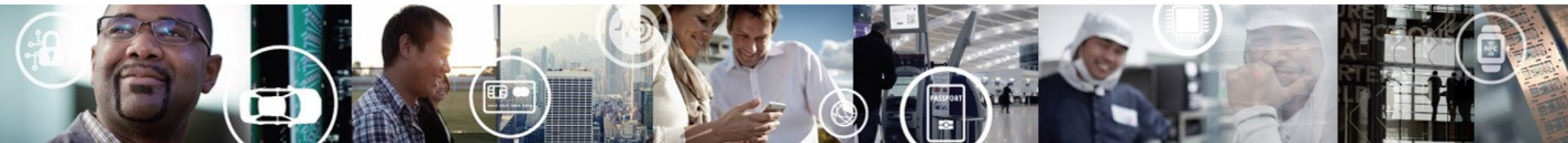


EU-NET-T1756

RF POWER SOLUTIONS FOR INDUSTRY, AVIONICS, MILITARY, CELLULAR AND COOKING MARKETS

LAURENT GAUTHIER - FAE - RF POWER
MARCH 22nd, 2016

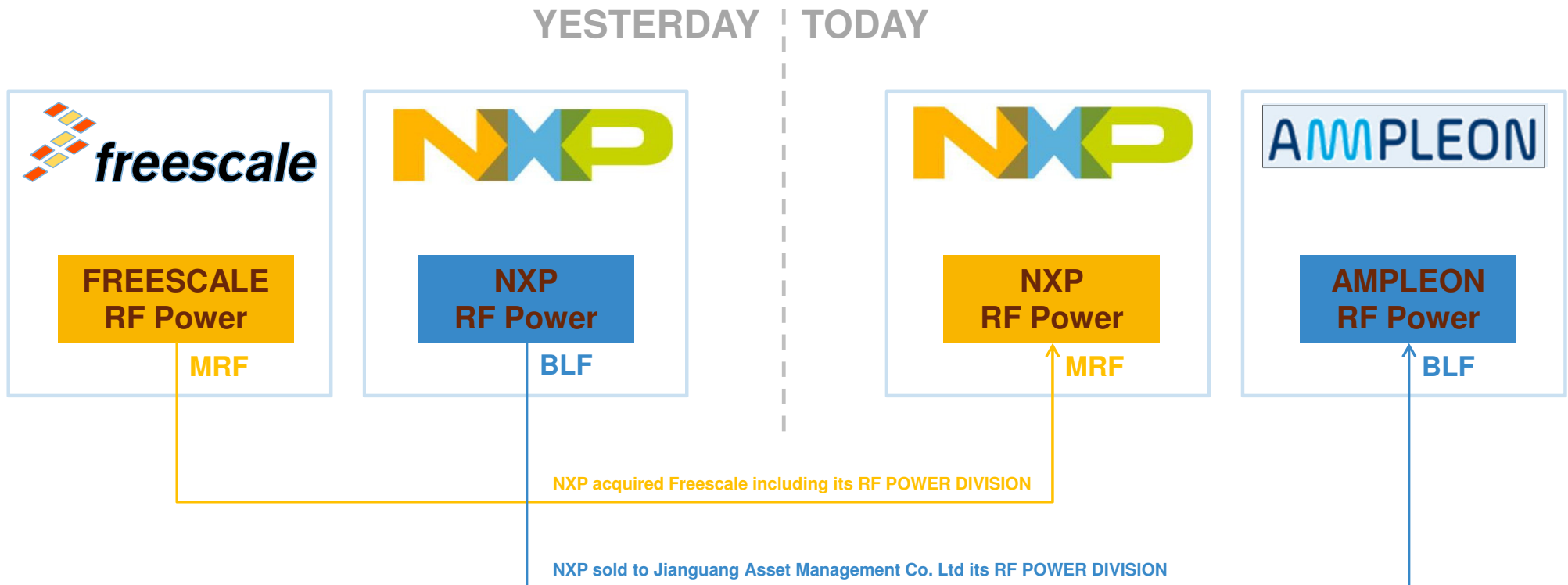


SECURE CONNECTIONS
FOR A SMARTER WORLD

Agenda

- RF Org
- RF Power for Industry
- RF Power for Avionics
- RF Power for Mobile Radio
- RF Power for RF Cooking Oven
- RF Power for Cellular
- RF Power for Military applications

NXP - Freescale merger : Impact on RF Power



NXP 5 BUSINESS UNITS

Security & Connectivity

Best-in-class security, contactless performance and the most complete solutions to produce unmatched mobile and IoT solutions

Automotive

Sensor and processing technology driving all aspects of the secure connected cars of today and the autonomous cars of tomorrow

RF Power

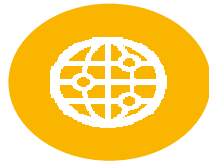
Solutions spanning the wireless infrastructure, industrial, broadcast, mobile radio, aerospace & defense and cooking markets

Digital Networking

High-performance multicore solutions that transport, analyze and secure data from the edge of the network to the cloud

Standard Products

Leading supplier for all major automotive, identification, wireless infrastructure, industrial, mobile, lighting, consumer and computing manufacturers



NXP RF Power Markets

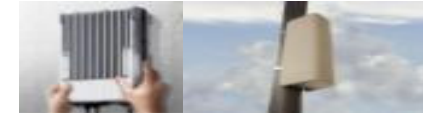
Cellular Power Amplifiers

- Base Stations
- Repeaters
- From GSM to LTE



Small Signal RF

- Pico-cells
- Pre-drivers
- Novel PA components



ISM (Industrial, Scientific, Medical)

- Laser/Plasma generator
- Medical
- Particle Accelerators
- Industrial Heating



Broadcast

- FM
- VHF TV
- UHF TV



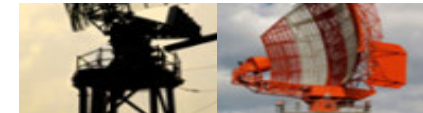
Land Mobile Radio

- Handheld
- Vehicle
- Base stations



Commercial Avionics

- Distance Measuring
- Transponders
- L- and S-band Radars



RF Cooking

- RF Ovens:
 - Commercial
 - Consumer



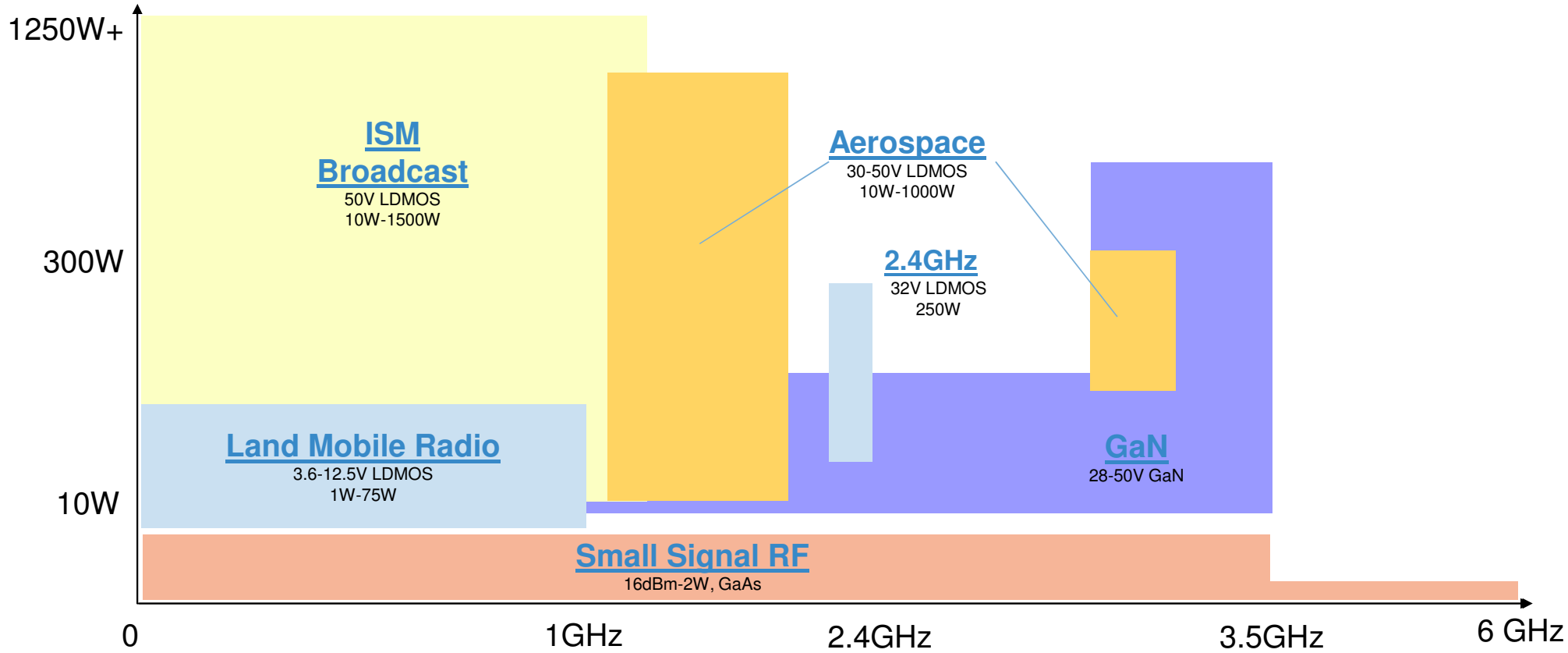
Military & Defense

- Radar
- Communications
- Electronic Warfare



Frequency Coverage

(without Cellular)



RF POWER FOR INDUSTRY



SECURE CONNECTIONS
FOR A SMARTER WORLD

NXP Strategy for ISM Applications

- **2010-2013**: Released industry-first portfolio of 5 extremely rugged transistors in ceramic from 25 to 1250 W.



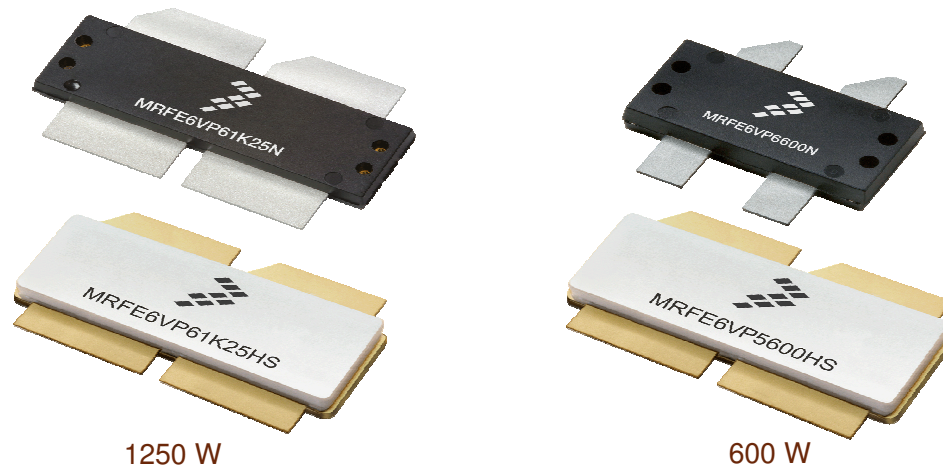
- **2013-2015**: Complemented this portfolio with 5 extremely rugged transistors in plastic package enabling low thermal resistance



- **2016**: Introducing the 1500 W **MRF1K50H** and **MRF1K50N**, industry's highest power transistors for ISM, FM broadcast and sub-GHz aerospace applications. Pin-compatible (same PCB) with existing solutions.



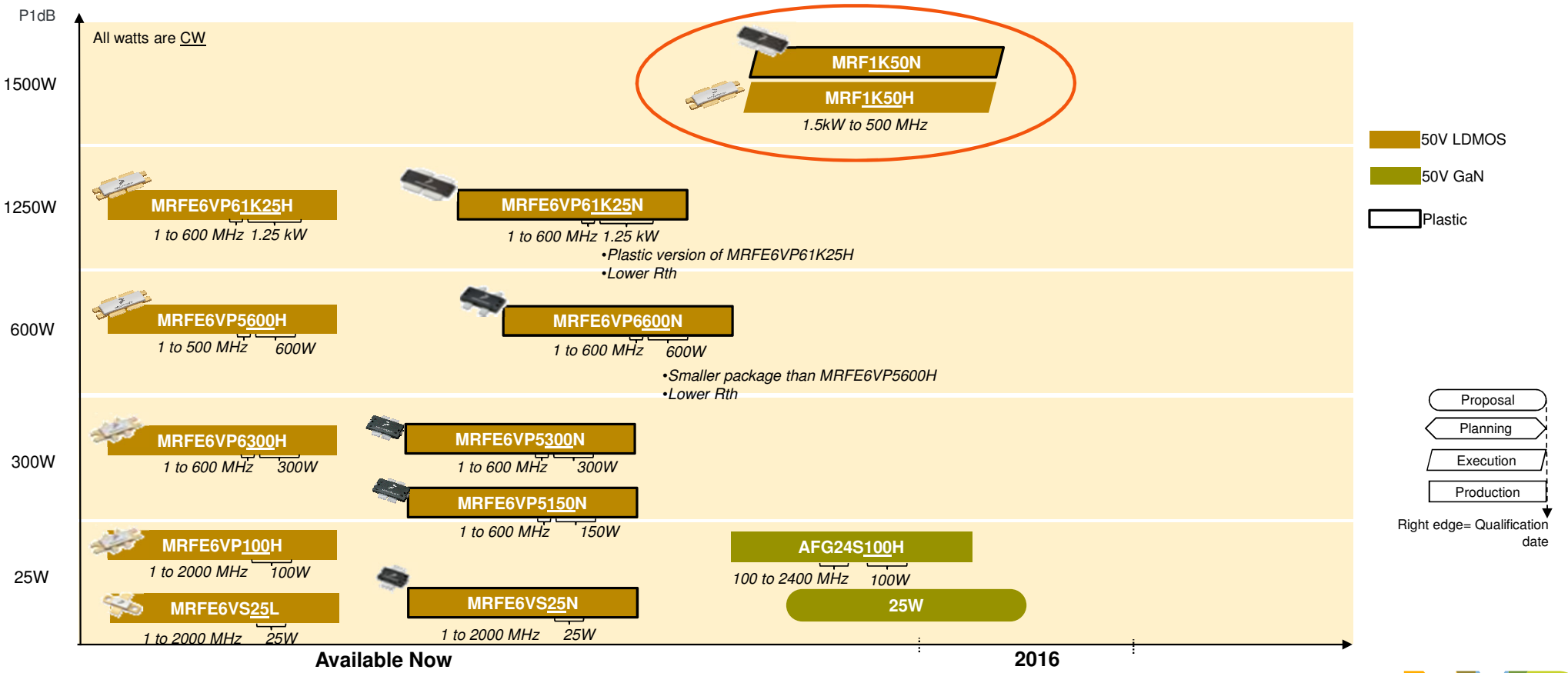
NXP Differentiator : More Power with Plastic Packaging



