Longevity is Volume
Demand-Pull Driven**

**Not Recommended for
Non-Telecom Applications**

Multi-Market

Industrial, Avionics, Mil/Aero

Unique PNs sold from catalog or extension to the catalog for Pulsed, linear & CW Applications.

Medium Volume, High Production Mix

Life Cycle 15+ years

Longevity Statement

Type Number	Launch Date	Longevity Date	Longevity Duration
ART1SOFE	2020/12/04	2035/12/05	15 years
ART1KGFH	2020/09/15	2035/09/16	15 years
ART1K6PH	2020/09/17	2035/09/18	15 years
ART1K6PHG	2021/03/04	2036/03/04	15 years
ART2K0FE	2020/05/01	2035/05/02	15 years
ART2K0PE	2020/07/03	2035/07/04	15 years
ART2K0PEG	2020/10/02	2035/10/03	15 years
ART35FE	2020/11/27	2035/11/28	15 years
BLA6G1011L-200RG	2011/10/25	2021/10/25	10 years
BLA6G1011L5-200RG	2011/10/25	2027/10/25	16 years
BLA8G1011L-300	2015/01/23	2025/01/23	10 years
BLA8G1011L-300G	2015/01/23	2025/01/23	10 years
BLA8G1011L5-300	2015/01/23	2025/01/23	10 years
BLA8G1011L5-300G	2015/01/23	2025/01/23	10 years
BLA9G1011L-300	2018/01/08	2033/01/08	15 years
BLA9G1011L-300G	2018/01/08	2033/01/08	15 years
BLA9G1011L5-300	2018/01/08	2033/01/08	15 years
BLA9G1011L5-300G	2018/01/08	2033/01/08	15 years
BLA9H0912L-1200P	2018/10/23	2033/10/23	15 years
BLA9H0912L-250	2019/05/31	2034/05/31	15 years
BLA9H0912L-250G	2019/05/31	2034/05/31	15 years

Listed on Website

Managing Product Life Cycle

Manage from Early Design thru Sunset

Communication Project Volume Forecast w/ Supplier

Longevity

Project schedule ~ Product life cycle

Replacement Products

New Product w/ similar features
Close Equivalent

Die Banking

Hold Wafer Bank in long term storage

Sunset

End of Life

AMPLEON

Q2 2022

Products



ART (ADVANCED RUGGED Technology)

ART2K0 2000W Transistor 65V

- (B_{VDSS}) of 200V min
- 65:1 VSWR Withstand Capability
- Low Coss enables peak efficiencies <400MHz

- Vdd 65V
- 1 thru 400MHz
- Gp~25dB
- Efficiencies up to 85%
- VSWR Withstand 65:1

Packages



SOT539A
ART2K0FE



SOT539B
ART2K0FES



SOT1248C
ART2K0FESG

ART1K6 1600W Transistor 55V

- (B_{VDSS}) of 180V min
- 65:1 VSWR Withstand Capability
- Low Coss enable peak efficiencies < 450MHz

- Vdd 50V for 1400W
- Vdd 55V for 1600W
- 1 thru 450MHz
- Gp~25dB
- “Drop in” replacement to BLF188
- Efficiencies up to 85%
- VSWR Withstand 70:1

Packages



SOT539A
ART1K6FH



SOT539B
ART1K6FHS



SOT1248C
ART1K6FHSG

Extremely Rugged Transistors in ceramic

Freq [MHz]	Type Number	Technology	Package	P1dB (W)	V _{DS} (V)	Efficiency (%)	Gain (dB)	Replacing
1-400	ART1K6FH	ART 50V	SOT539A	1600	50/55	77	29	BLF188XR
1-400	ART1K6FHS	ART 50V	SOT539B	1600	50/55	77	29	BLF188XRS
1-400	ART1K6FHG	ART 50V	SOT1248C	1600	50/55	77	29	BLF188XRG
1-450	ART700FH	ART 50V	SOT1214A	700	50/55	81.5/80	27/28.5	BLF184XR
1-450	ART700FHS*	ART 50V	SOT1214B	700	50/55	81.5/80	27/28.5	BLF184XRS
1-450	ART700FHG*	ART 50V	SOT1214C	700	50/55	81.5/80	27/28.5	BLF184XRG
1-400	ART2K0TFES*	ART 65V	ACC1230-6F	2000	65	78	27	
1-400	ART2K0TFEG*	ART 65V	ACC1230-6G	2000	65	78	27	
1-400	ART2K0FE	ART 65V	SOT539A	2000	65	78	27	
1-400	ART2K0FES	ART 65V	SOT539B	2000	65	78	27	
1-400	ART2K0FEG	ART 65V	SOT1248C	2000	65	78	27	
1-650	ART150FE	ART 65V	SOT467C	150	65	74.6	30.6	BLF573;BLF881**
1-650	ART35FE	ART 65V	SOT467C	35	65	78	30.4	BLF571

