

flex[®]

Powering 5G/RFPA





- 1 | **5G introduction**
- 2 | **RFPA/5G application overview**
- 3 | **Product presentation**
- 4 | **Q&A**

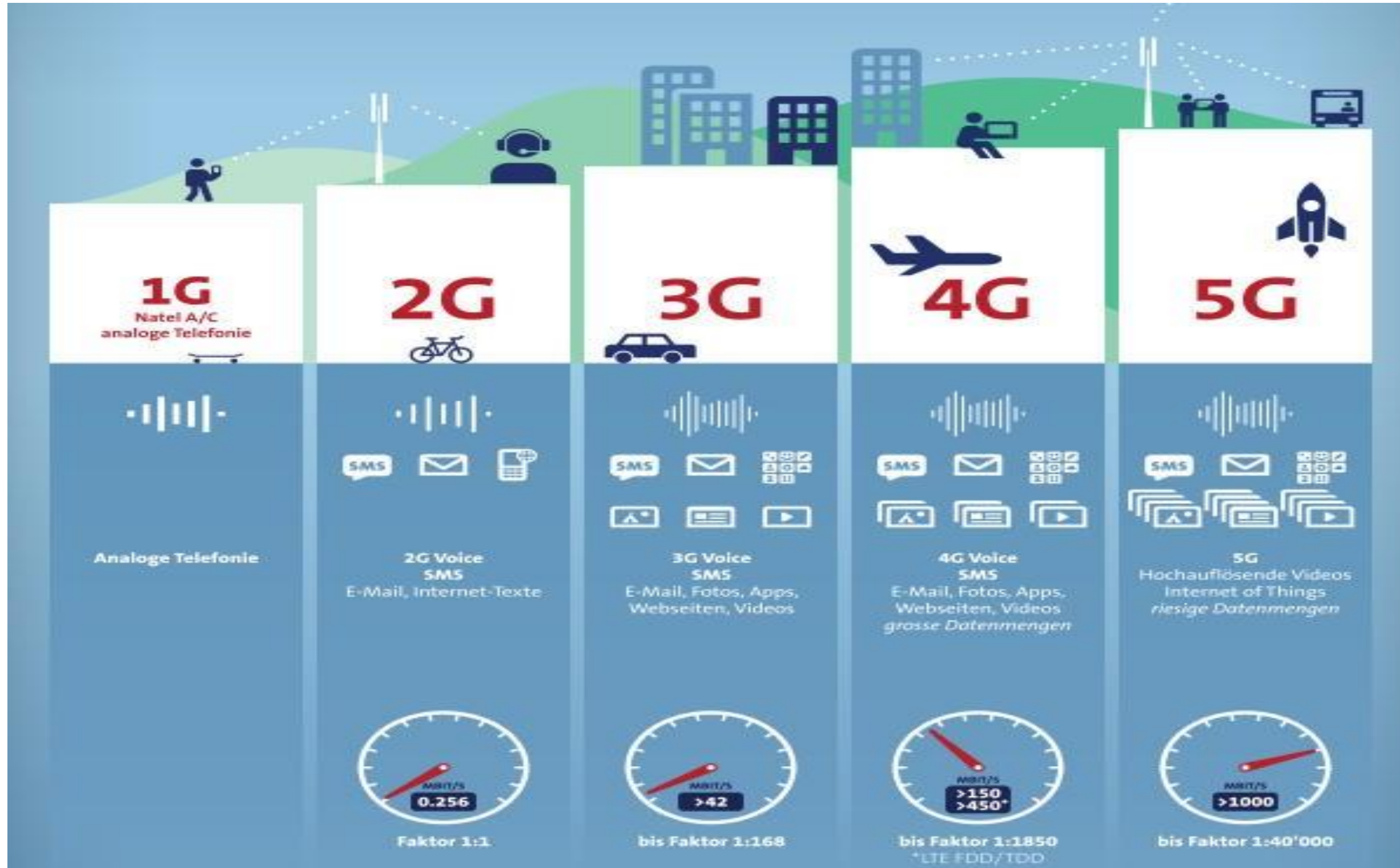




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Evolution of mobile communication tech



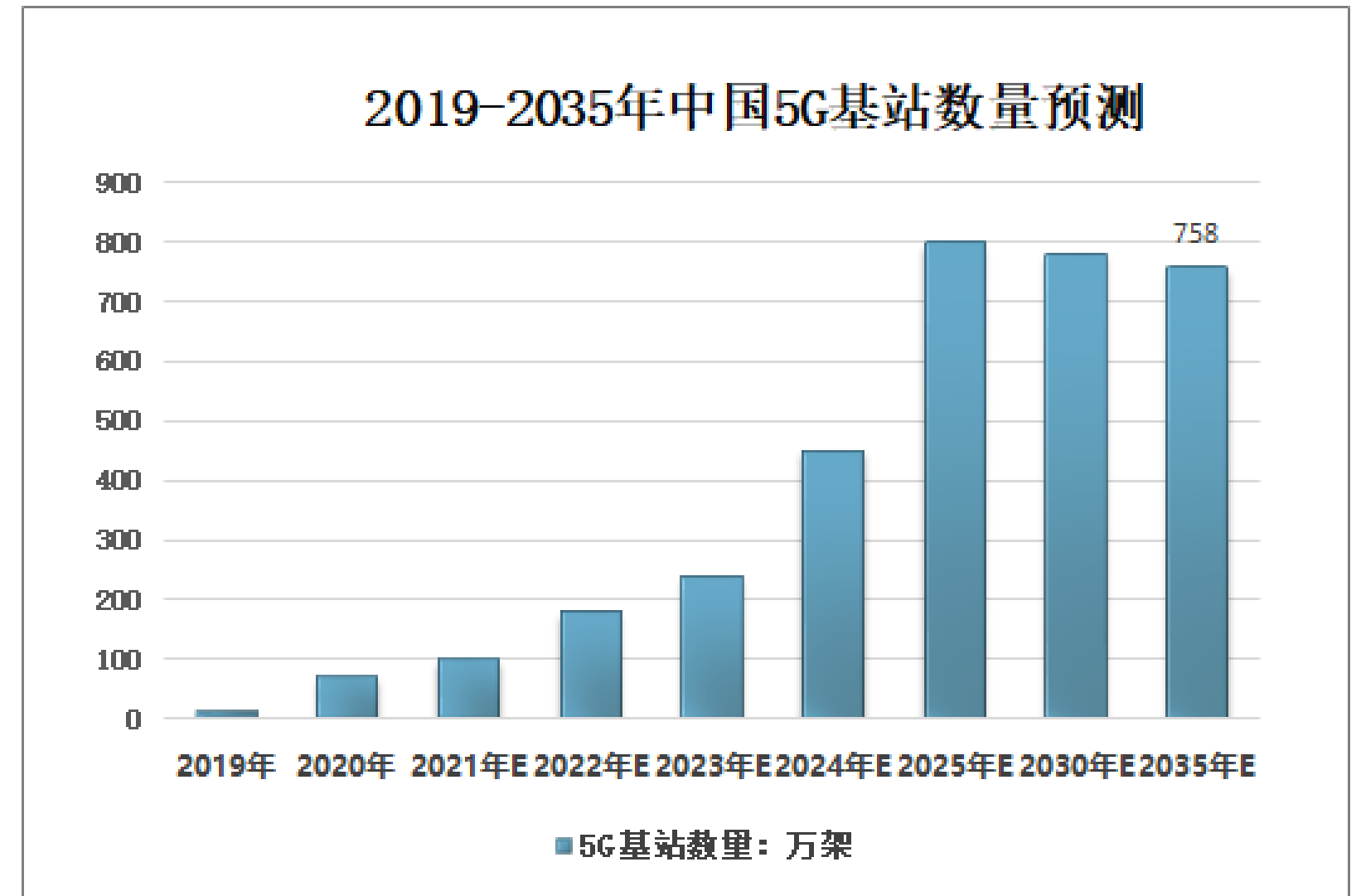
5G launches worldwide

- 5G launches continue worldwide
- By mid-Aug 2021, 176 operators in 72 countries/territories had launched one or more 3GPP-compliant 5G services.
- By 2025, 5G networks are likely to cover one-third of the world's population.
- 5G devices captured more than two-thirds (69%) of global smartphone revenue in Q1 2021, with their shipments reaching 39% of the global total for the quarter.
- 5G means uncountable applications for a fully connected life → increased data traffic
- Urge for new infrastructure with new base stations and global networks → more power is required



5G development in China

- During pandemic, mobile data traffic has increased by 40 % (comparing March 2019 with March 2020)
- In 2019 & 2020 operators invested a sum of \$78 billion USD (equals 1/5 of revenue) in network rollouts
 - Aggressive 5G rollout
 - 200 million new 5G connections
 - 600 000 new 5G base stations
- Mobile operators play a key role in achieving sustainability development goals by
 - Delivering connectivity and access to life-enhancing services
 - Sustainable development with focus on energy saving solutions and reduce emission supporting transition to zero-carbon economy



Source: 'The Mobile Economy China 2021' by GSMA, 2021

Requirements for operators and equipment vendors

- Radio Frequency Power Amplifier (RFPA) one of the most expensive and power-hungry components
- RFPA designers are increasingly moving from LDMOS to Gallium Nitride, (GaN), transistors
- Envelope Tracking/Restoration (ET/ER) has emerged as a key RFPA design technique
 - very efficient DC/DC converter required
- DC/DC converter needs to handle broadband RFPA output bias voltage in synchronization with the amplitude variation of the modulated RF input signal
- Operators vs equipment vendors, Open-RAN.