Top benefits of plastic over ceramic:

- Lower **thermal resistance** (30%), enabling smaller heatsink or better reliability
- Tighter **dimensional tolerance**, enabling assembly automation
- Same thermal expansion (copper on copper), enabling better reliability (no **CTE** mismatch at solder joint)
- Tin-platted** instead of gold-platted: more reliable soldering
- Over-molded** instead of air-cavity: enables washing the board after assembly

ISM : <600 MHz



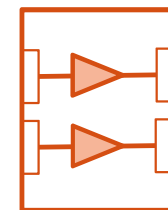
MRF1K50H / MRF1K50N

1.50 kW LDMOS Transistor

- Unmatched Input and Output
- Push-Pull
- Housed in an NI-1230 air-cavity ceramic package (H version) or OM-1230 over molded plastic (N version)
 - 30% lower Rjc with plastic version
- Extreme Ruggedness: 65:1 VSWR
- Product Longevity Program: warranted availability until 2031
- Recommended Driver: MRFE6VS25N (25W)

Planned Reference Circuits

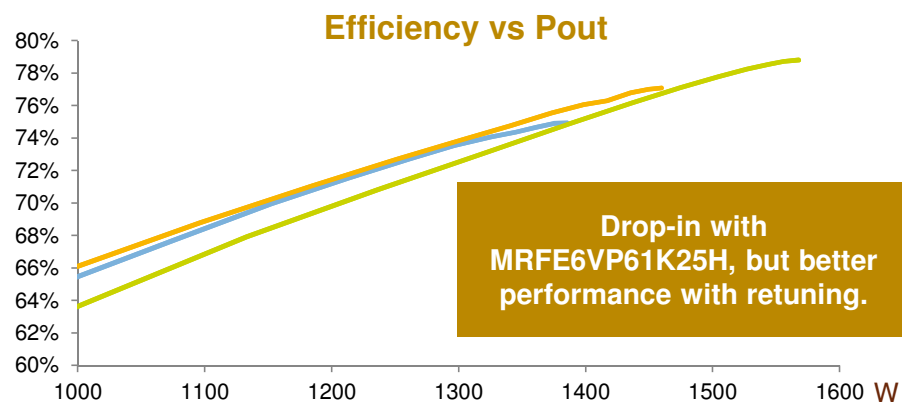
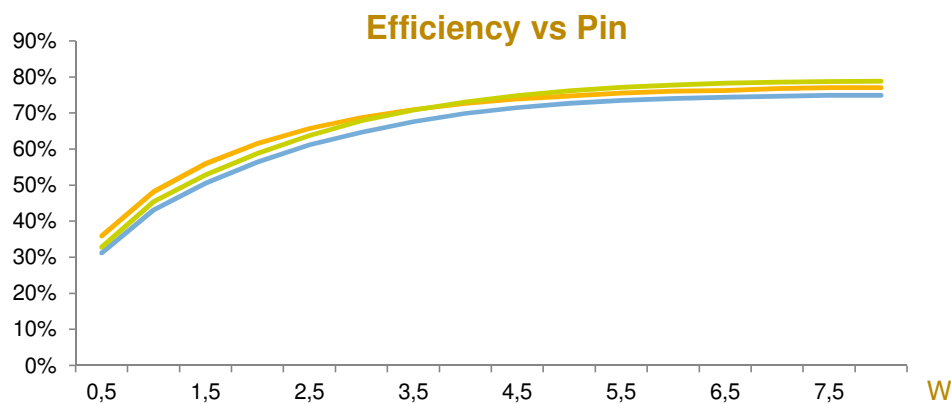
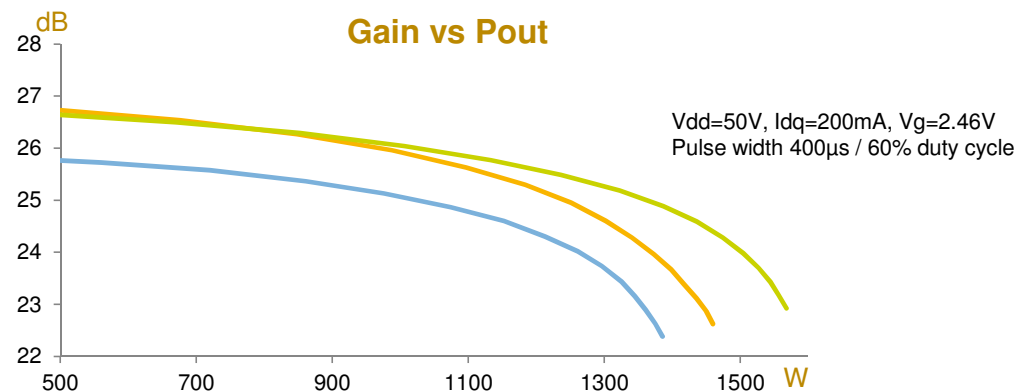
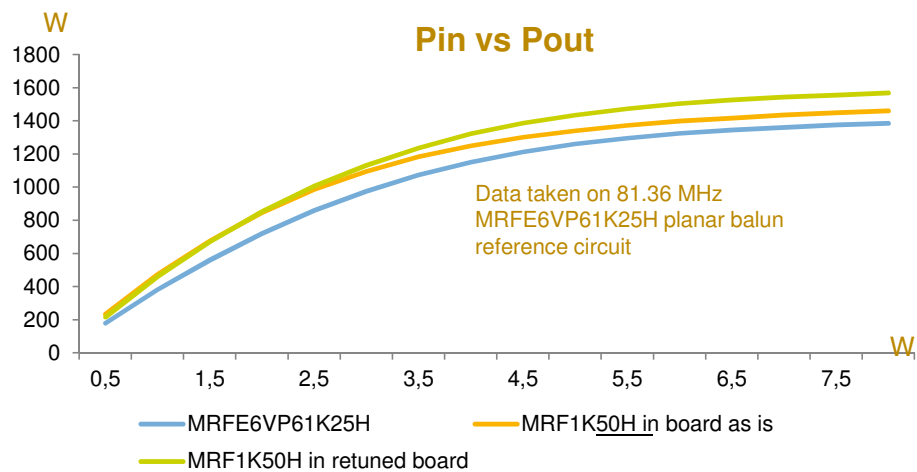
Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)
81.36 MHz	Laser	1500 CW	23.3	77.4
87.5 MHz	FM (88-108 MHz circuit)	1345 CW	23.5	81.2
98 MHz		1526 CW	24.1	79.4
108 MHz		1389 CW	23.6	80.0



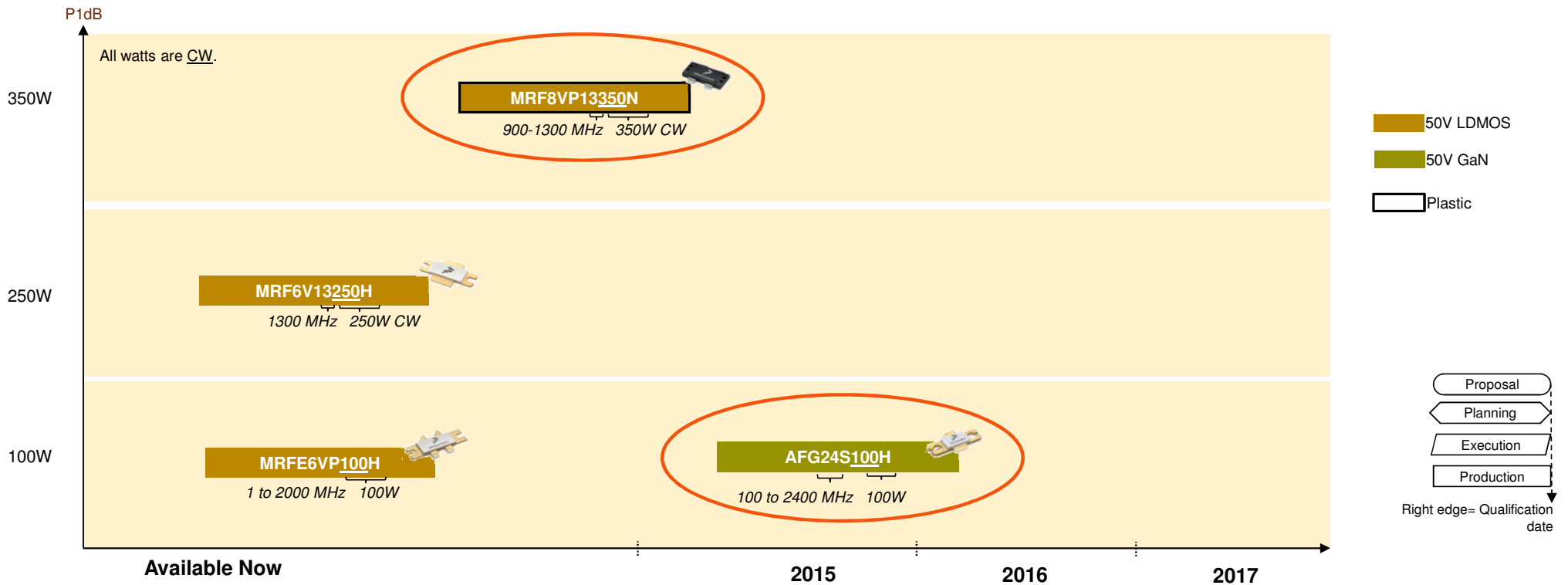
Comparison with Existing Solutions

	MRFE6VP61K25H	Competitor	MRF1K50H
Rated Output power	1250W	1400W	1500W
Narrowband performance @ 81.36 MHz	1350W CW 23.5 dB gain 75 % eff.	1200 W CW 27.1 dB gain 77.8 % eff.	1500 W CW 23.3 dB gain 77.4% eff.
Wideband performance over 88-108 MHz	1250W CW 23 dB gain 75 % eff.	1320 W CW 22.5 dB gain tbd eff.	1520 W CW 24.1 dB gain 79.4% eff.
VSWR max	65:1	65:1	65:1

MRF1K50H Performance Comparison @ 81.36 MHz



ISM : 915 MHz & 1300 MHz



MRF8VP13350N

350 W LDMOS Transistor in Plastic

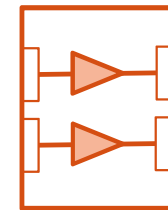
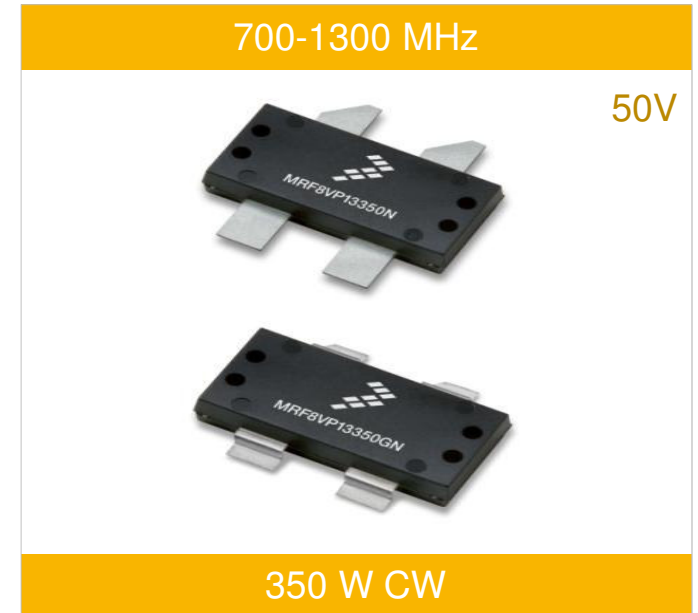
NEW

Designed for industrial heating/welding at 915 MHz and particle accelerators at 1300 MHz

- Input pre-matched
- Push Pull
- Housed in OM-780 over-molded plastic package
- High ruggedness: 10:1 VSWR
- Product Longevity Program: warranted availability until 2030
- Recommended driver: MRFE6VS25N (25W)

Available Reference Circuits

Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)	Size (inch)
915 MHz	Indus. heating	350 CW	20.7	67.5	1.6 x 2.0
1300 MHz	Synchrotron	350 CW	17.2	57	3 x 4



NEW

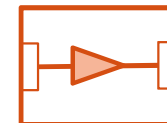
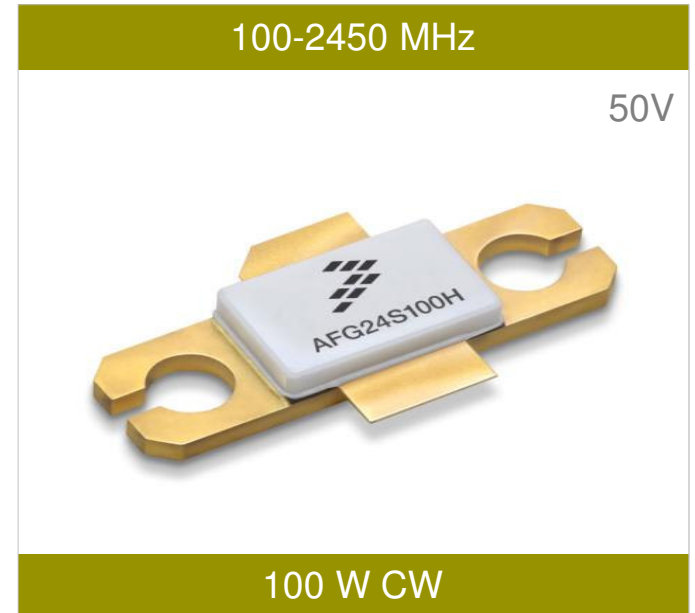
AFG24S100H