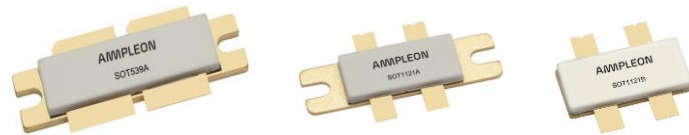
*Coming soon

**Up to 650MHz applications



Wideband LDMOS Transistors in ceramic Packages

Freq [MHz]	Type Number	Technology	Package	P1dB (W)	V _{DS} (V)	Efficiency (%)	Gain (dB)	Recommended driver	Replacement for
1-700	BLF978P	Gen9	SOT539A	1200	50	80	25.5	BLP15H9S30(G)	BLF578
1-700	BLF974P	Gen9	SOT539A	500	50	77	25	BLP15H9S10(G)	BLF574
1-860	BLF984P(S)	Gen9	SOT1121A(B)	450	50	77	25	BLP15H9S10(G)	BLF884P
1-1500	BLF647P(S)	Gen7	SOT1121A(B)	200	32	70	18	BLP0427M9S20	BLF647 (ICN8)



High Efficiency Amplifier Design with BLF978P for 500 MHz Particle Accelerators

- Suitable for pulsed and CW operation
- Optimized efficiency up to 700 MHz with 45 V supply
- High power gain > 22 dB with optimal gain flatness
- Low thermal resistances

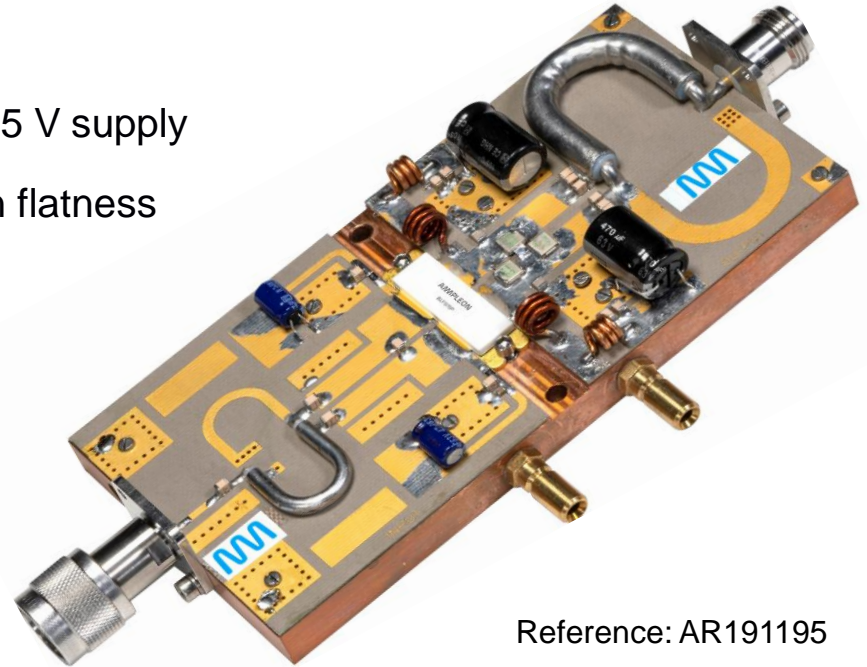
@45 V, CW pulsed

Frequency (MHz) 500

P_{1dB} (W) 812

Gain@P_{1dB} (dB) 22.3

Efficiency@P_{1dB} (%) 71.6



Reference: AR191195

High Efficiency Amplifier Design with BLF974P for 230 to 236 MHz Scientific Applications

- Suitable for Pulsed and CW operation
- Optimized for highest efficiency up to 700 MHz
- High power gain > 25 dB with optimal gain flatness
- Low thermal resistance