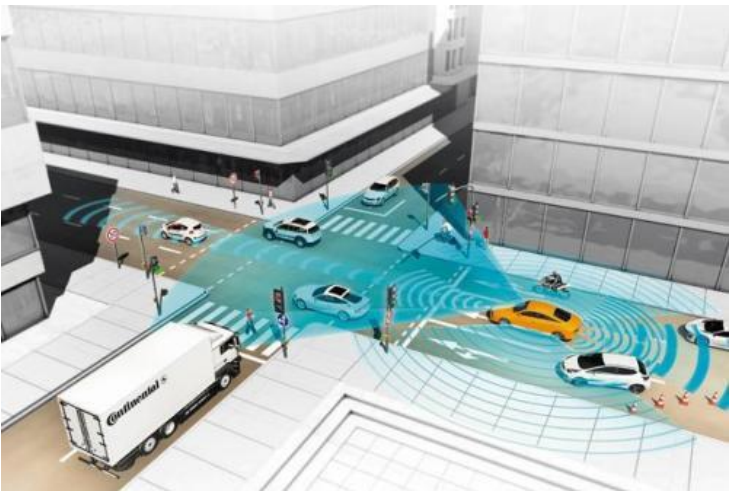


5G usage scenarios

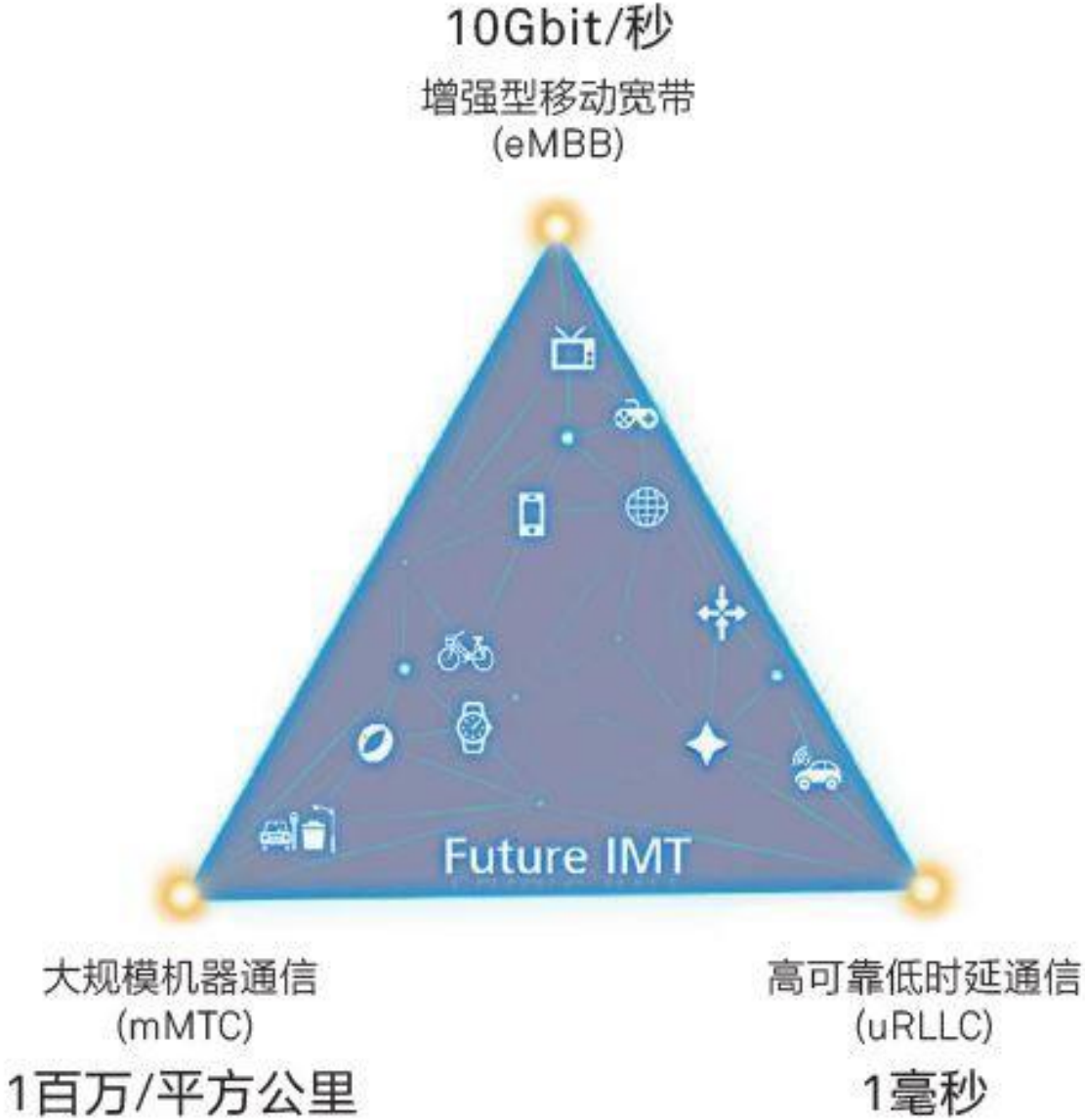
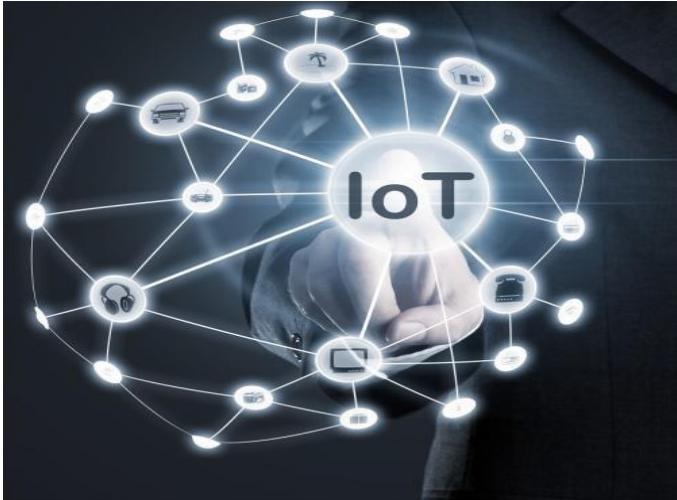
eMBB 大宽带速度快