100 W CW Wideband GaN Transistor

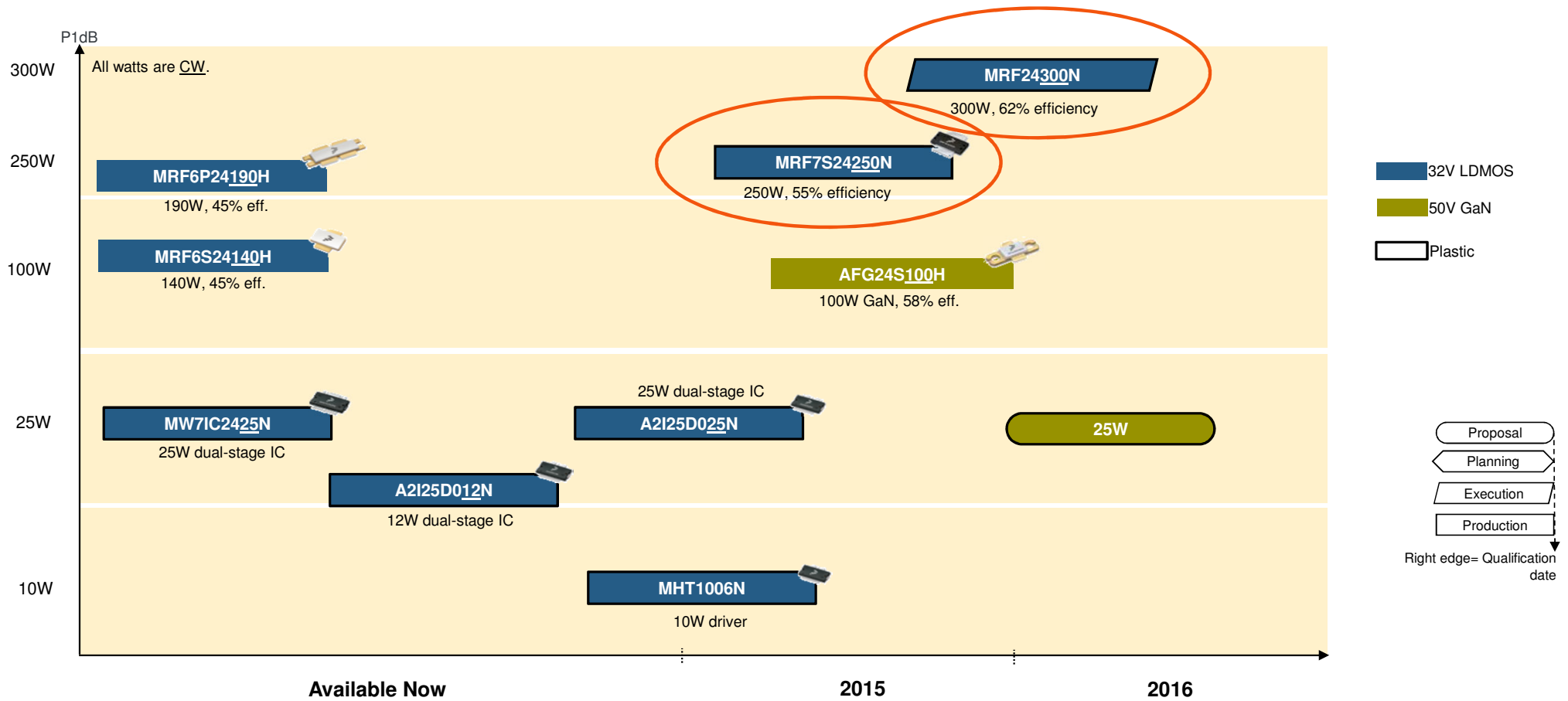
- Advanced GaN on SiC
- 100W CW across 100-2450 MHz
- Housed in NI-360 air-cavity ceramic package
- High Ruggedness: 20:1 VSWR
- Product Longevity Program: warranted availability until 2025
- Typical Applications
 - EMC testers
 - Scientific research
 - Professional mobile radios
 - Wideband drivers
 - General purpose wideband amplifiers

Planned Reference Circuits

Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)
200-2500	Land Mobile BTS	80 W CW	12	45



2.45 GHz Portfolio



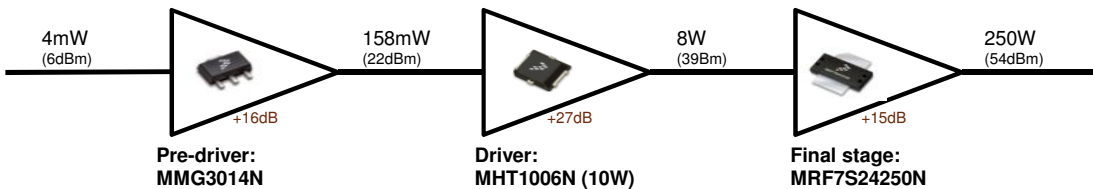
NEW

MRF7S24250N

250 W LDMOS Transistor for 2.4 GHz

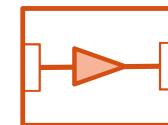
- Input and Output pre-matched
- Single Ended
- Housed in OM-780 over-molded plastic package
- High ruggedness: 10:1 VSWR
- Product Longevity Program: warranted availability until 2025

Typical Line Up



Available Reference Circuits

Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)	Size (inch)	Link
2450	Industrial heating	250 CW	15	55	2 x 3	Go
2450	3-stage line-up	250 CW	44	51	2 x 3	Go



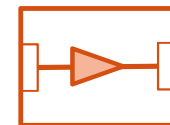
MRF24300N

300 W LDMOS Transistor for 2.4 GHz

- Input and Output pre-matched
- Single Ended
- Housed in OM-780 over-molded plastic package
- Ruggedness: circulator needed at 32V
- Highest efficiency on the market

Planned Reference Circuits

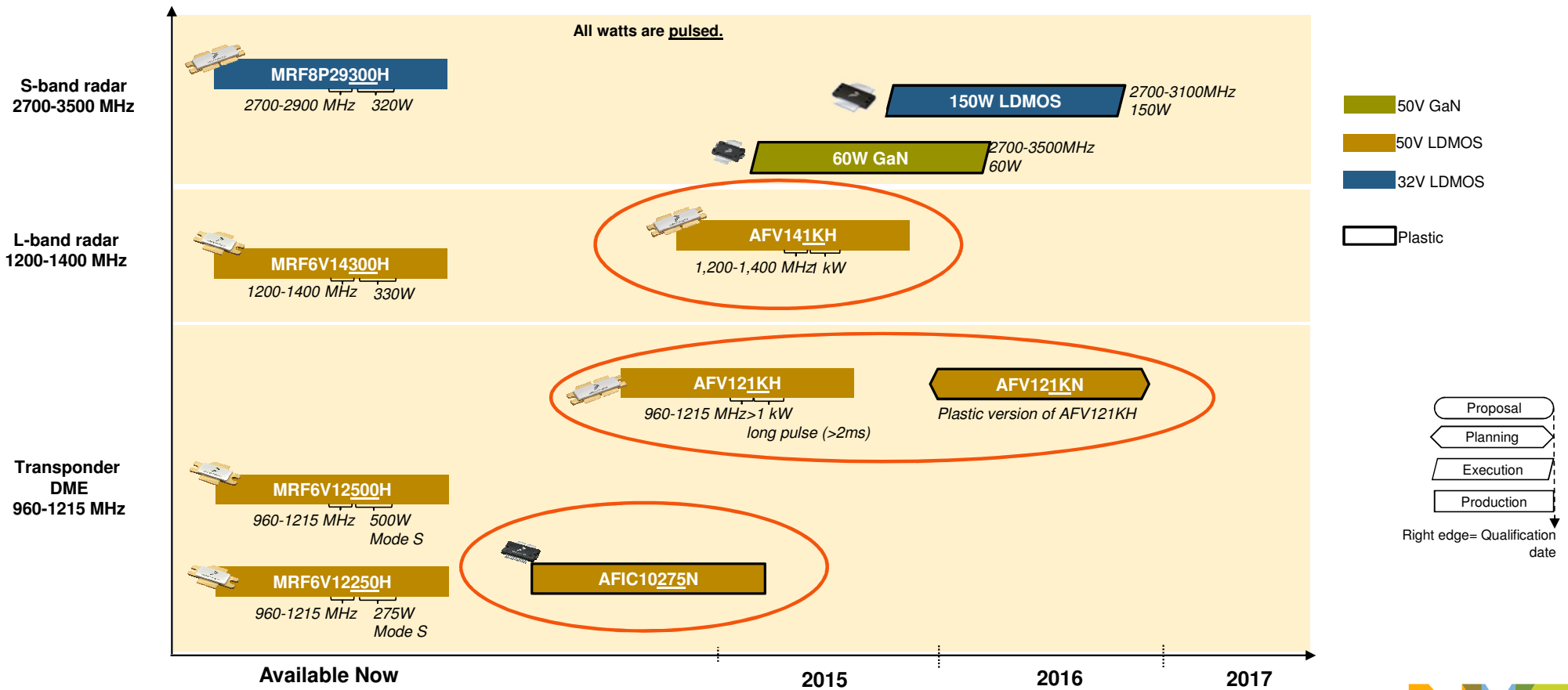
Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)	Size (inch)
2450	Industrial heating	300 CW	15	60	2 x 3



RF POWER FOR AVIONICS



Aerospace : Final Stage Transistors



AFV141KH

1 kW LDMOS Transistor for L-Band Radar

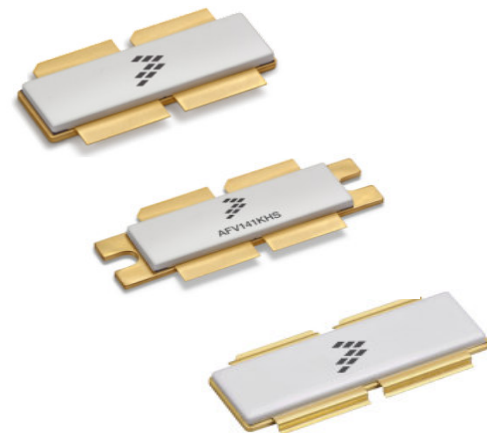
- New generation: Airfast
- Pre-Matched Input and Output
- Housed in NI-1230 air-cavity ceramic package
- High Ruggedness: 20:1 VSWR
- Recommended driver: MRF6VP3091N (60W in L-band)

Planned Reference Circuits

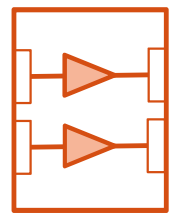
Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)
1200-1400	L-band radar	1kw	15	45

1200-1400 MHz

50V



1 kW Pulse



NEW

AFV121KH

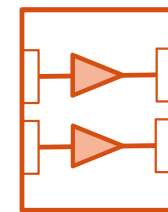
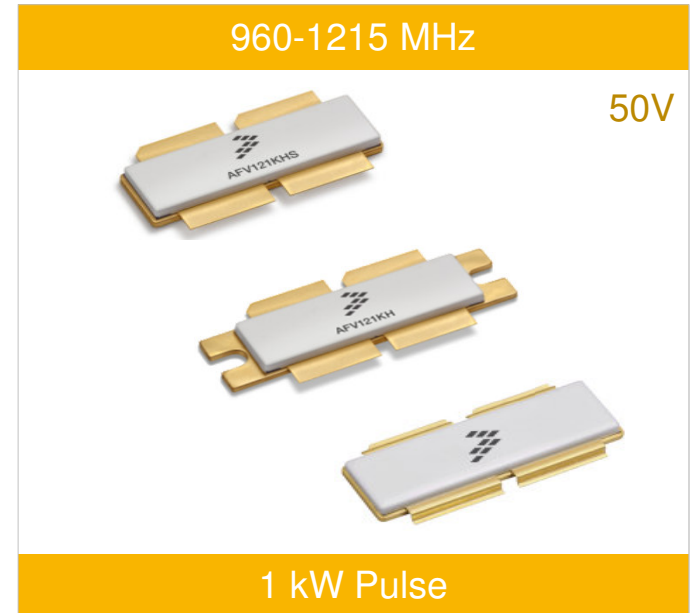
1 kW LDMOS Transistor for avionics applications

- New generation: Airfast
- Pre-Matched Input and Output
- Designed for long-pulse applications (>2ms)
- Housed in NI-1230 air-cavity ceramic package
- High ruggedness: 20:1 VSWR
- Product Longevity Program: warranted availability until 2030
- Recommended driver: MRFE6VS25GN (25W)