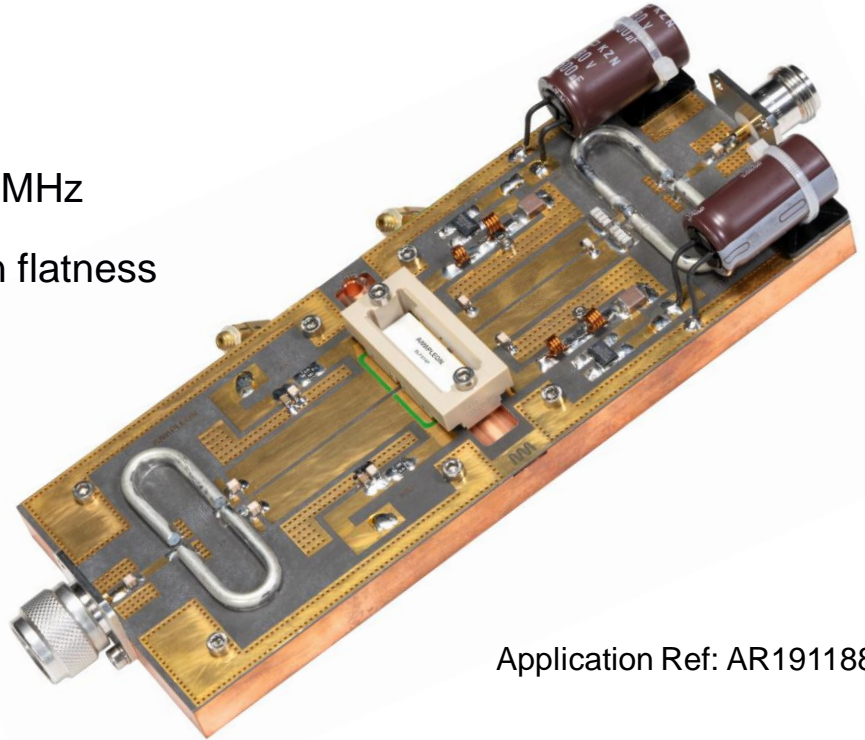
@50 V CW pulsed

Frequency (MHz) 230 - 236

P_{1dB} (W) 650

Gain@P_{1dB} (dB) 27.4

Efficiency @P_{1dB} (%) 76.7



Application Ref: AR191188

High Power compact 325 MHz Particle Accelerator, Design based on ART1K6PH

- High power: 1500 Watts at 325 MHz
- Small footprint particle accelerator design
- Supply up to 55 V
- Robust design withstanding >65:1 VSWR
- Packed in plastic OMP1230 for lowest R_{th}

@53 V	CW	CW pulsed
Frequency (MHz)	325	325
P_{3dB} (W)	1390	1520
Gain @P_{3dB} (dB)	19.5	20.2
Efficiency @P_{3dB} (%)	68.4	73.6



Application Ref: AR201041

Ultra compact design for 13.56MHz based on ART2K0FE designed for max power

- Full CW application for 13.56MHz
- Optimized design for max power 1600W @ 60V
- Changing BOM of application the same PCB design can be tuned for max CW power or tuned to max eff
- Lowest volume 152x60X30mm due to unique patented multilayer coplanar balun