uRRLC 高可靠低时延



mMTC 海量机器连接

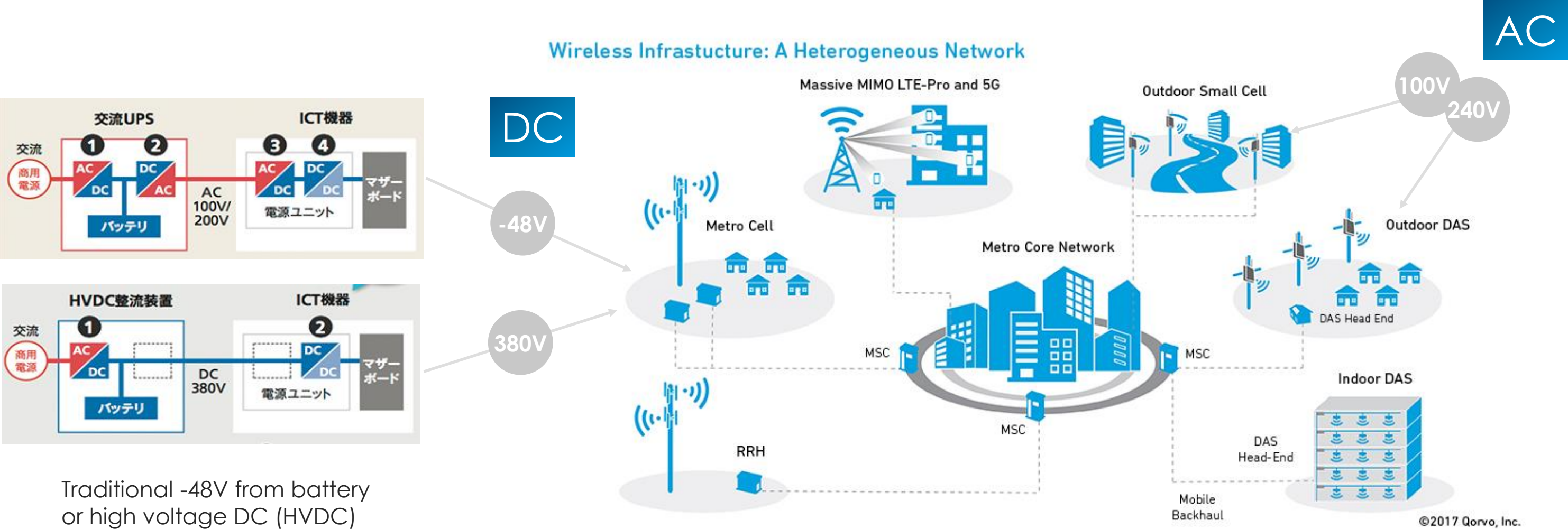




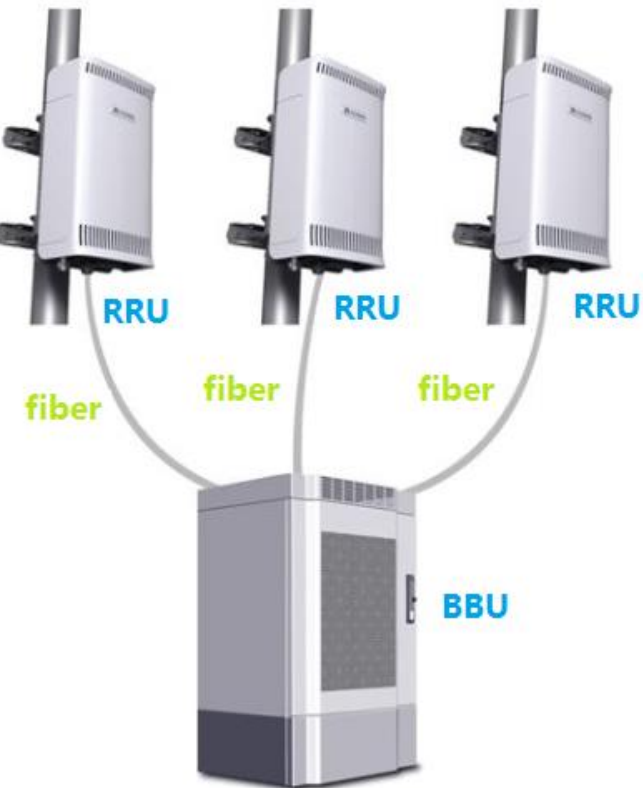
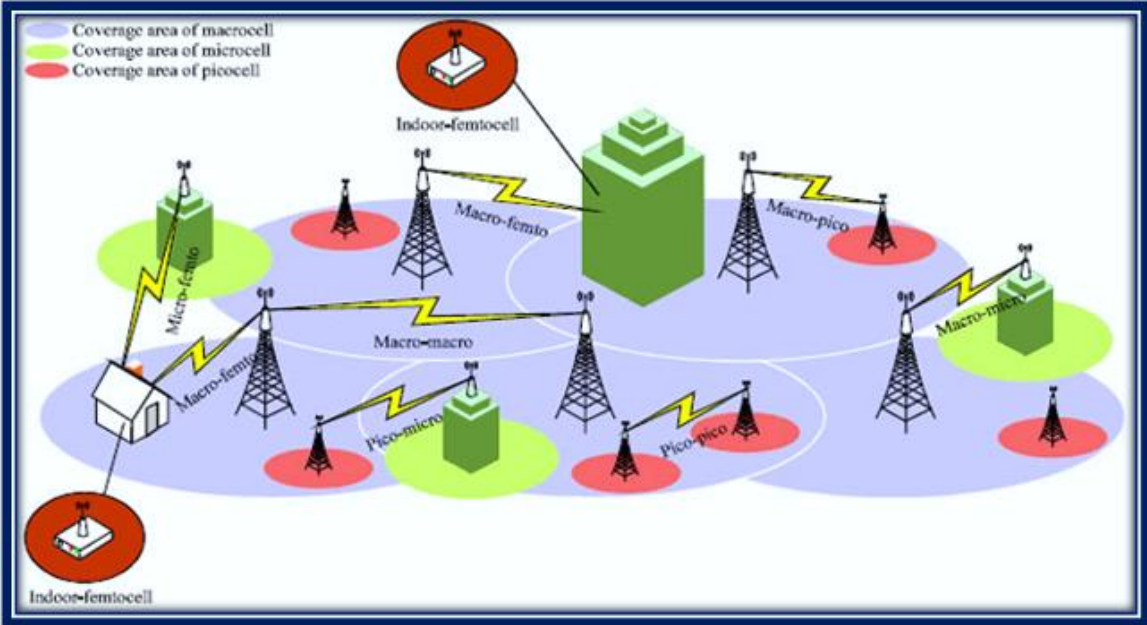
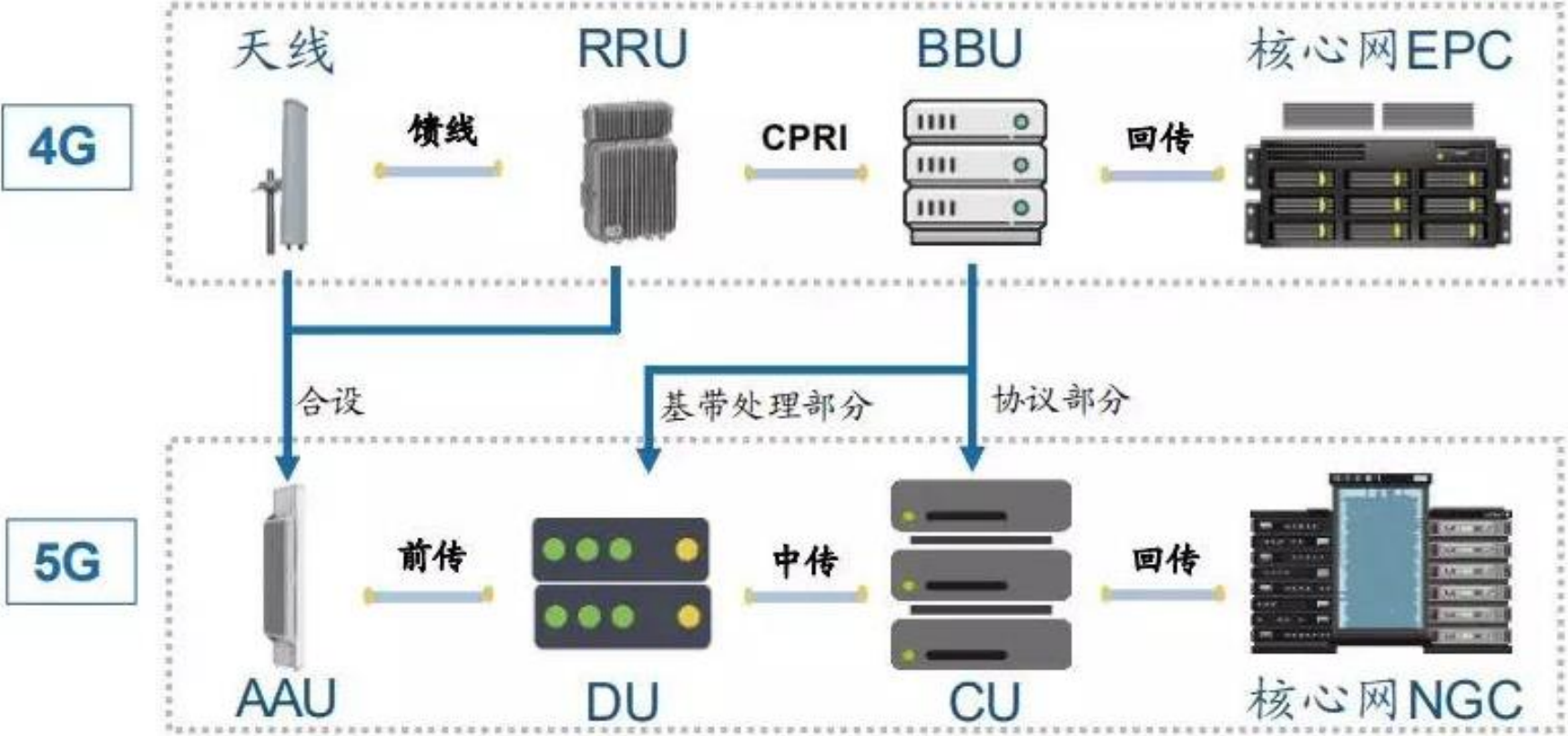
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Powering 5G radio network applications



Macro-base stations



Marco-base stations • BBU & RRU applications



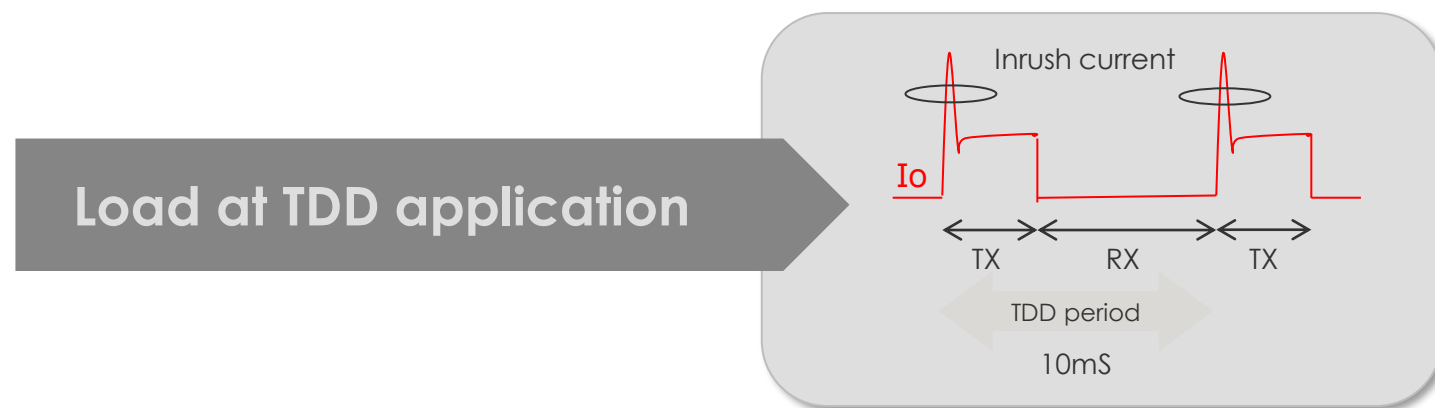
RFPA • technical requirements & challenges

REQUIREMENTS:

- TDD mode load: better transient response and higher OCP setpoint
- Height tolerance < 0.5mm
- Baseplate OTP on all kinds of conductions > 100°C, perhaps increase to 110 °C in future
- DAC active trimming
- -40 °C to 100° C operating temperature

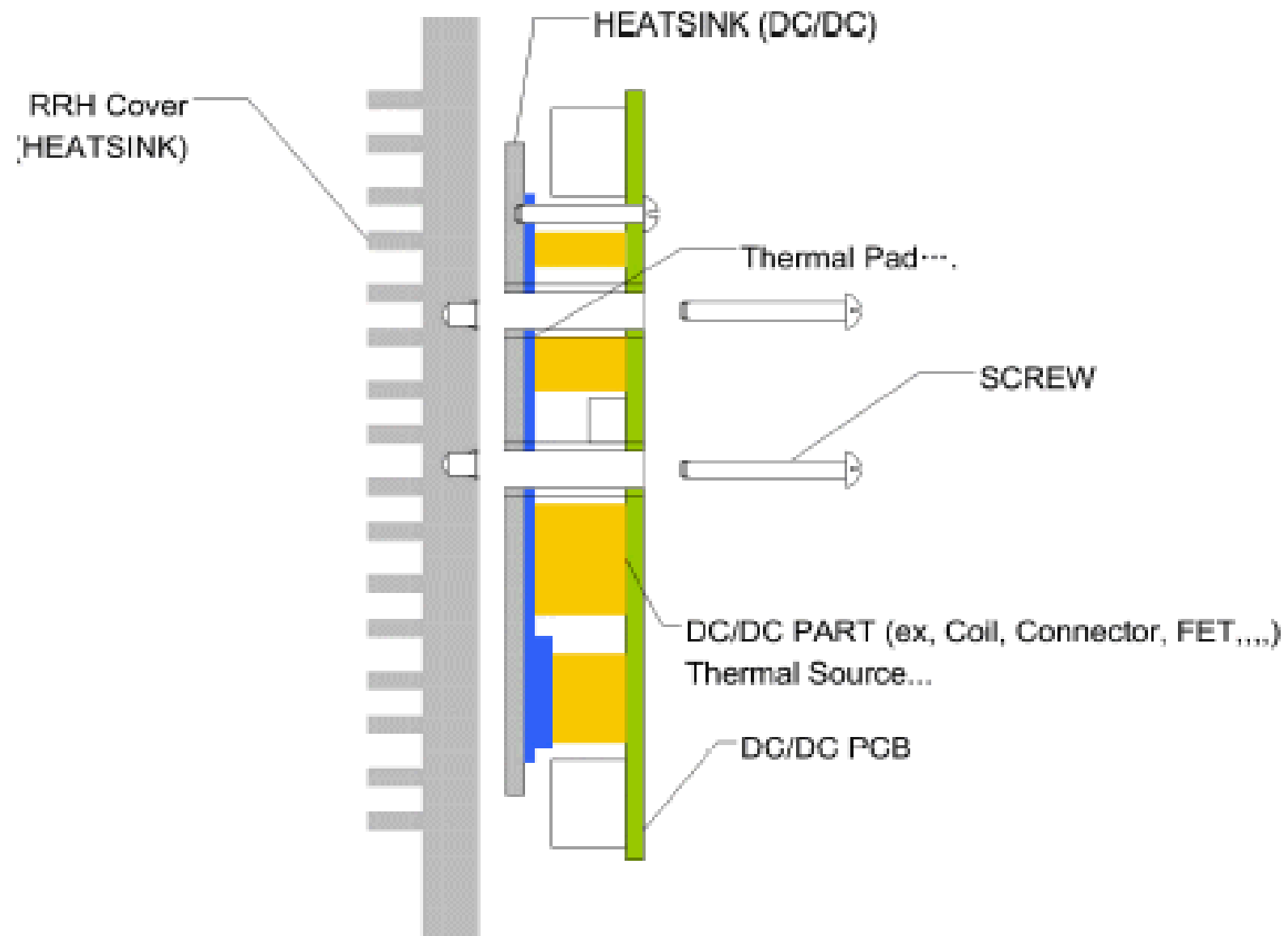
CHALLENGES:

- Cost
- TDD load
- Time to market (TTM)
- Efficiency
- Reliability
- Cold/high temperature performance



Mounting requirements

Thermal performance plays an important role



5G/RFPA portfolio

half brick



PKJ4716A
half brick
14-35 V_{out} / 700 W



PKJ4716H
half brick
25-55 V_{out} / 700 W



BMR685
Digital / half brick
25-55 V_{out} / 1300 W

quarter brick



PKM4516AD
quarter brick
14-35 V_{out} / 500 W



PKM4516HD
quarter brick
25-55 V_{out} / 500 W



BMR683
Digital / quarter brick
28 V_{out} / 500 W

eighth brick



PKB4216C
eighth brick
15-33 V_{out} / 200 W

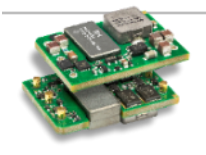


PKB4216HD
eighth brick
40-55 V_{out} / 250 W

sixteenth brick



PKU-D 100W
36-75 V_{in}
12 V_{out}



PKU4116C 100W
36-75 V_{in}
10-33 V_{out}



PKU-D 110W*
36-60 V_{in}
55 V_{out}

100 W

200 W

500 W

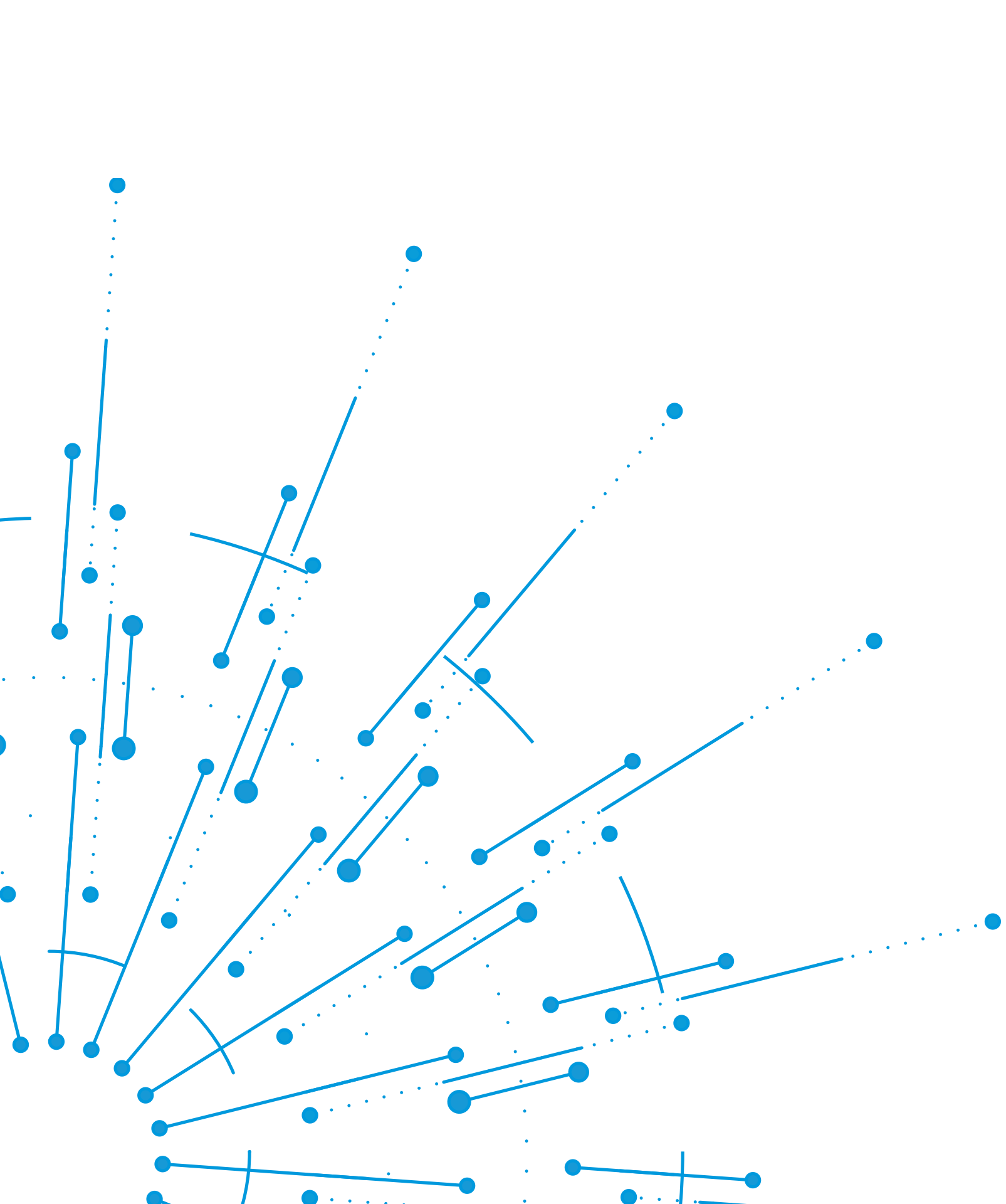
700 W

1300 W



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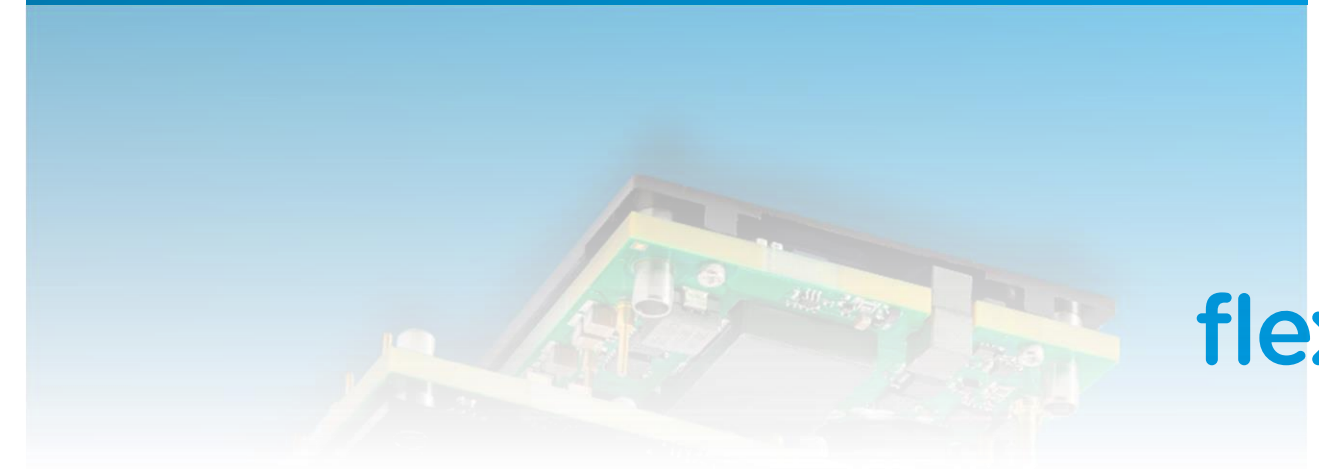
BMR685

First **digital** half brick for RFPA up to
1300 W P_{out}

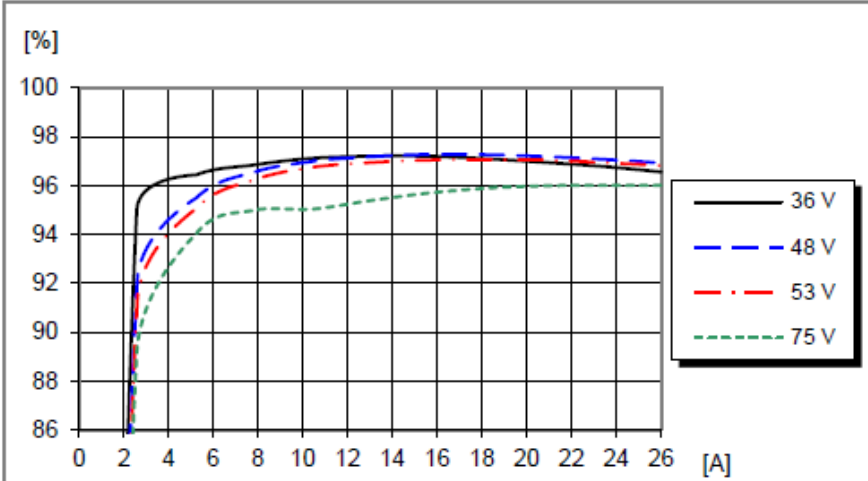
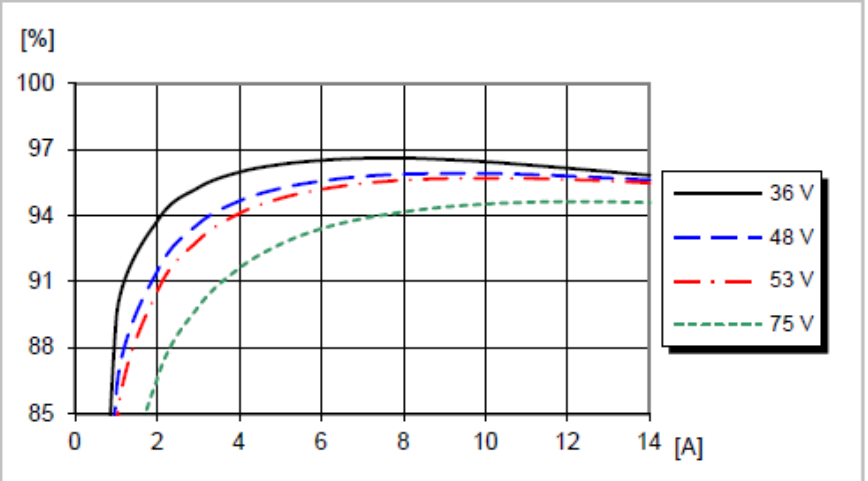
Designed for **high power GaN and
LDMOS RFPA** applications