Available Reference Circuits

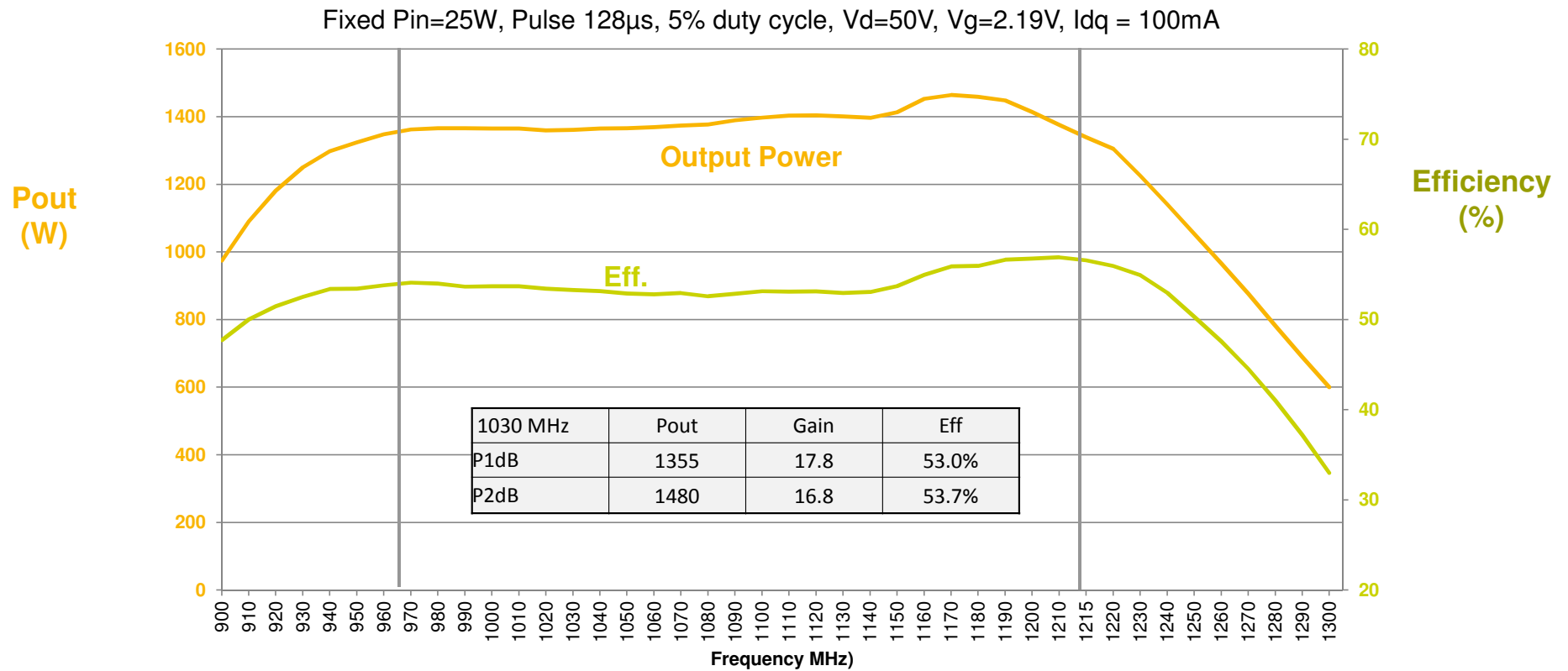
Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)	Size (inch)	Link
960-1215	ADS-B or DME	1200 Pulse	17	51	3 x 4	Go

Soon available in plastic package : AFV121KH



AFV121KH Wideband Performance

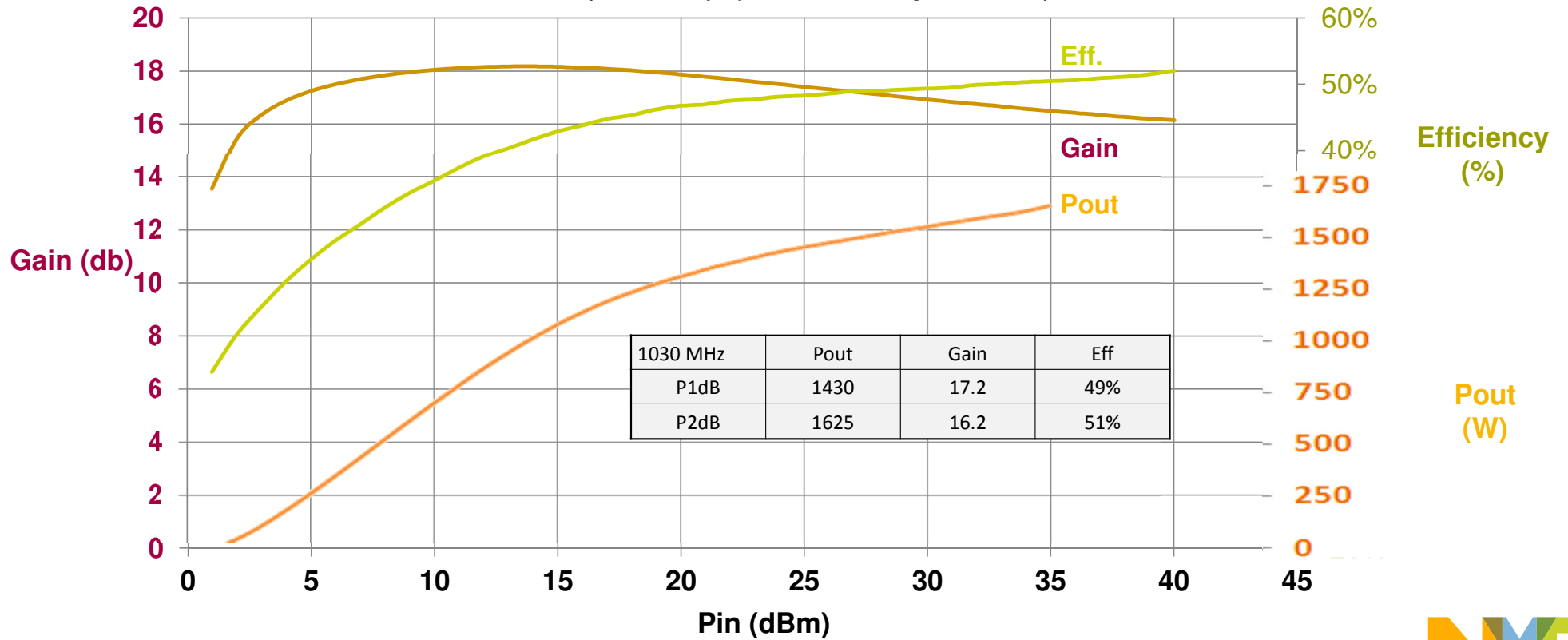
In NXP wideband 960-1215 MHz reference circuit



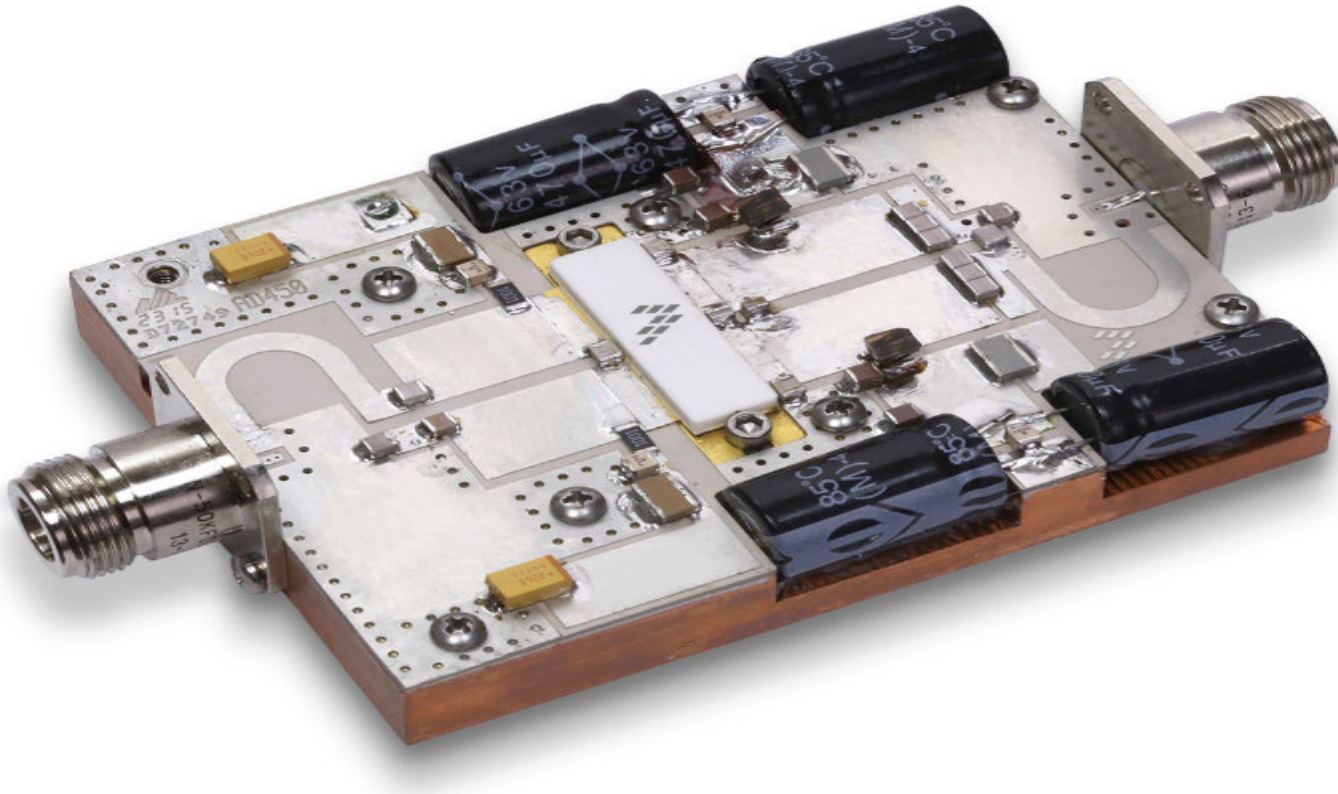
AFV121KH Narrowband performance

In NXP preliminary narrowband 1030 MHz circuit

1030 MHz, Pulse 120μs, 5% duty cycle, Vd=50V, Vg=2.02V, Idq = 100mA



AFV121KH Planar Balun Circuit – Design in Progress



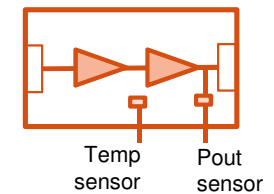
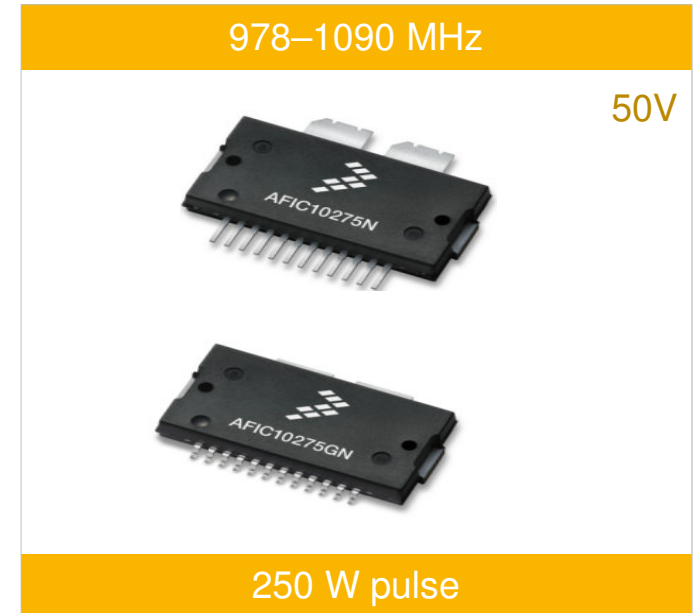
AFIC10275N

Dual-Stage LDMOS Transistor

- New generation: Airfast
- Matched input, unmatched output
- Dual-stage IC: 30.5 dB gain in single package
- Housed in TO-270 over-molded plastic package
- High ruggedness: 10:1 VSWR
- Integrated temperature and output power sensors
- Product Longevity Program: warranted availability until 2030
- Recommended driver: MMG3014N (25dBm)

Available Reference Circuits

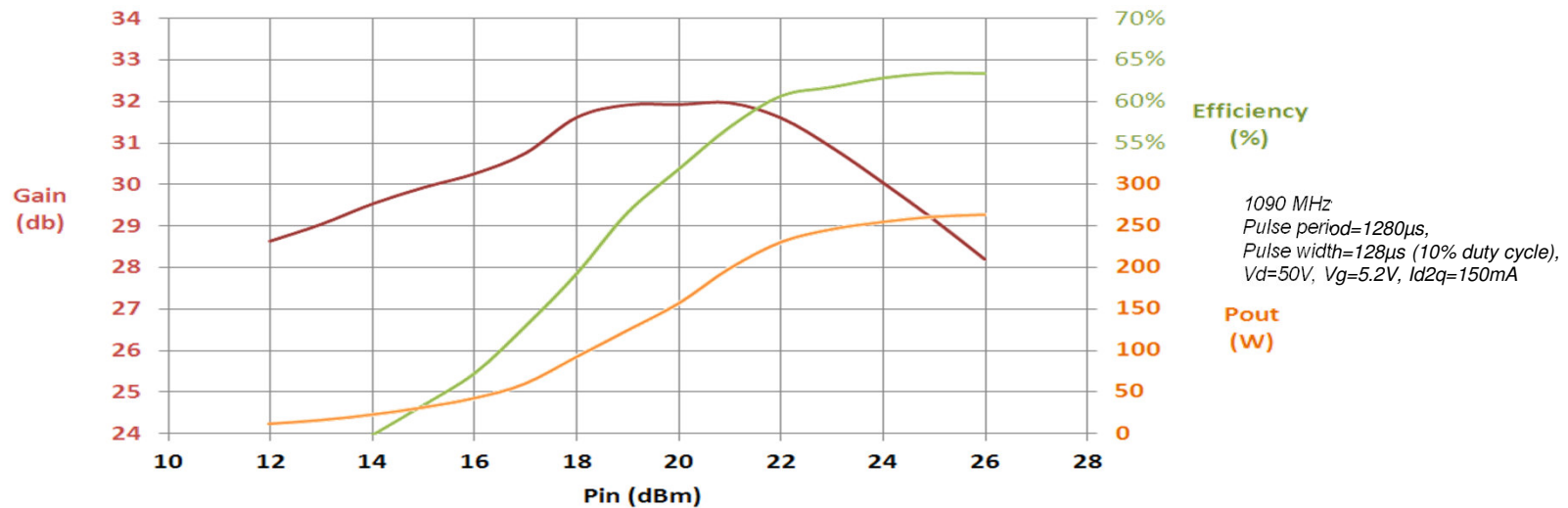
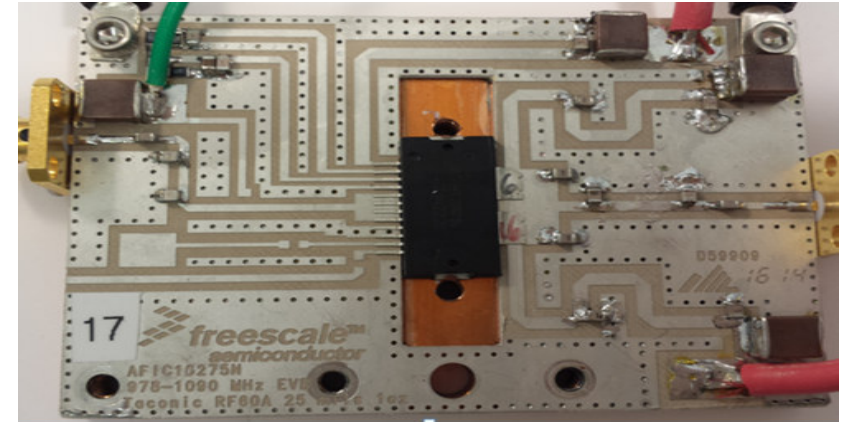
Board Frequency (MHz)	Example of application	Power (W)	Gain (dB)	Drain Eff. (%)	PCB Size (inch)	Link
1090	ADS-B	250 pulse	30.5	62	1.9 x 2.7	Go