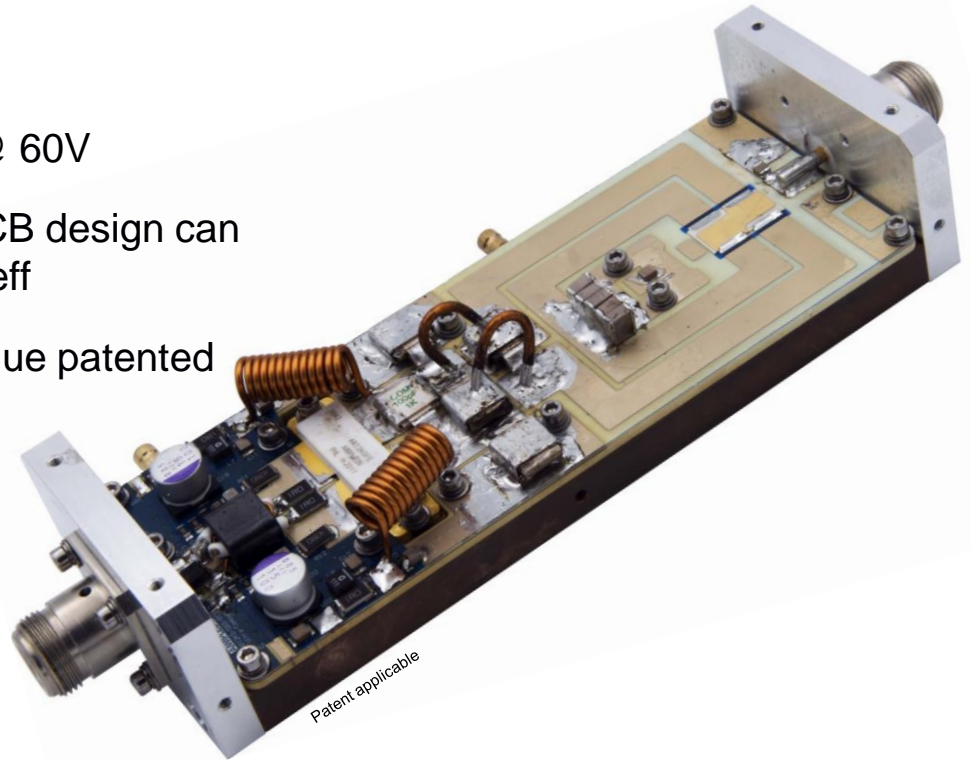
@60 V, CW

Frequency (MHz) 13.56

Power @P_{3dB} (W) 1600

Gain @P_{1dB} (dB) 29.6

Efficiency@P_{3dB} (%) 76.5



Application Ref: AR211135

Ultra compact design for 13.56MHz operating in Class E for max efficiency with ART2K0FE

- Full CW application for 13.56MHz
- Tuned for max efficiency 90% @ $P_{6dB}=1005W$
- Changing BOM of application the same PCB design can be tuned for max CW power or tuned to max eff
- Lowest volume 152x60X30mm due to unique patented multilayer coplanar balun

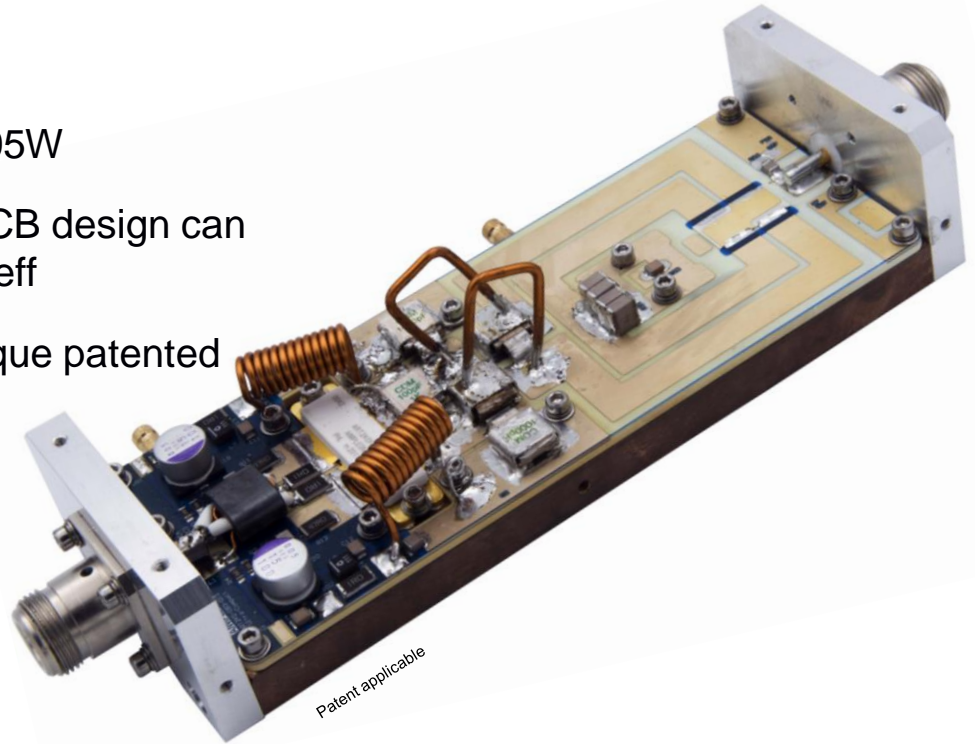
@60 V, CW

Frequency (MHz) 13.56

Power @ P_{6dB} (W) 1005

Gain @ P_{1dB} (dB) 29.6

Efficiency@ P_{6dB} (%) 90



Application Ref: AR211135

New GaN Product Portfolio in Ceramic Packages

Freq [MHz]	Type Number	Package	Psat (W)	V _{DS} (V)	Efficiency (%)	Gain (dB)	Recommended driver	Sample Availability
1-3500	CLF3H0035(S)-100	SOT467C(B)	100	50	60	14.2	CLF3H0060(S)-30	Yes
1-6000	CLF3H0060(S)-30	SOT1227A(B)	30	50	60.4	16.7		Yes
900-1400	CLL3H0914L(S)-700	SOT502	700	50	68	16.5	BLP15H9S30	Yes
2700-3100	CLS3H2731L(S)-700	SOT502	700	50	55	14		3Q
1-6000	CLF3H0060L(S)-10	SOT1227A(B)	10	50	60	14		Yes
2400-2500	CLF2425H4LS300P	SOT1214	350	50	70	14	BLM2425M9S20	3Q
1300	CLF13H4LS700P	SOT1214	700	50	73	15	BLP15H9S30	4Q



Tom Dekker

Tom.dekker@ampleon.com