Product overview • BMR685

- 工业标准半砖尺寸: 61mm*57.9mm*12.7mm
- 功率密度: 473W/in³
- 输入电压范围: 36V~75V
- 输出: 50V/1300W
- 输出电压范围: 25V~55V
- 效率: 97% , 48Vin输入半载
- 高度尺寸精度: 0.2mm
- 优秀的热降额特性
- 输入和输出隔离电压: 2250Vdc
- 兼容PMBus通讯协议
- 电压, 电流和温度监控
- 输出电压可软件更改
- 快照 (Snapshot) 功能



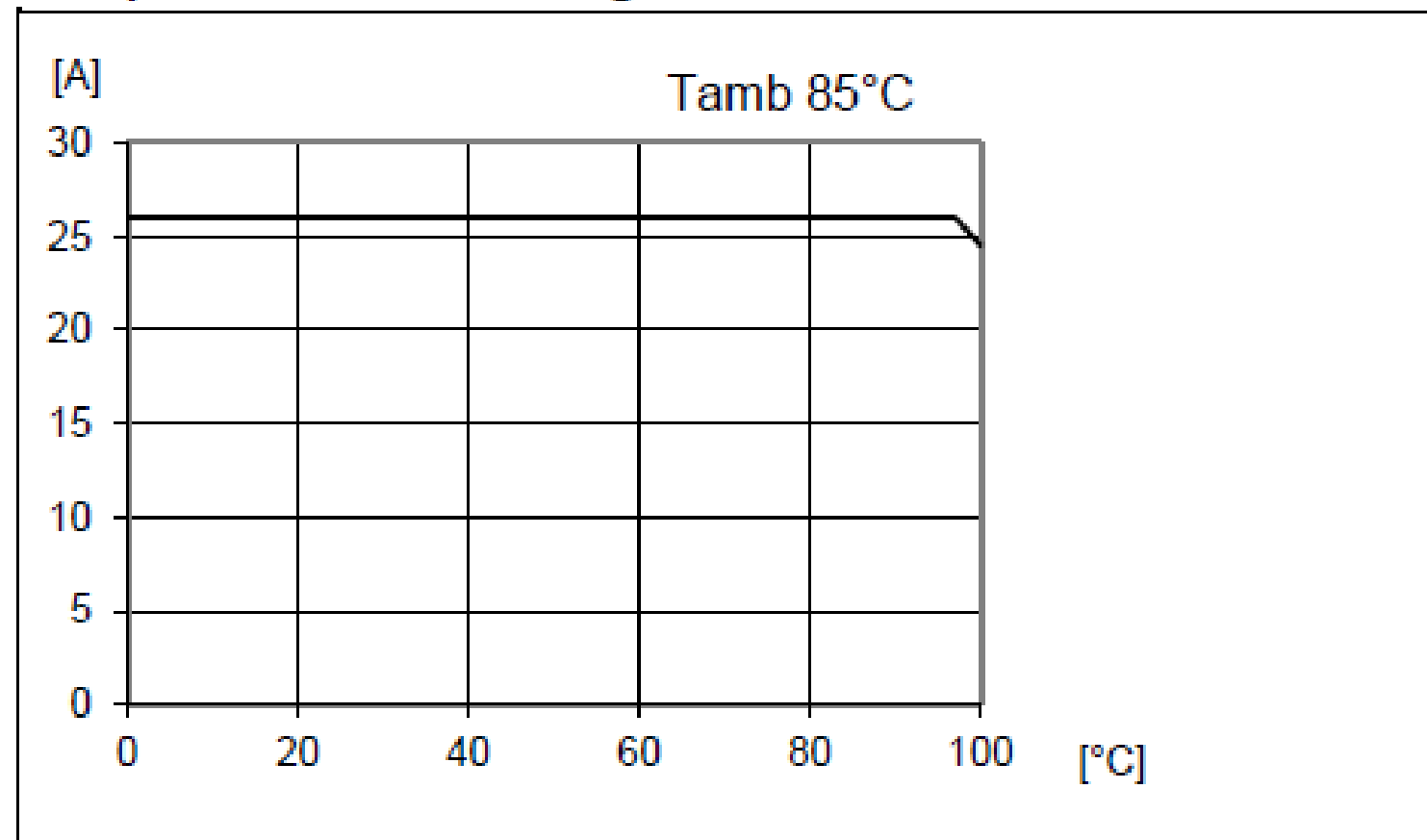
BMR685 1300W vs PKJ4716H 700W 50V

产品型号	BMR685 ^{NEW}	PKJ4716H
外观		
输出功率	1300W	700W
功率密度 (W/in^3)	475	256
效率曲线	Efficiency  Efficiency vs. load current and input voltage at T_{P1} = +25°C	Efficiency  Efficiency vs. load current and input voltage at T_{P1} = +25°C.

优秀的热降额特性，满足密闭环境的应用

- 环境温度85度，基板温度100度时，支持满载输出

Output Current Derating – Cold wall sealed box

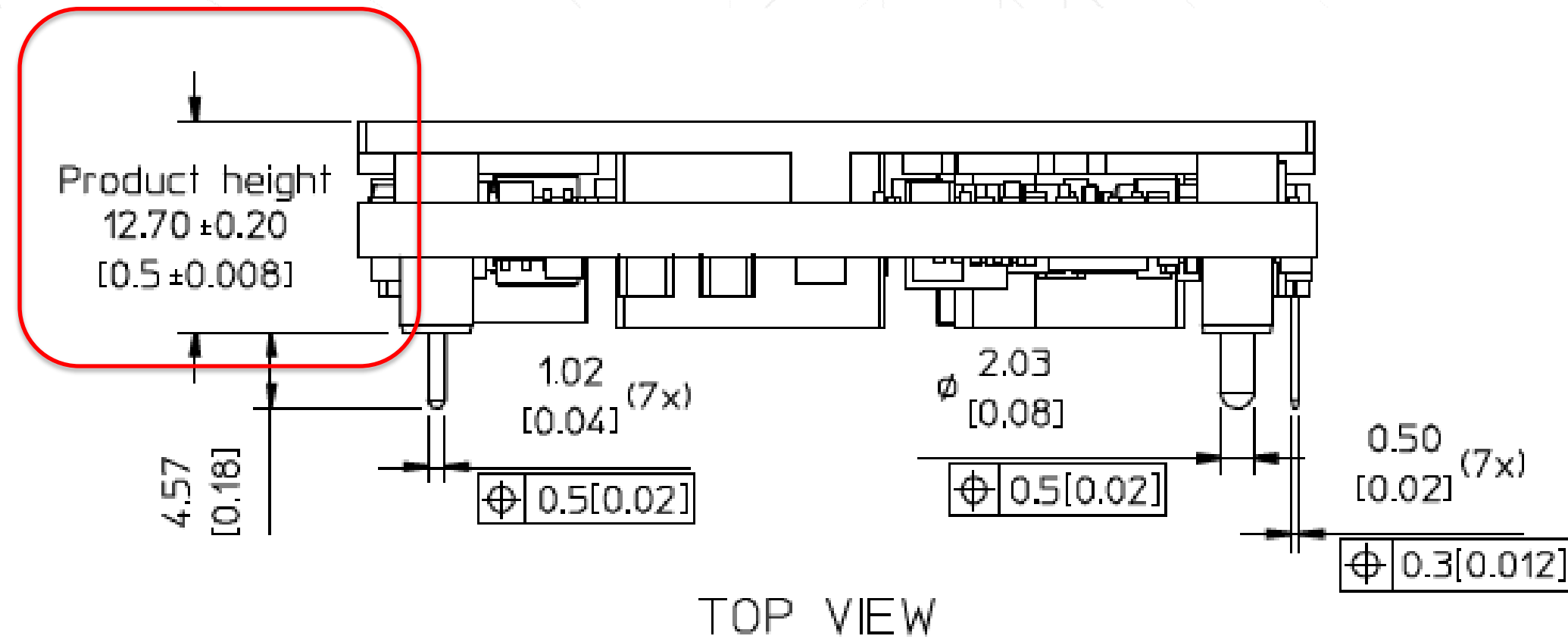


Available load current vs Base plate temperature.
 $V_I = 48\text{ V}$. See Thermal Consideration section.