AFIC10275N 250W @ 1090 MHz

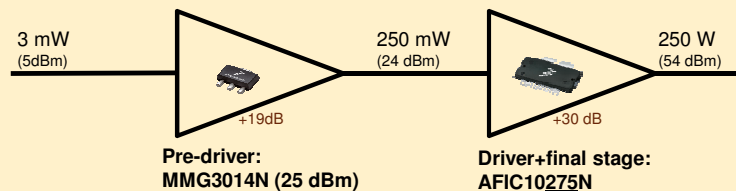
- Frequency: 1090 MHz
- Functional performance @ 50V:
 - Power = 250 W
 - Gain = 30.5 dB
 - Efficiency = 62 %

Size: 1.9 x 2.7" (4.8 x 6.9 cm)

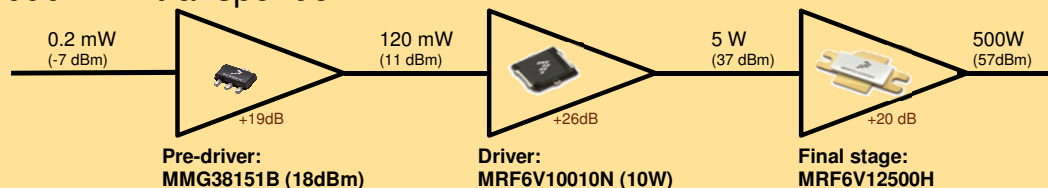


Proposed Line-up for Air Traffic Control

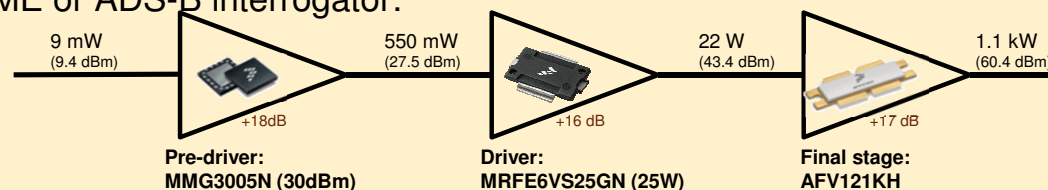
Line-up for **250W** 1090 MHz transponder:



Line-up for **500W** 1090 MHz transponder :

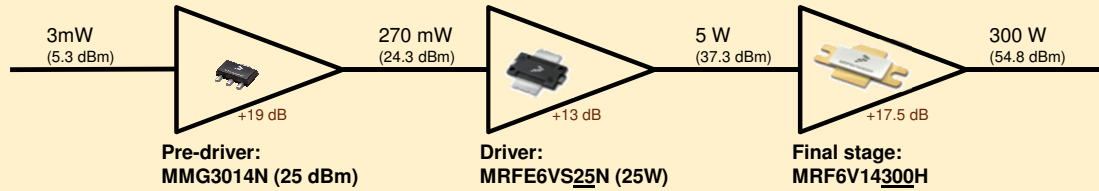


Line-up for **1kW** DME or ADS-B interrogator:

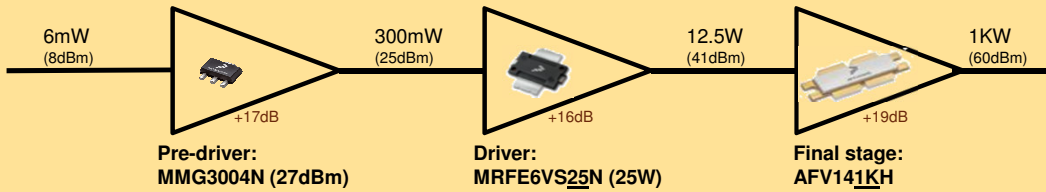


Proposed Line-up for Radars

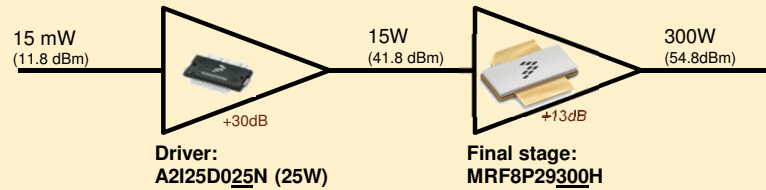
Line-up for 300W L-band:



Line-up for 1kW L-band:



Line-up for 300W S-band:

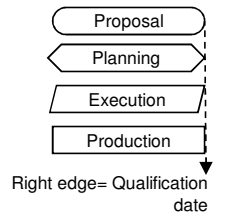
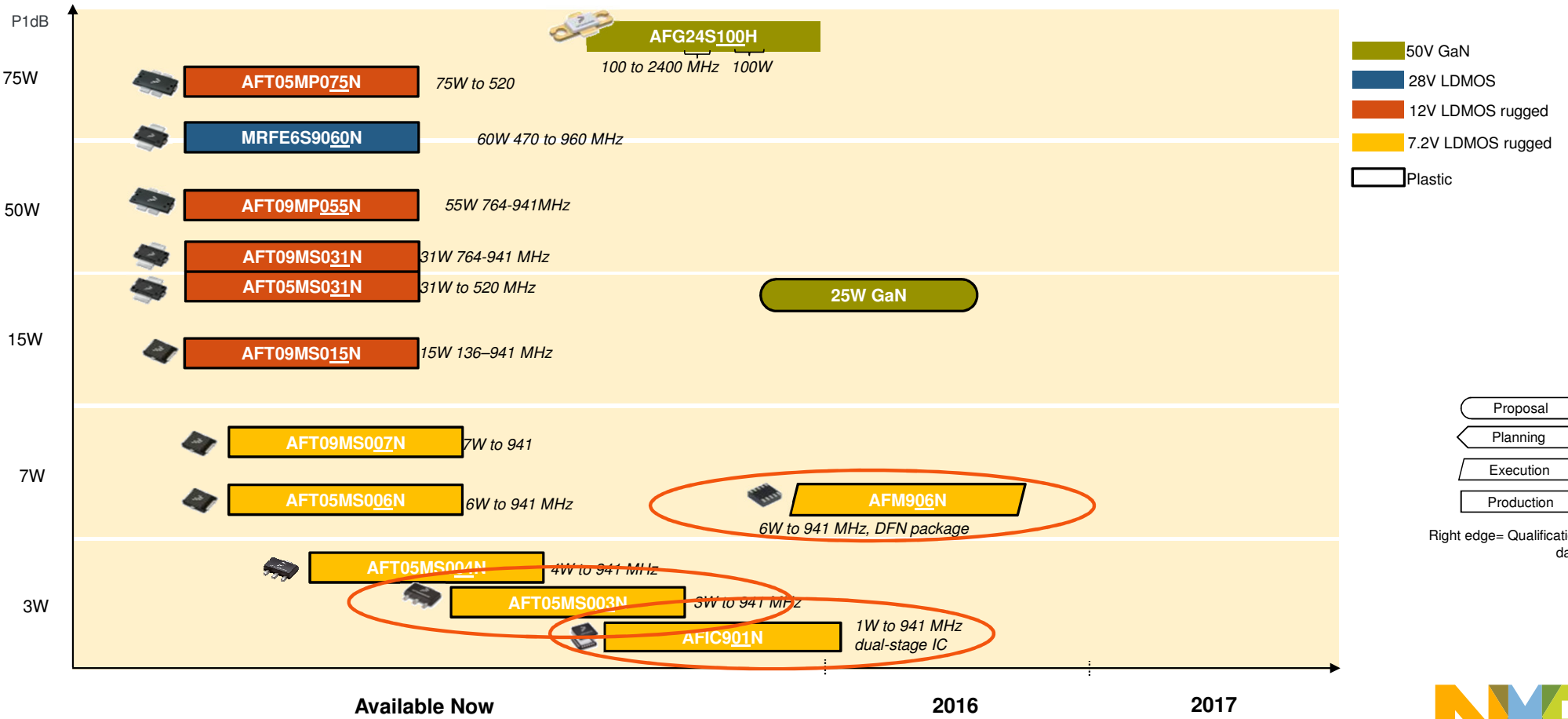


RF POWER FOR MOBILE RADIO



Mobile Radio

All watts are CW.



NEW

AFIC901N

1 W Frequency-Configurable LDMOS RFIC

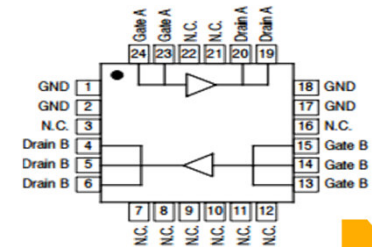
Two-stage LDMOS Driver

- External interstage matching allows optimization for range of voltages and frequencies
- 1W output power
- No driver needed: 0dBm input (30dB gain)
- Housed in a QFN 4 x 4 package
- Extreme Ruggedness: 65:1 VSWR
- Product Longevity program: warranted availability until 2030

Available Reference Circuits

Board Frequency (MHz)	Power (W)	Gain (dB)	Drain Eff. (%)	PCB Size	Link
136-175	1 CW	30.6	62.1	0.83 x 1.88"	Go
350-520	1 CW	27.4	61.5		Go
760 – 870	1 CW	27.6	57.0		

Same PCB used for all reference circuits



AFM906N

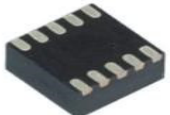
- Unmatched Input and Output
- **Same performance as AFT05MS006N**
- Housed in an DFN 4x6 over-molded plastic package
- Extreme Ruggedness: >65:1 VSWR

Planned Reference Circuit

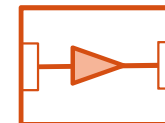
Board Frequency (MHz)	Power (W)	Gain (dB)	Drain Eff. (%)	Size (inch)
135-175	6 CW	14	60	0.83 x 1.86

136-941 MHz

7.5V



6 W CW (P1dB @ 7.5V)



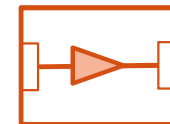
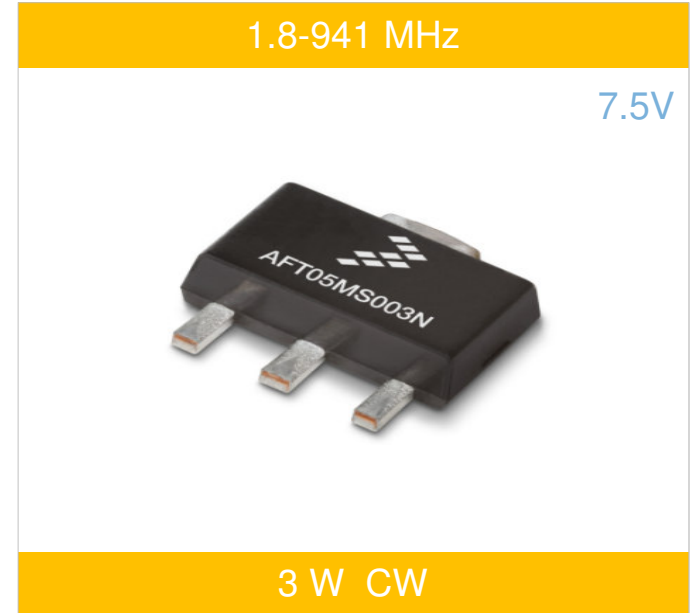
NEW

AFT05MS003N

- Unmatched Input and Output LDMOS transistor
- Housed in an SOT89 over-molded plastic package
- Extreme Ruggedness: handles >65:1 VSWR

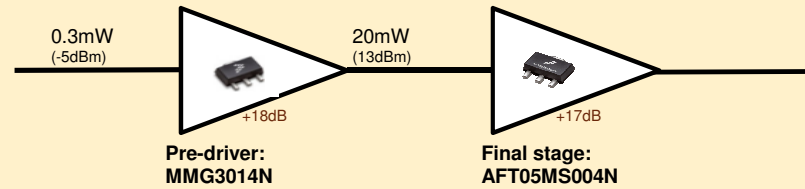
Available Reference Circuits

Board Frequency (MHz)	Power (W)	Gain (dB)	Drain Eff. (%)	PCB Size	Link
136-175	3.4 CW	17.3	67.3	0.83 x 1.86"	Go
350-520	3.4 CW	15.3	75.4	0.83 x 1.86"	Go

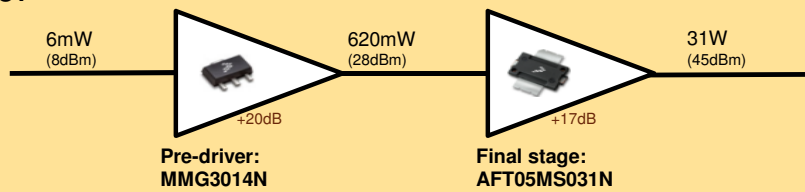


Possible Line-up for Mobile Radio

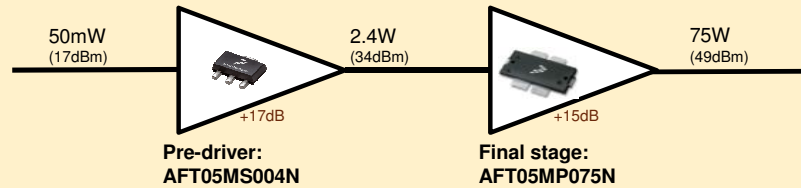
Line-up for **handheld** radio:



Line-up for **mobile** (vehicle) radio:



Line-up for **BTS**:



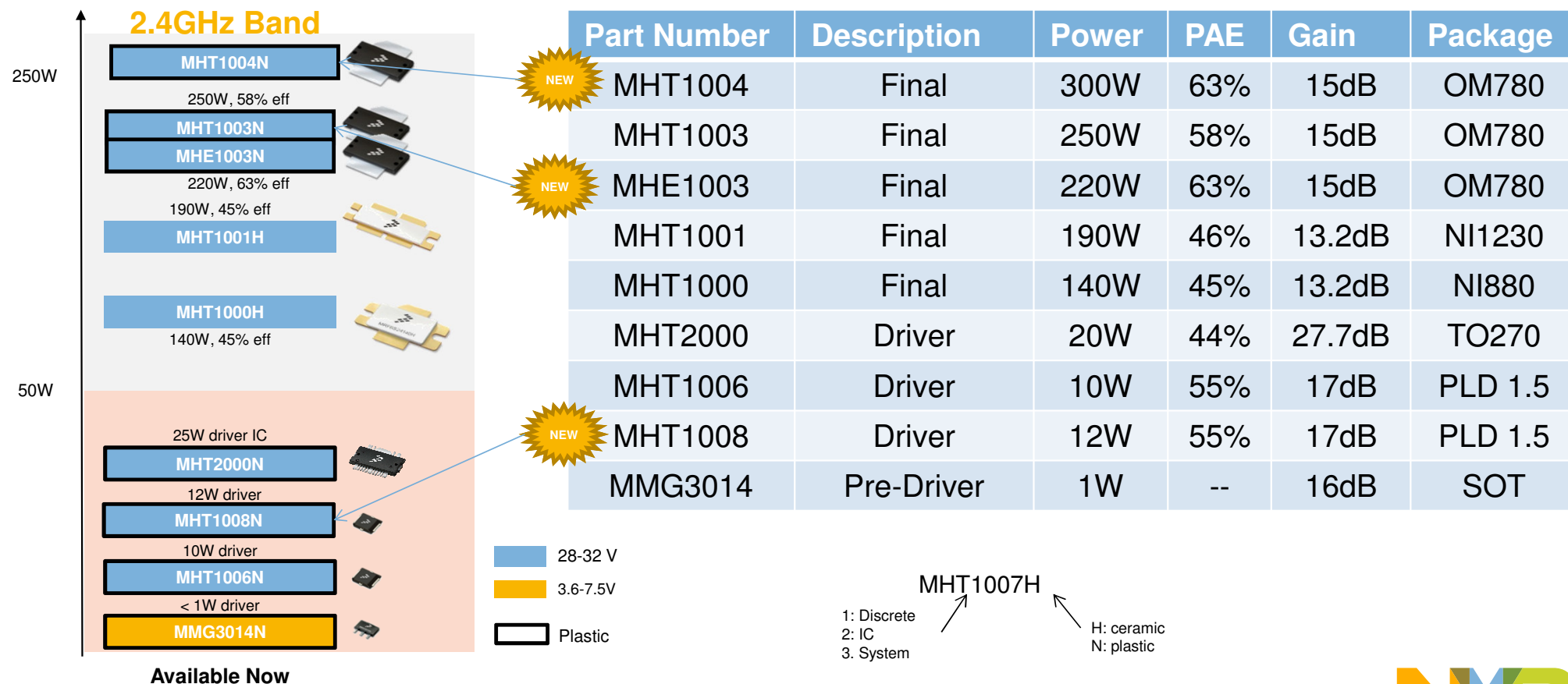
RF POWER FOR COOKING



NXP RF Cooking Component Trend

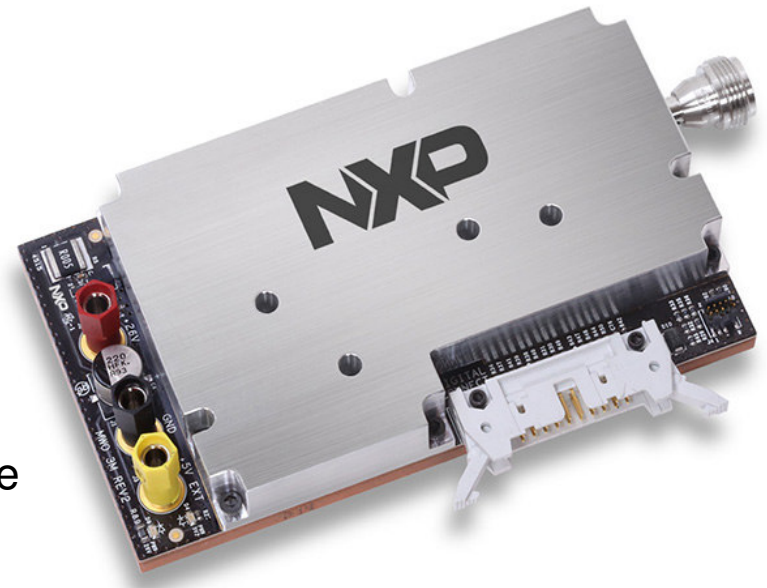
	2012	2014	2015	2017
Normalized Price	1	0.68	0.60	0.28
Attributes	45% Eff 190W	58% Eff 250W	63% Eff 250W	63% Eff 250W

Production MW Heating Device Devices

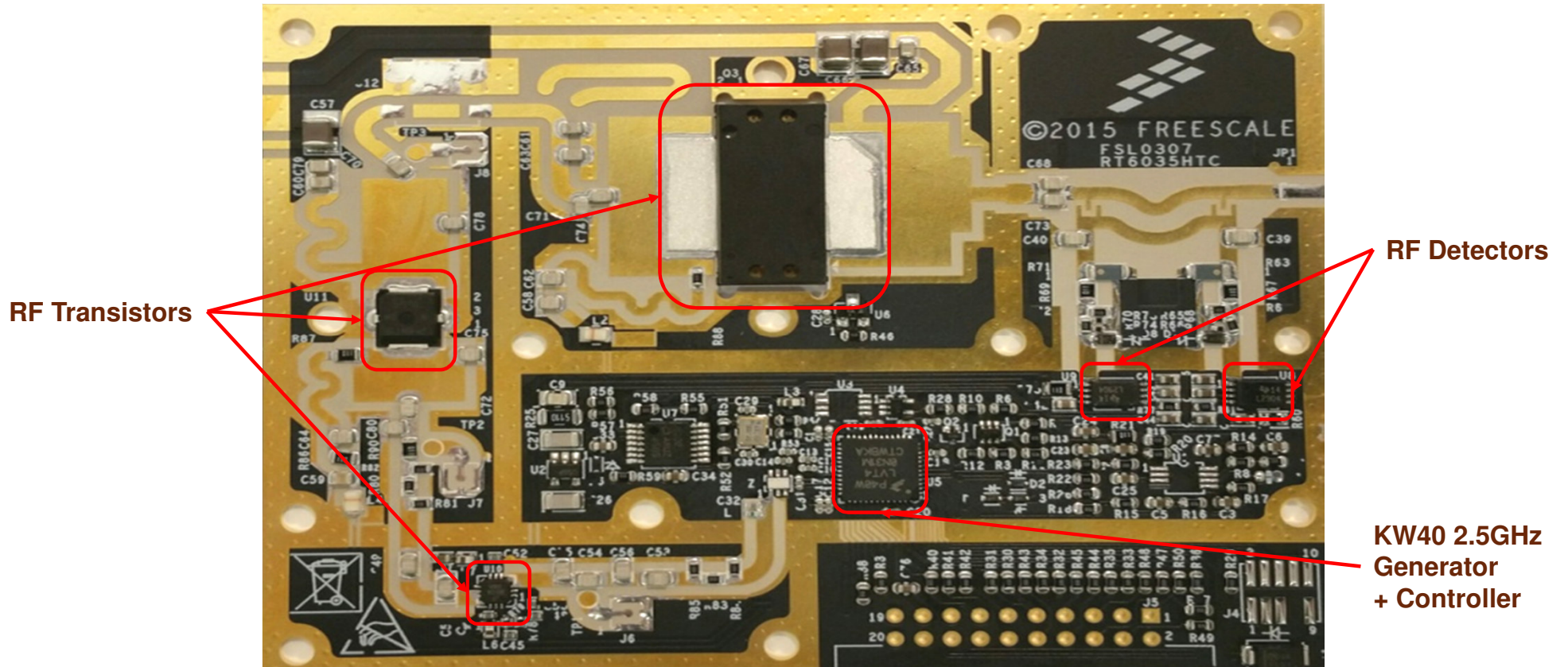


RF Cooking Module Design Philosophy and Objective

- Modular Scalability
 - Easily scale system output power from 250W to 1000W
 - Design circuit for future re-use to scale power, number of channels, other features
- High Volume Manufacturable
 - Designed for high throughput manufacturing
 - Consumer cost structure
- Integration
 - Enable smallest size
 - Fit within appliance control and communications structure
 - Enable circuit to silicon integration



Cooking Module Circuit Integration



SAGE

Intelligent Cooking Appliance Reference Design

- ✓ Smart, adaptive cooking device
- ✓ Delivers consistent culinary excellence
- ✓ Enhances convenience
- ✓ Enables advanced apps and services, real-time customer insight



RF POWER FOR MILITARY



NXP RF Military EMEA Engagement Model

RF Military Business

- Military is a separate business within NXP RF
- Enables focus on Military market and customers
- Specialized, dedicated support for defense applications
 - Enable our existing RF technologies for this market
- Focus applications: Communications, Radar, Jammers/EW

Military Part Numbering (MMRF series)

- Enables tracking of Military business
- Targets support by dedicated Mil Mkt/Apps/Systems team
- Data Sheet specs/features, Applications fixtures, Data packs targeted and optimized for Military end uses
- Longevity guarantee of 10 or 15 years for all Military (MMRF) devices
- Ensures proper compliance processes when needed (e.g. non EAR99 parts)
- Hides frequency & power information (customers like)



RF POWER FOR CELLULAR

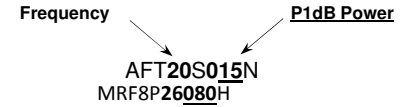


NXP Airfast

Industry-Leading RF LDMOS and GaN Technologies for Cellular Infrastructure Applications

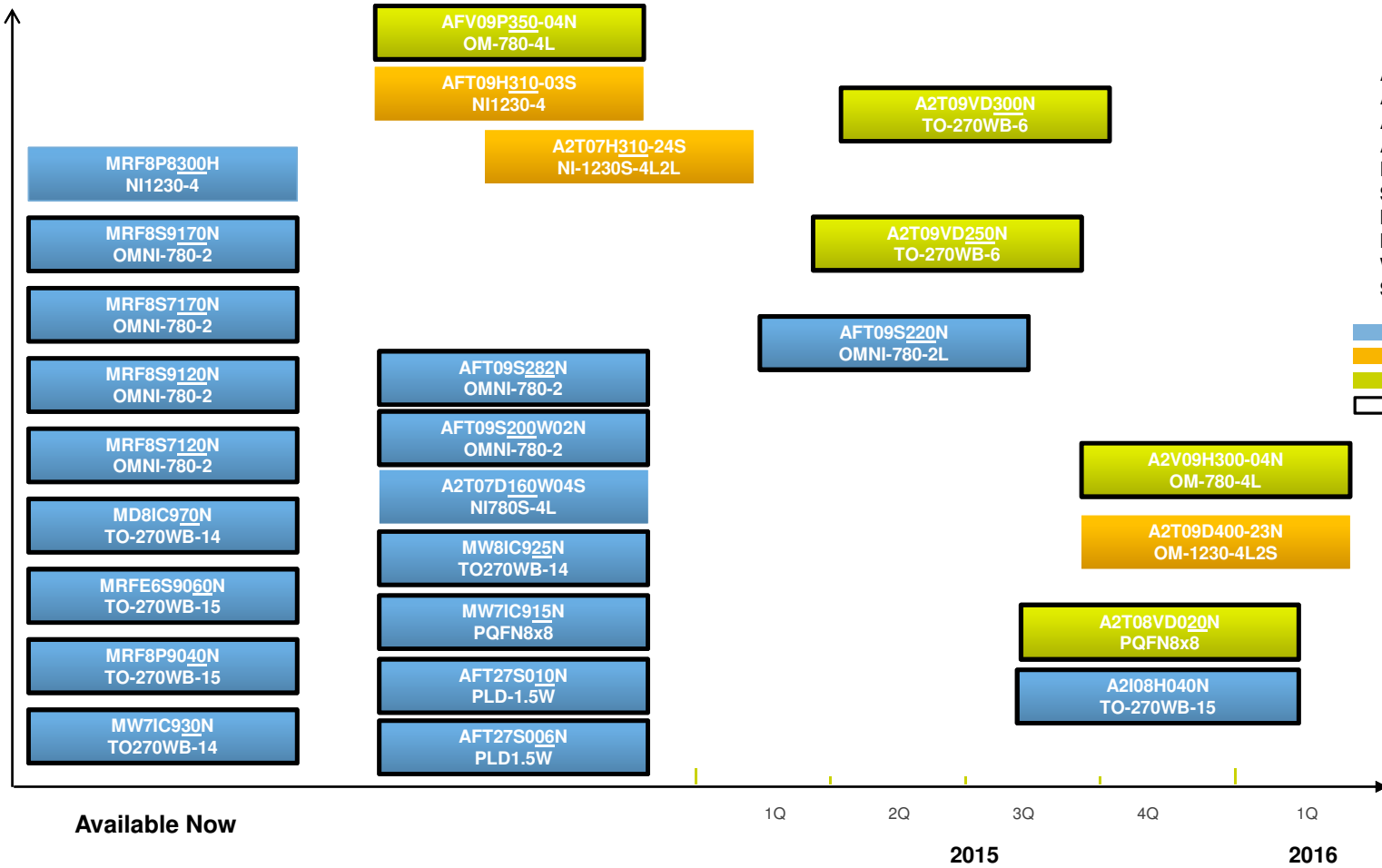
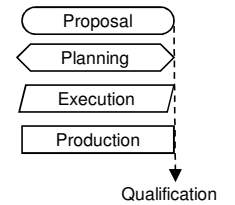