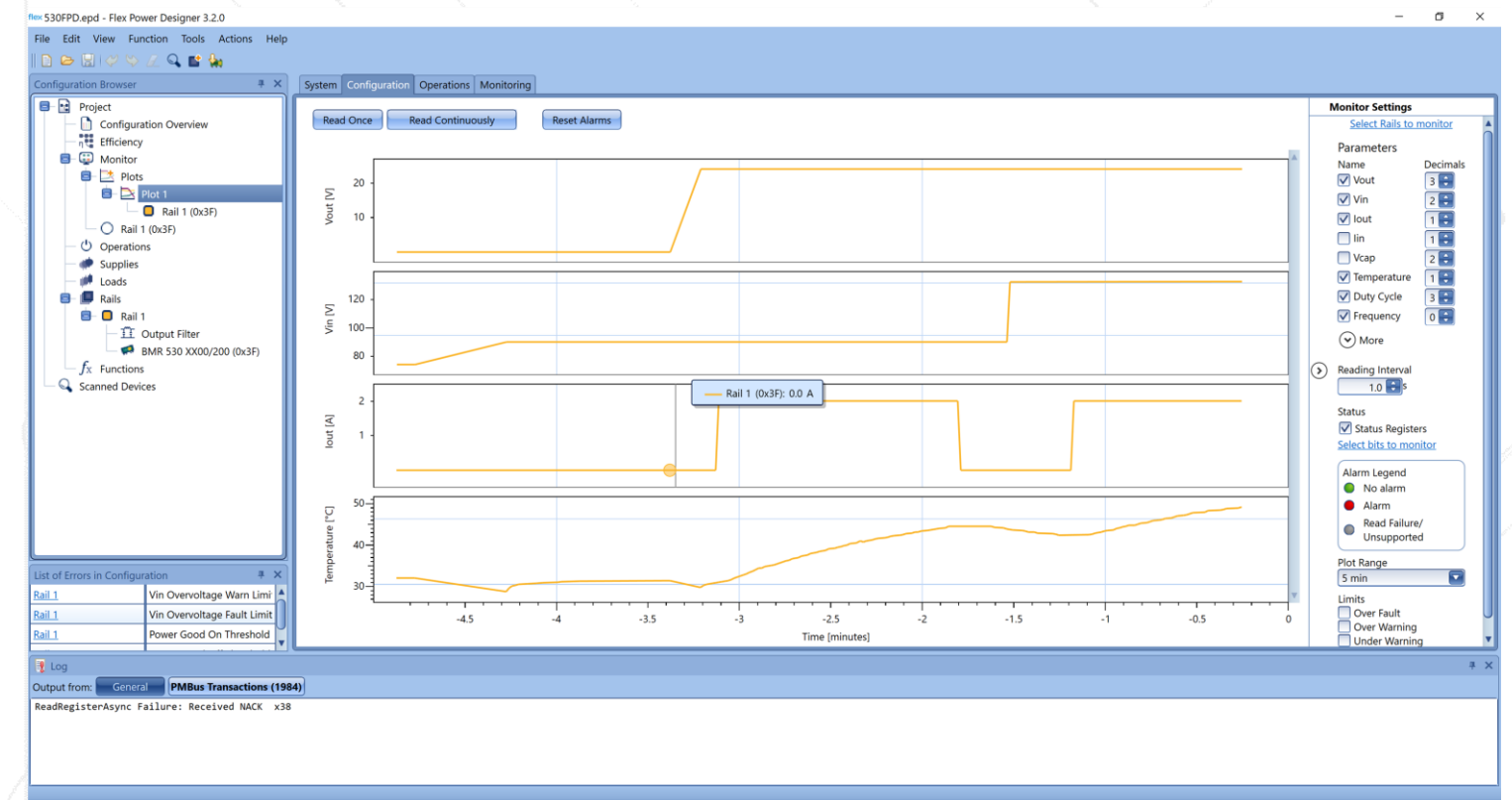
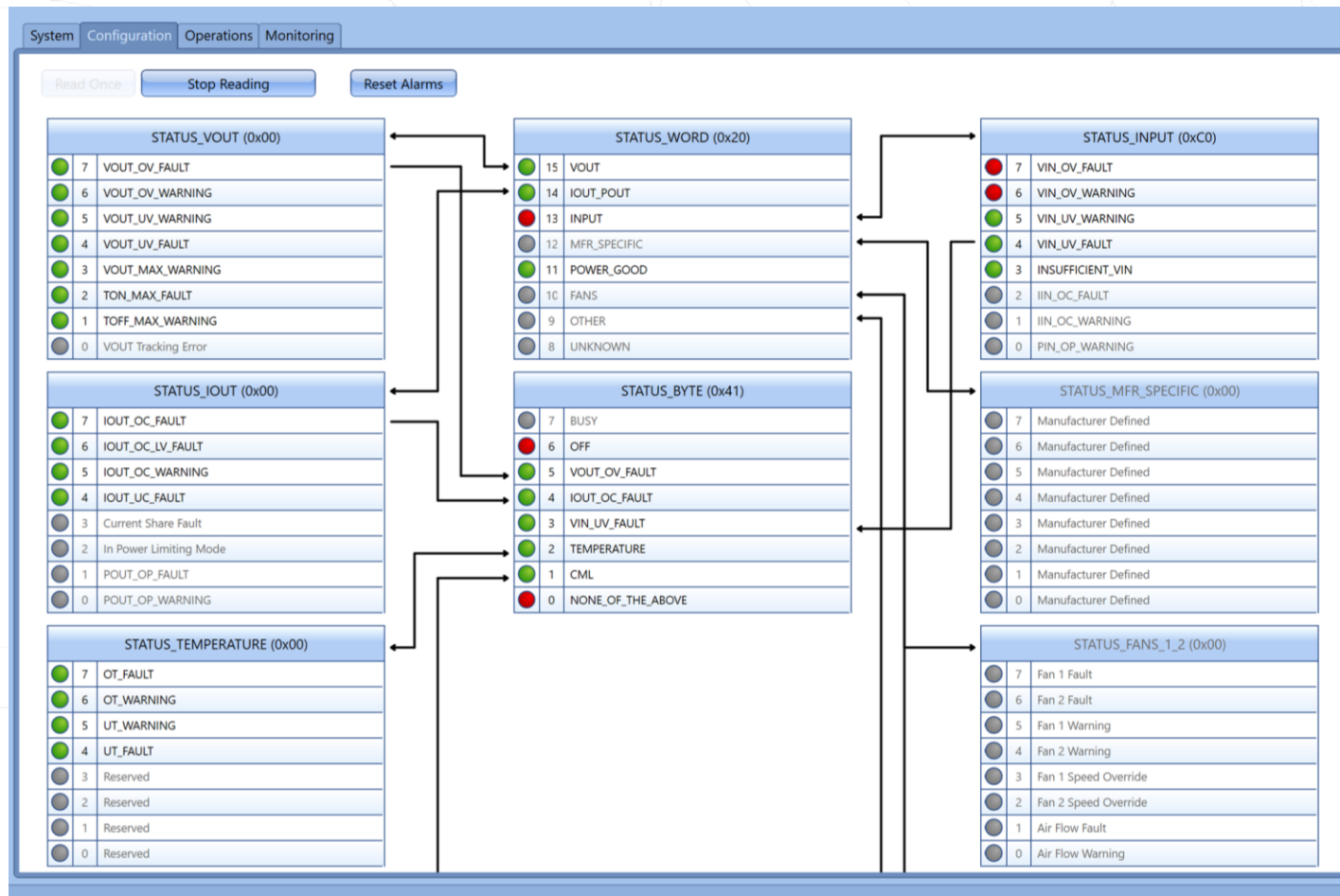
较小的高度尺寸公差

- 高度尺寸公差为 $\pm 0.2\text{mm}$ ，方便客户的结构和热设计



数字功能

- ❖ 标准DOSA数字电源封装（可提供兼容模拟产品管脚封装无数字管脚的产品）
- ❖ 使用标准PMBus通讯协议
- ❖ 提供可软件配置的输入欠压，过压保护；输出过压，过流和过温保护
- ❖ Flex Power Designer（FPD）软件可支持BMR685的配置和状态监控
- ❖ FPD的画图功能-通过PMBus接口读取模块工作状态信息形成图形化数据
- ❖ 监控功能-实时状态信息读取，方便故障现象的诊断
- ❖ 快照功能-模块下电时，自动记录失效状态信息到模块内部的闪存存储器里，方便客户后期故障分析



快照功能

- ❖ **Snapshot** – 记录所有状态和告警信息
- ❖ 当输入跌落到输入关机点，Vin_off(可配置)，模块记录所有状态信息和最后的工作时间信息

Configuration Browser

Project

Configuration Overview

Efficiency

Monitor

Plots

Rail 1 (0x3F)

Operations

Supplies

Loads

Rails

Rail 1

Output Filter

BMR 530 XX00/200 (0x3F)

Functions

Scanned Devices

List of Errors in Configuration

Rail 1	Vin Overvoltage Warn Limi
Rail 1	Vin Overvoltage Fault Limit
Rail 1	Power Good On Threshold

System Configuration Operations Monitoring

Rail Definition Basic Current Sharing Data Sheet Dynamic Bus Voltage Hybrid Regulated Ratio Re