Roadmap 720-960MHz

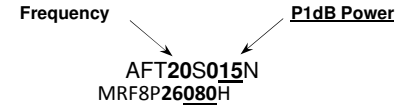


AFT: Airfast Transistor
A2T: Airfast 2 Transistor
AFV: Airfast 50V
A2I: Airfast 2 IC
P or D: Push-Pull / dual path
S: Single Ended
H: Asymmetric Doherty (HiP)
N: plastic
W: large VBW
S: earless

■ 28Volts LDMOS
 ■ 28Volts LDMOS asymmetric (HiP)
 ■ 50Volts LDMOS
 □ Over-Molded Plastic

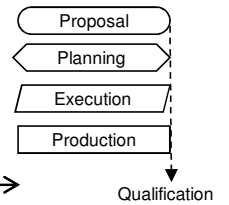
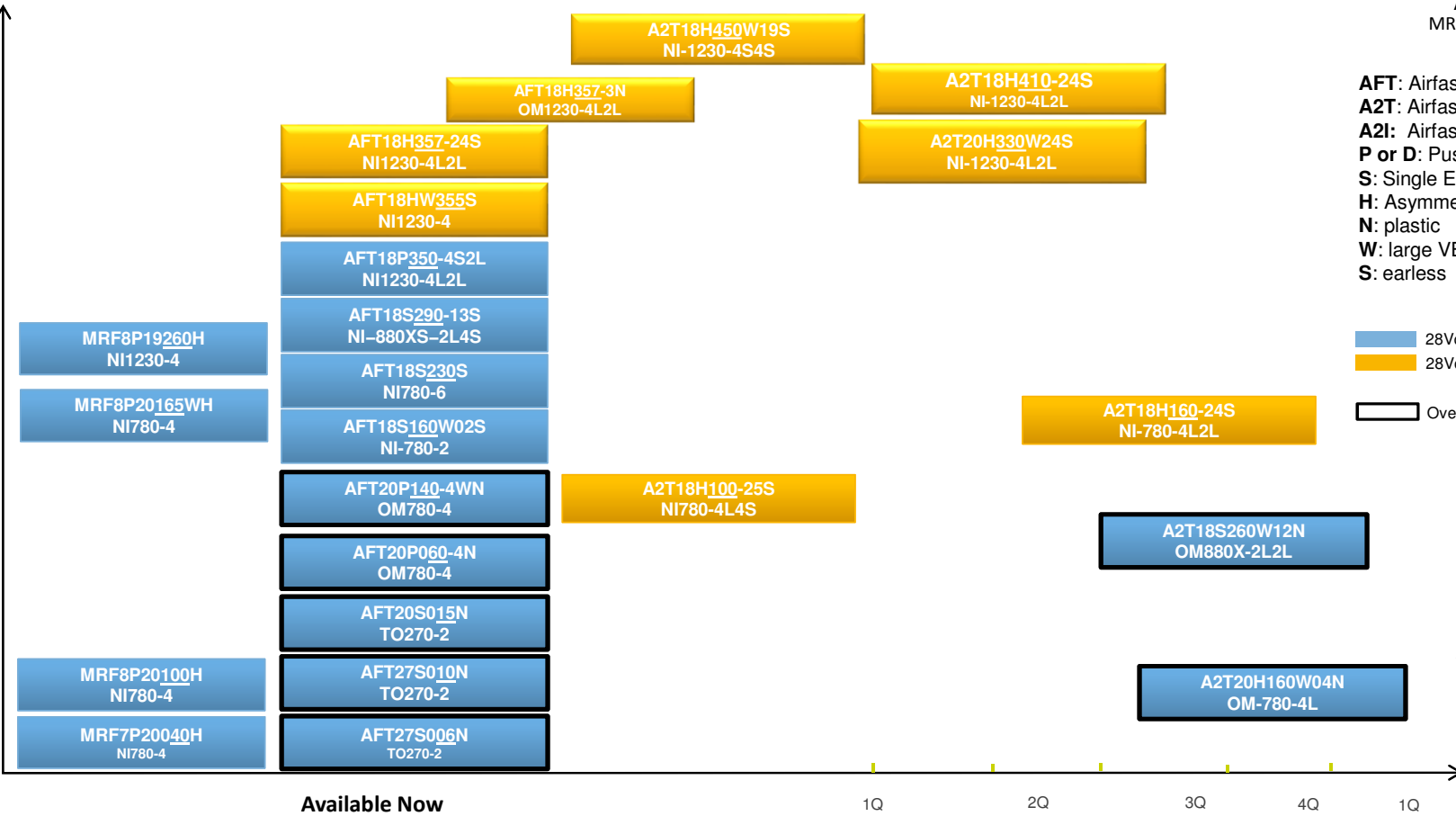


Roadmaps Discrete 1.8/1.9 GHz

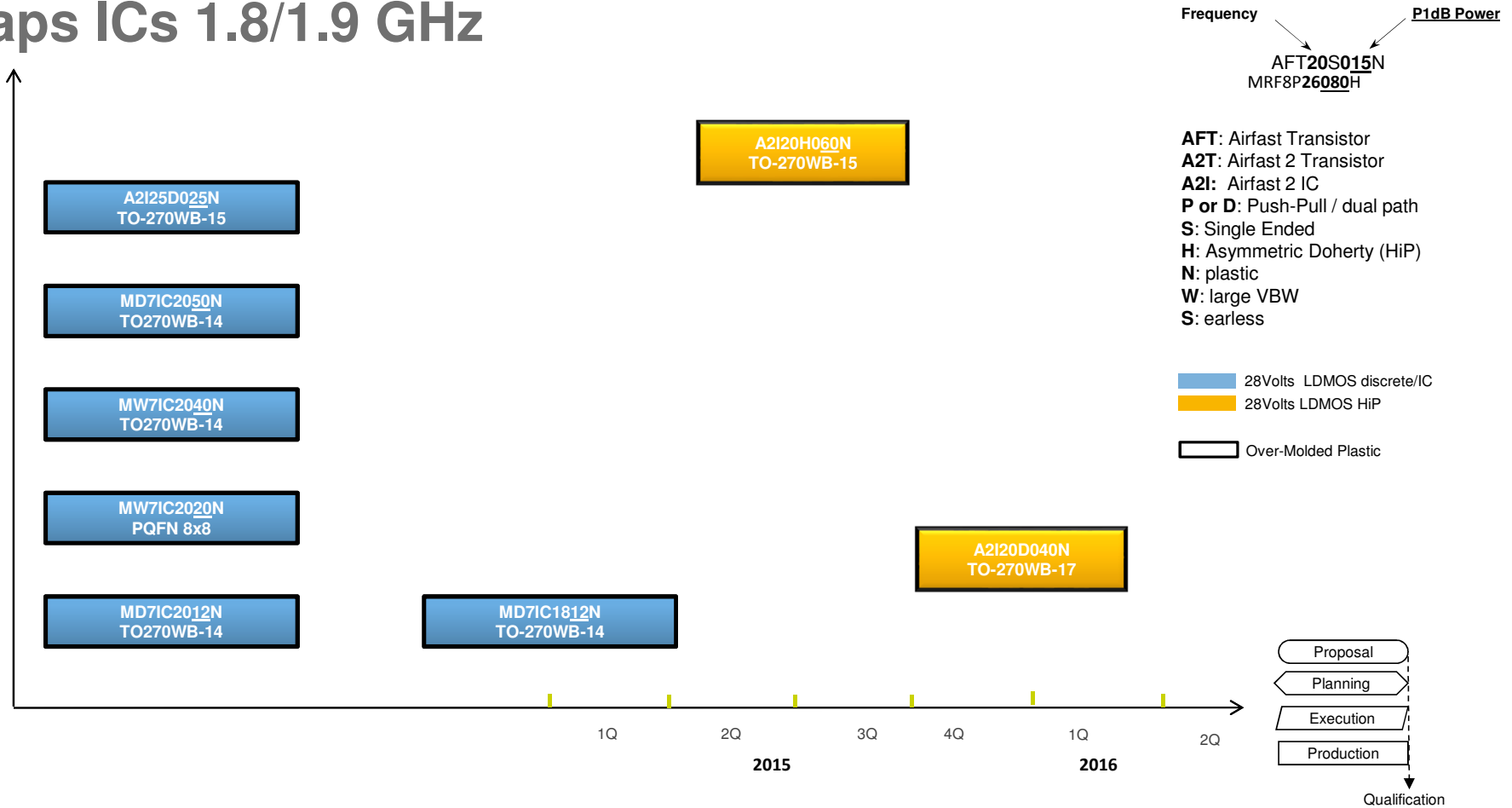


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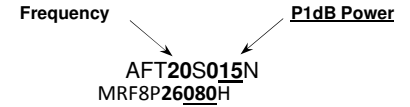
28Volts LDMOS discrete/IC
 28Volts LDMOS HiP
 Over-Molded Plastic



Roadmaps ICs 1.8/1.9 GHz

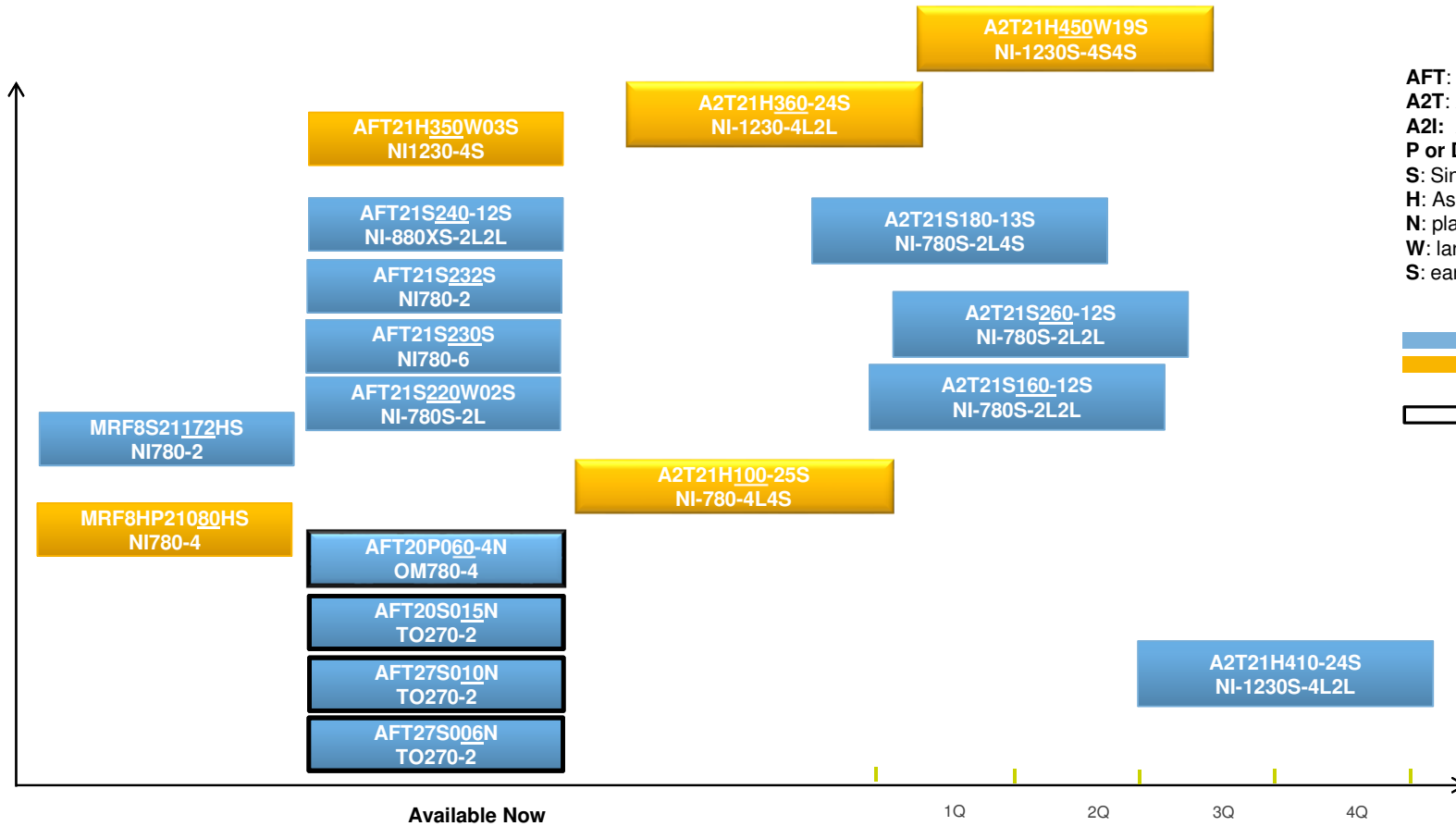
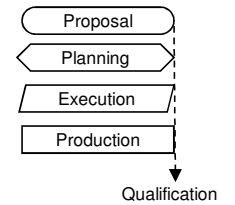


Roadmaps Discretetes 2.1 GHz

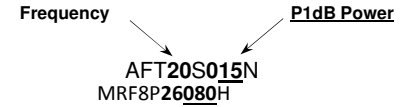
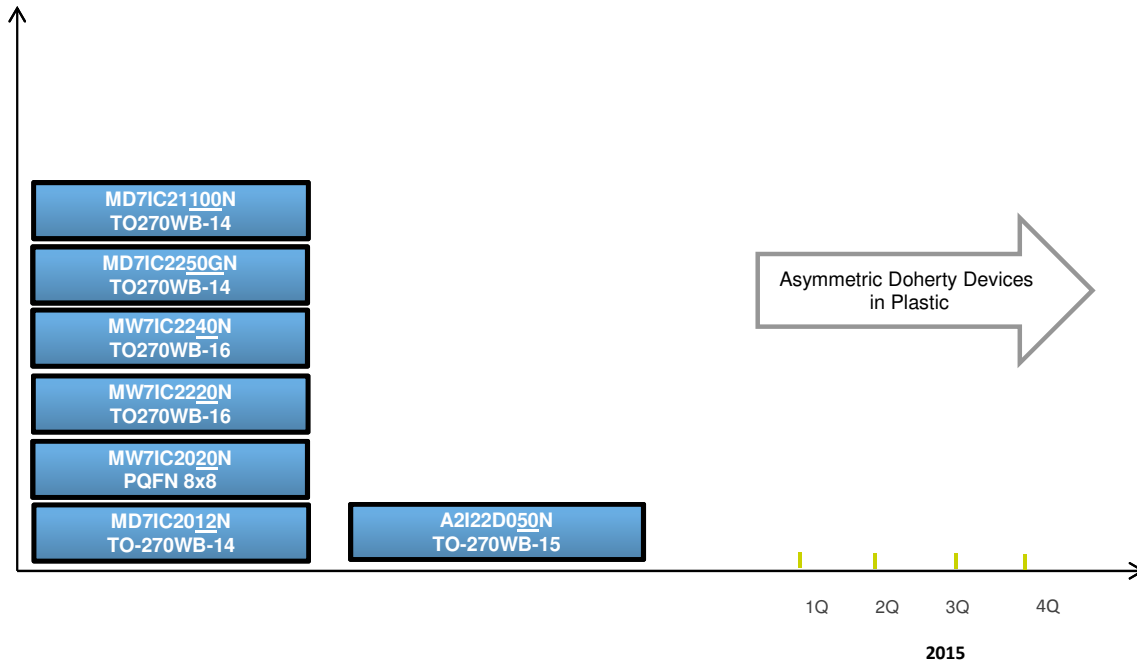


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28Volts LDMOS discrete/IC
 28Volts LDMOS HiP
 Over-Molded Plastic

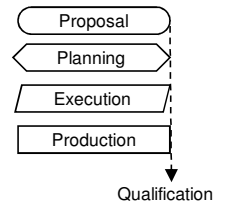


Roadmaps ICs 2.1 GHz

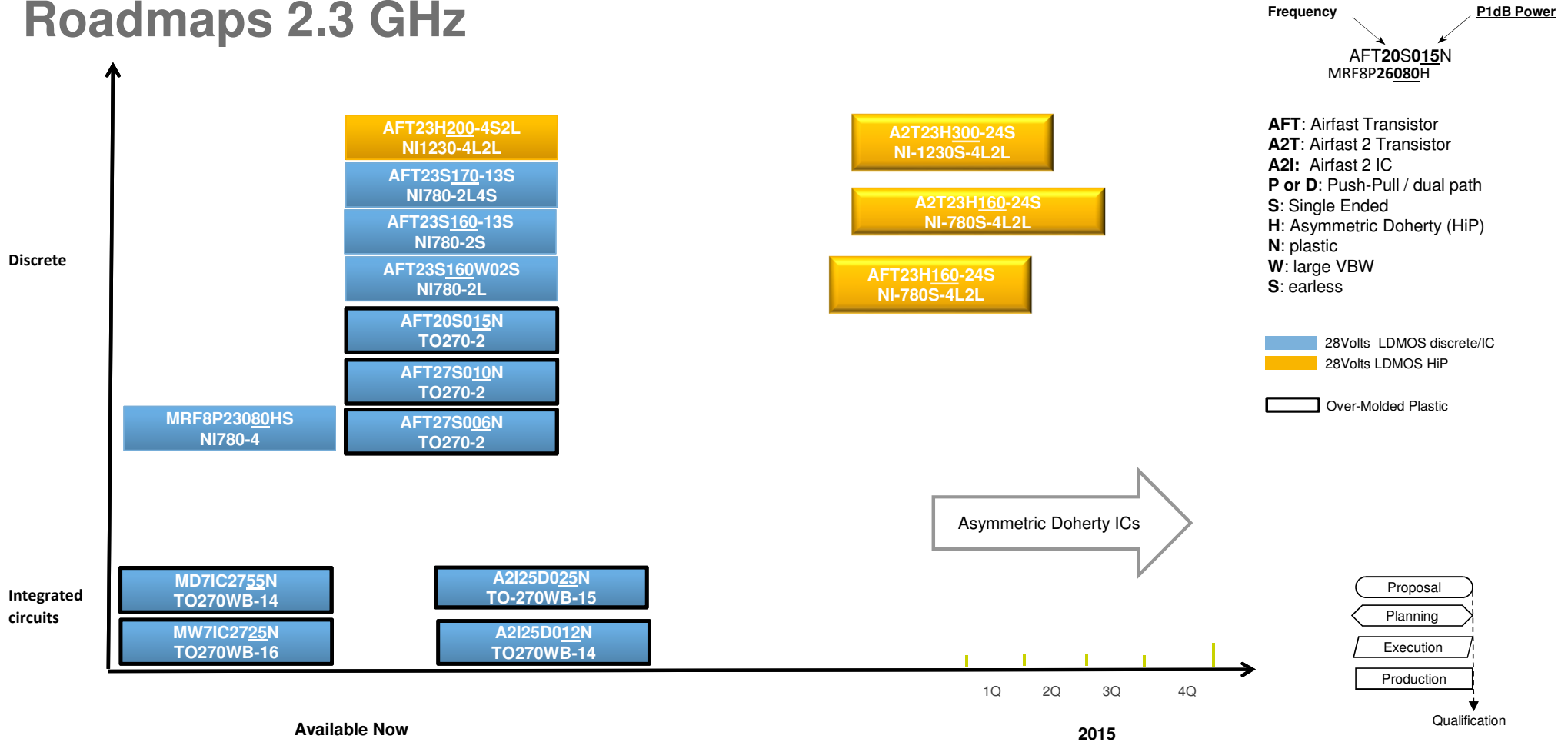


- AFT:** Airfast Transistor
- A2T:** Airfast 2 Transistor
- A2I:** Airfast 2 IC
- P or D:** Push-Pull / dual path
- S:** Single Ended
- H:** Asymmetric Doherty (HiP)
- N:** plastic
- W:** large VBW
- S:** earless

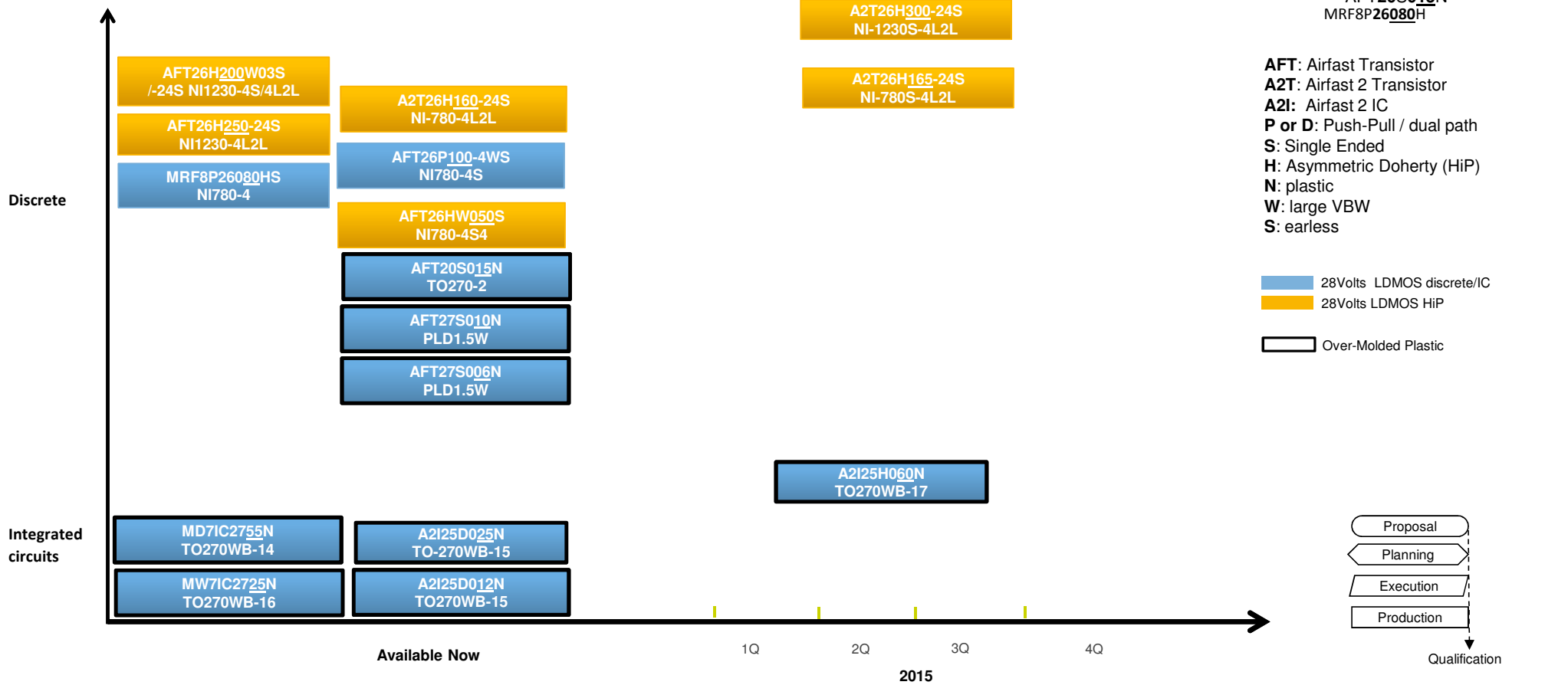
- 28Volts LDMOS discrete/IC
- 28Volts LDMOS HiP
- Over-Molded Plastic



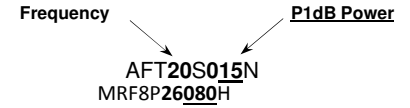
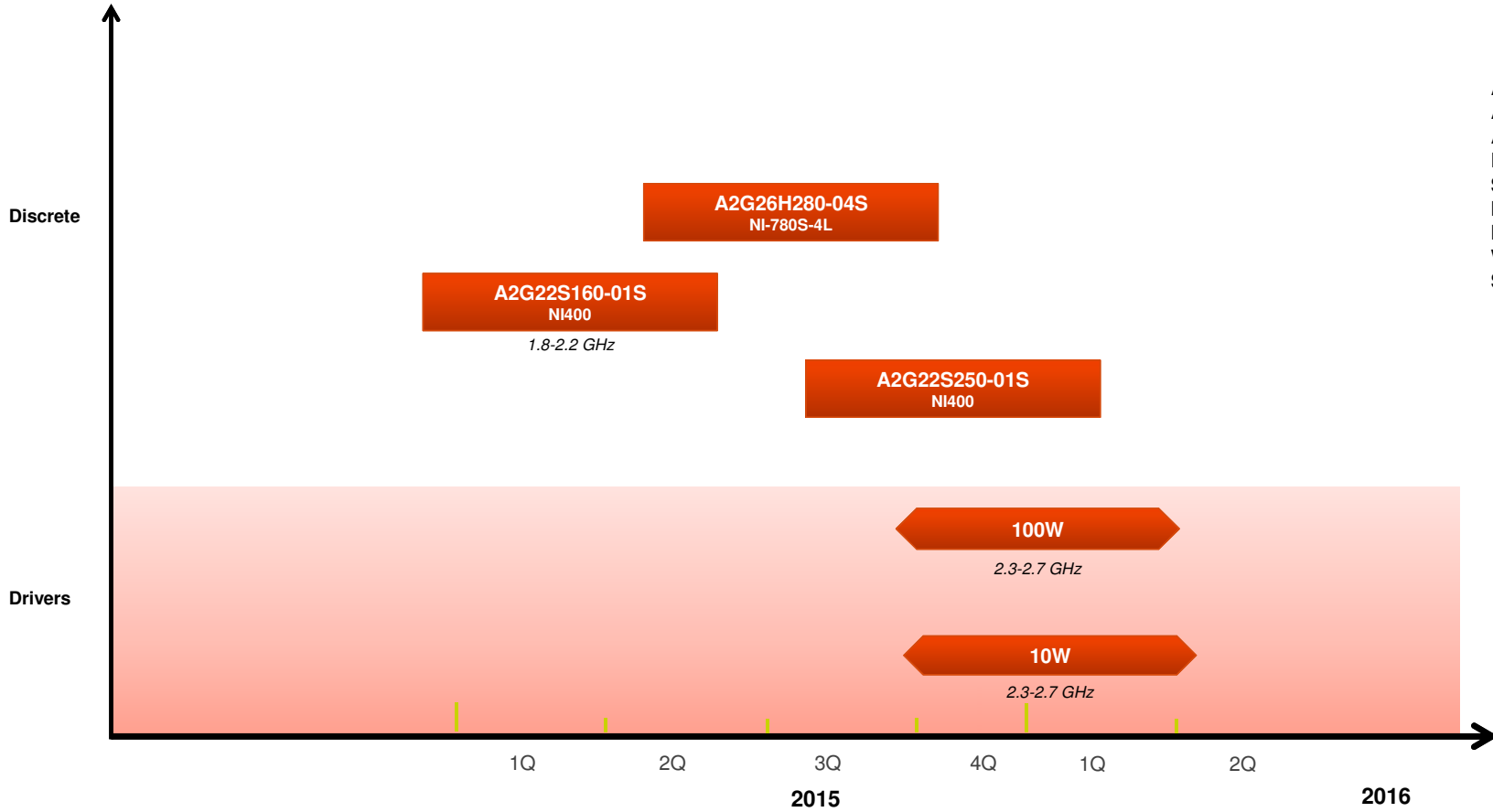
Roadmaps 2.3 GHz



Roadmaps 2.6 GHz

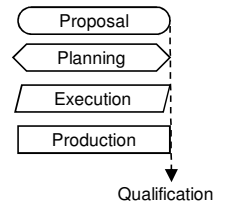


Roadmaps GaN



AFT: Airfast Transistor
A2T: Airfast 2 Transistor
A2I: Airfast 2 IC
P or D: Push-Pull / dual path
S: Single Ended
H: Asymmetric Doherty (HiP)
N: plastic
W: large VBW
S: earless

50V GaN





SECURE CONNECTIONS
FOR A SMARTER WORLD