Display mode

Configuration RAM ☒ Highlight difference Refresh from RAM

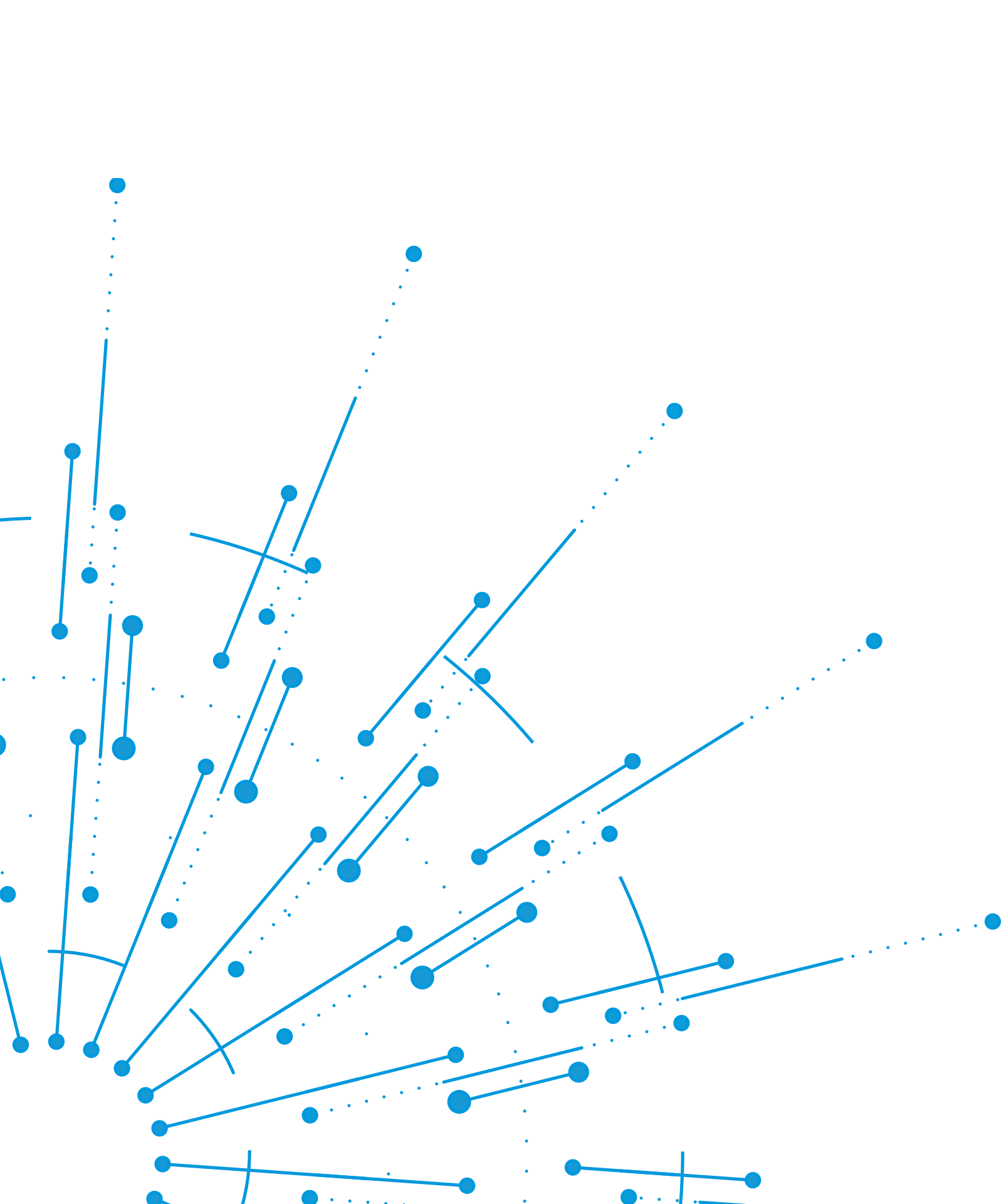
Filter, matches 1 of 117

Filter Text snapshot Clear Select/Type Filter Name

Name	Code	BMR 530 XX00/200 (0x3F)
MFR_GET_SNAPSHOT	0xD7	0x040040000000C8000041412000
Snapshot Cycles [255:240]		4 Times
Manufacturer Specific Status Byte [239:232]		0x40
Status Other [231:224]		0x00
Status CML [223:216]		0x00
Status Temperature [215:208]		0x00
Status Vin [207:200]		0xC8
Status Iout [199:192]		0x00
Status Vout [191:184]		0x00
Status Byte [183:176]		0x41
Status Word [175:160]		0x2041
Time in operation [159:144]		0 seconds
Temperature 2 [143:128]		34.625 °C
Temperature 1 [127:112]		30.75 °C
Load Current [111:96]		0 A
Output Voltage [95:80]		0.23535 V
Input Voltage [79:64]		50.25 V

Comparison • key features

	BMR685	PKJ4716H	Competitor A
Mechanical			
Dimensions	Half brick digital	Half brick analog	Half brick digital
Electrical			
Input voltage range	36-75 V	36-75 V	36-60 V
Output voltage	50 V	50 V	50 V
Output voltage range	25-55 V	25-55 V	50 V
Output power	1300 W	700 W	1300 W
Output current	26 A	14 A	26 A
Efficiency	97.2% half load	95.7 % half load	96.4% half load
Switching frequency	120 kHz	200 kHz	140 kHz
Ripple and noise	40 mV _{p-p}	60 mV _{p-p}	200 mV _{p-p}
Isolation	2250 V	1500 V	2250 V



PKU-D & PKU-C

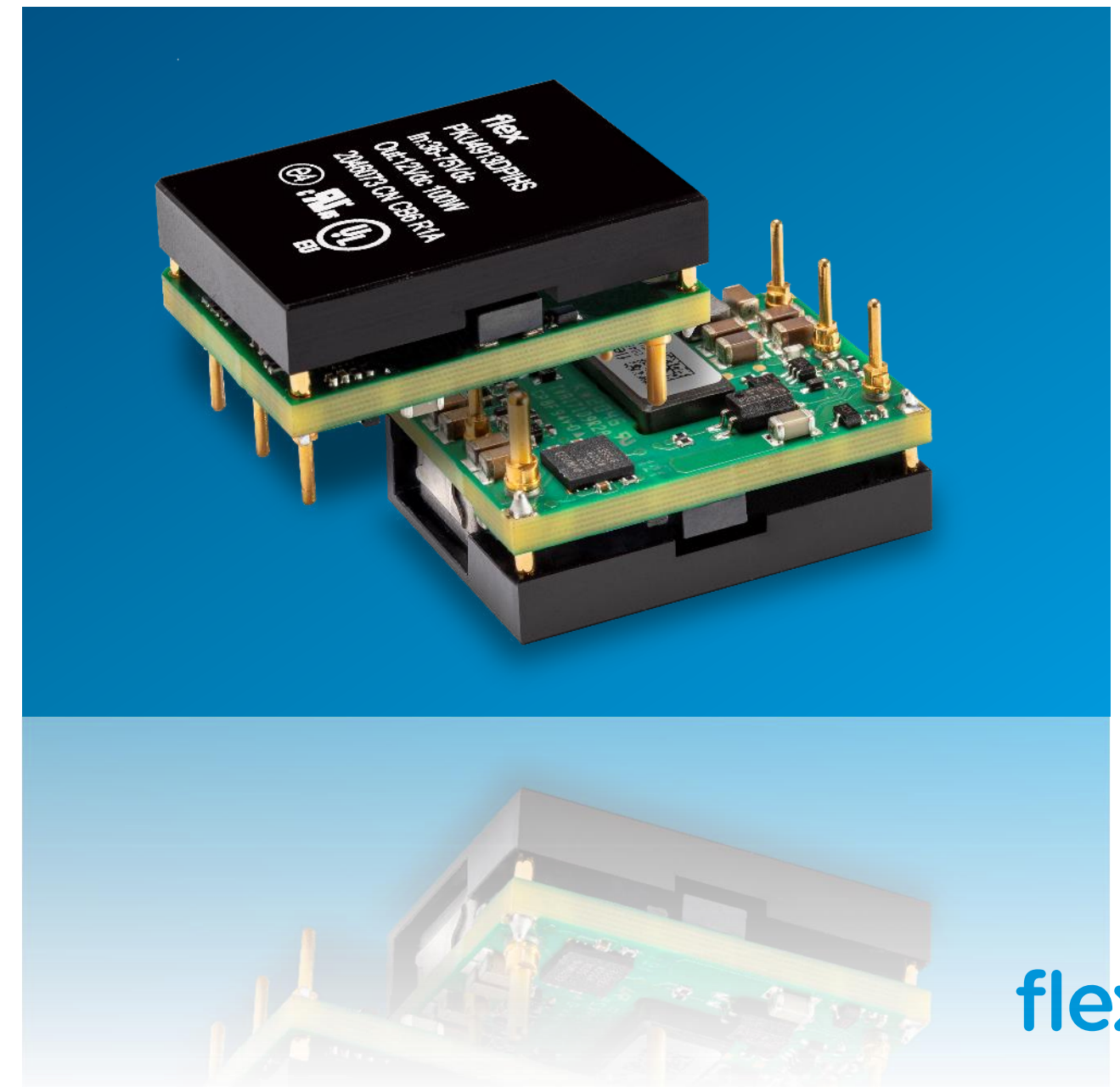
DC/DC converter in sixteenth brick format

Designed for **low power radio applications** such as microwave, small cells and indoor wireless coverage

Product overview • PKU-D

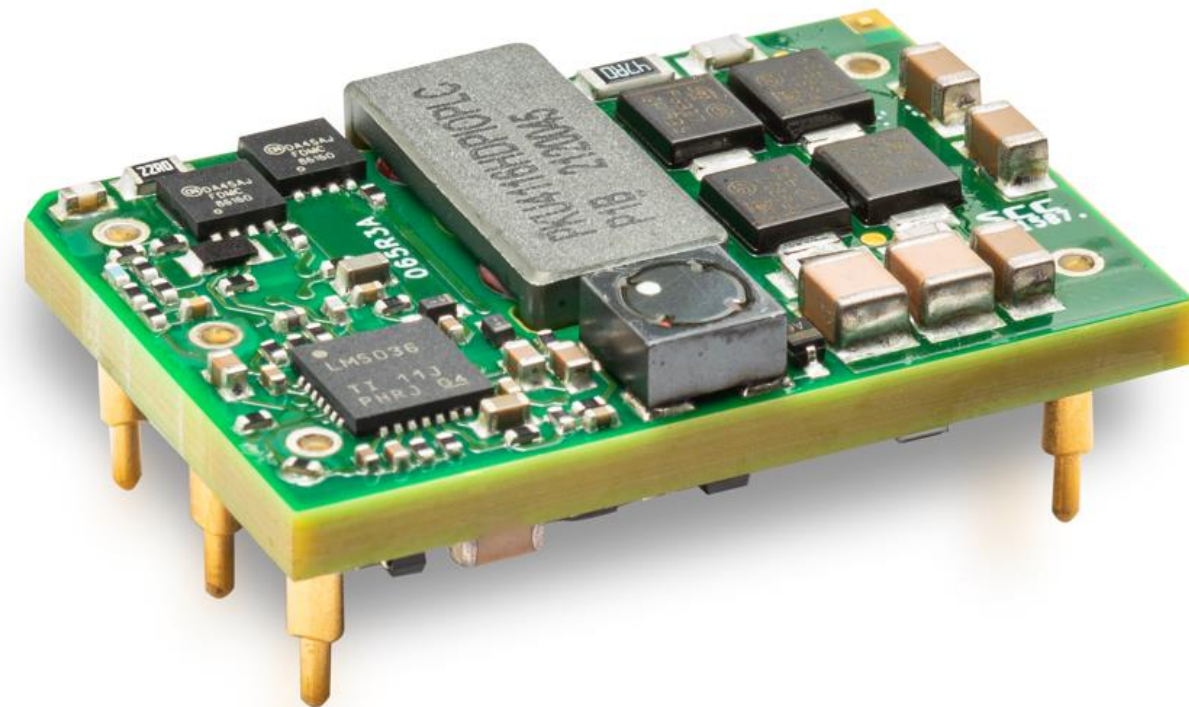
- Low profile sixteenth brick – available with baseplate
- Wide output trim range for low-power radio designs
- Excellent price/performance ratio
- Efficiency up to 95% half load
- Extremely good thermal performance
- Output power: 100-260 W
- Input: 36-75 V
- Output: 2.6 – 13.2 V

Dimensions:
33 x 22.9 x 11.3 mm
1.3 x 0.9 x 0.44 in



Product overview • PKU4116HD

- Isolated DC/DC
- Output power: up to 110 W
- Input: 36-60 V
- Output: 55 V
- Isolation 2250Vdc

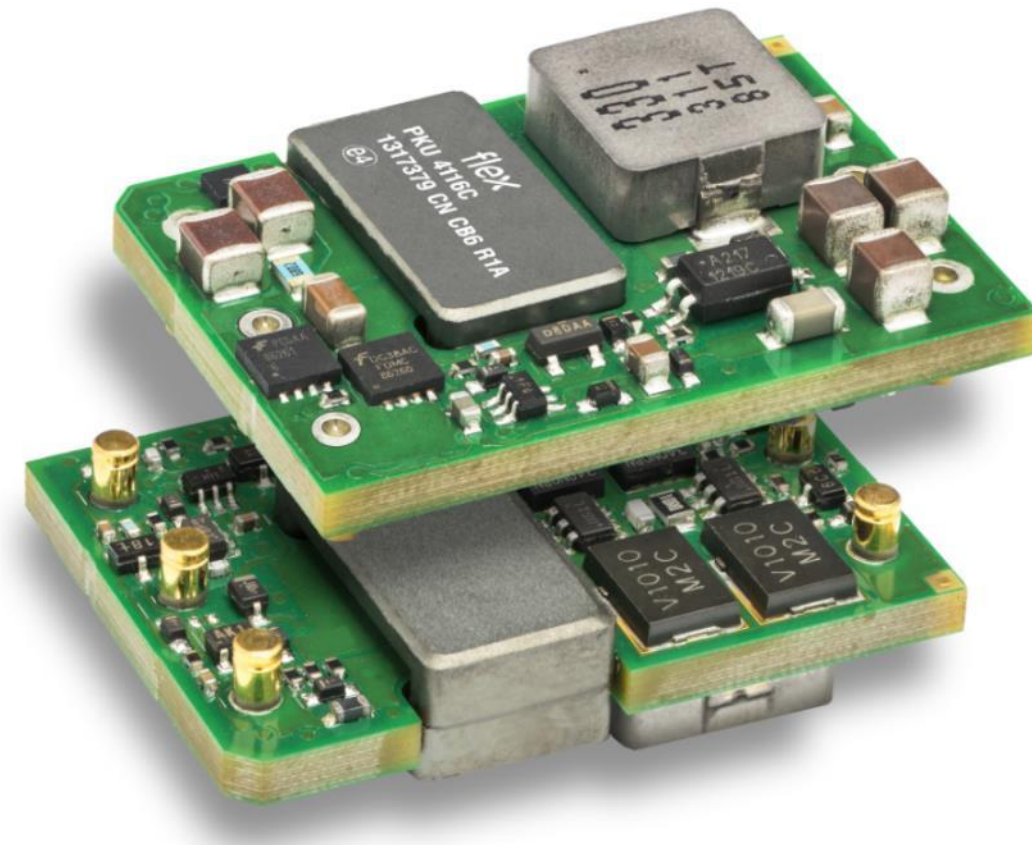


Dimensions:

33 x 22.9 x 9.8 mm
1.3 x 0.9 x 0.38 in

Product overview • PKU4116C

- Low profile sixteenth brick
- Isolated DC/DC
- Output power: up to 100 W
- Input: 36-75 V
- Output: 10 - 33 V
- Isolation 1500 V



Dimensions:
33 x 22.9 x 9.6 mm
1.3 x 0.9 x 0.38 in

Key features

	PKU4116C	PKU-D	PKU4116HD
Mechanical			
Dimensions	33 x 22.9 x 9.6 mm	33 x 22.9 x 11.3 mm	33 x 22.9 x 9.8 mm
Electrical			
Input voltage range	36-60 V	36-75 V	36-60 V
Output voltage	5-6 V	2.6-13.2 V	55 V
Output power	60 W	100 – 260 W	110 W
Output current	12 A	8.3 -33 A	2 A
Efficiency	93%	96%	92.4%
Switching frequency	300 kHz	500 kHz	500 kHz
Ramp-up time	10 ms	12 ms	19 ms
Isolation	1500 V	2250 V	2250 V

Application areas – focus for Flex Power Modules

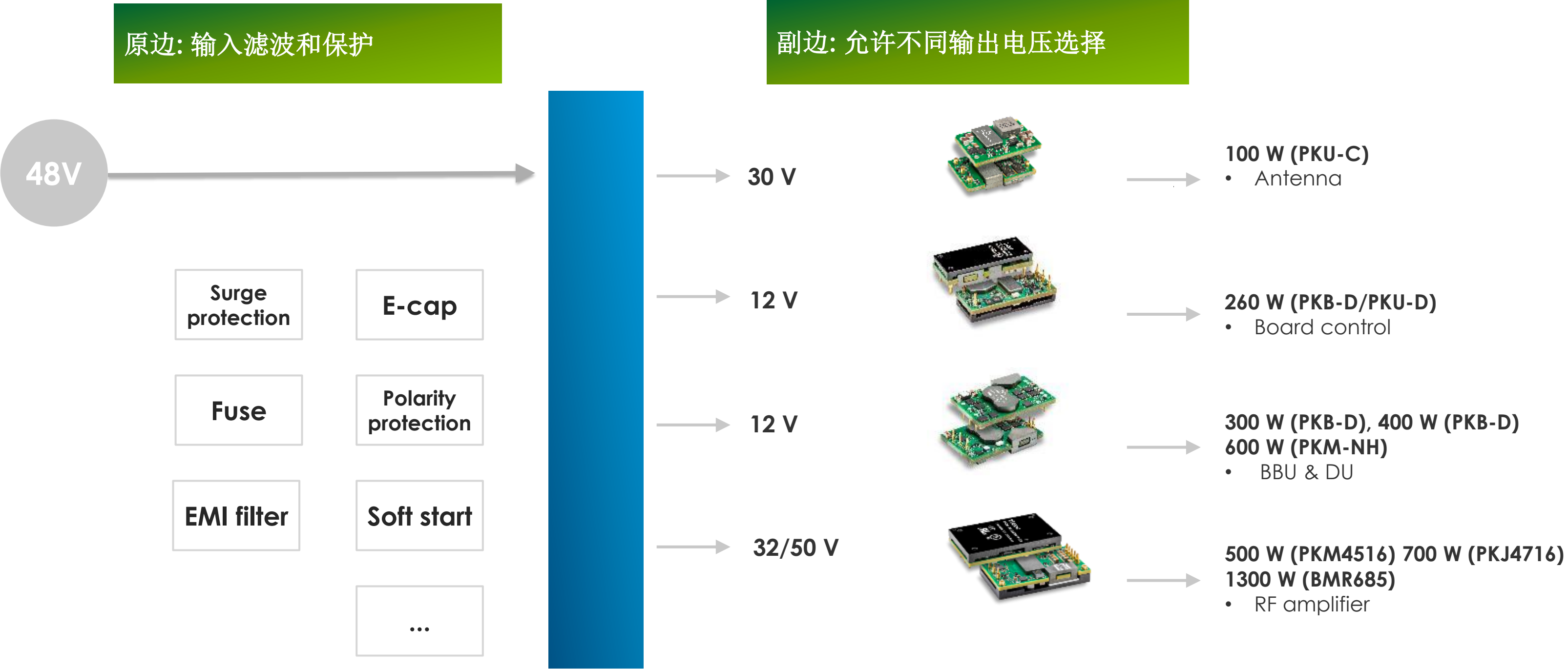
RFPA products

- RF Power Amplifiers (Telecom Radio) – RRH/RRU, RU
- Macro Base Stations
- 5G low/mid/high power
- AAS/Massive MIMO
- Microwave Indoor Units
- Power over Ethernet applications

PKU-D/PKU-C series

- Telecom Networks
 - Microwave backhaul/fronthaul
 - Small cells
 - In-building wireless
 - BBU, DU, CU
 - Distributed Antenna Systems (DAS)
 - Satcom
 - CATV

DC/DC solutions for 5G applications



Case Study 1

- Customer – a new player in the O-RAN Alliance HW infrastructure development
- Project – Massive MIMO 5G 32T32R reference design using ADI & Marvell
- Design consists of 2 sections:
 - Power Amplifier
 - Baseband
- Power Amplifier DC/DC requirements
 - 28 V with trim capability at up to 1000W. Needed digital interface for monitoring
- Baseband DC/DC requirements
 - 12 V at up to 200 W. Needed digital interface for monitoring
- Thermal – sealed box conduction cooling. Max case temperature of +100°C.

- **Power Amplifier**

- [BMR6830300/200](#) – 500 W 18-32 V Digital Quarter Brick

- **Radio**

- [BMR4560104/001](#) – 420 W 12 V Digital Quarter Brick



Case Study 2

- Customer – a key player in the O-RAN Alliance
- Design consists of 2 sections:
 - Power Amplifier
 - Radio
- Power Amplifier DC/DC requirements
 - 50 V with trim capability at up to 700 W * 2pcs
- Radio DC/DC requirements
 - 12 V at up to 450W
 - 30W up to 60W
- Thermal – sealed box conduction cooling. Max ambient temperature of +95°C.

- **Power Amplifier**

- [PKJ4716HD](#) – 700 W 50 V Half Brick with 25-55 V trim range

- **Radio**

- [PKB4413D](#) – 450 W 12 V Eighth Brick
- [PKU4116C](#) – 100 W 10~30V Sixteenth Brick



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Q&A

visit our website:
flexpowermodules.com

