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Design and Implementation of Microwave solid state power amplifiers for AWAKE

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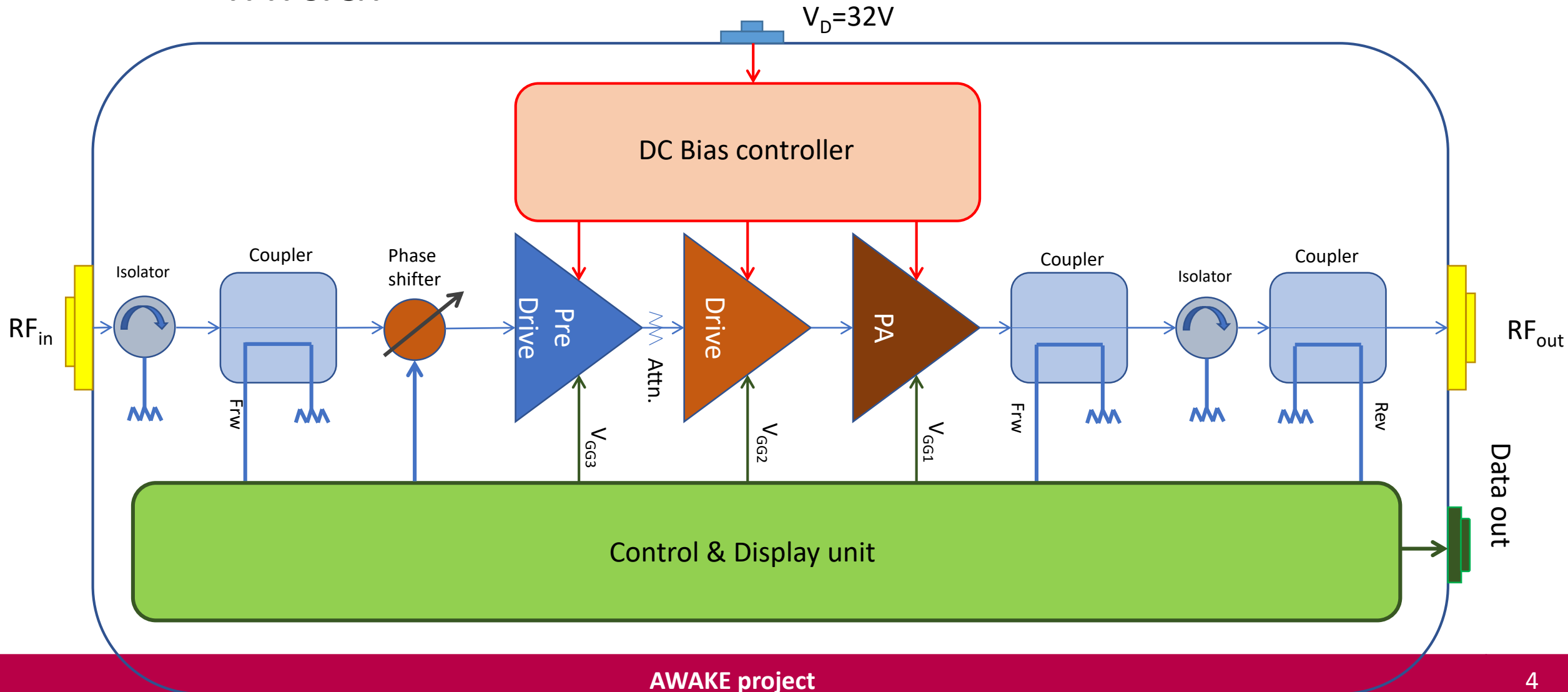
Topics

- ✓ Design steps in 250 W power amplifier at 3 GHz - From block diagram to measurement results
- ✓ Progress in the design of 200W and 1.6 kW solid state power amplifier at X-band

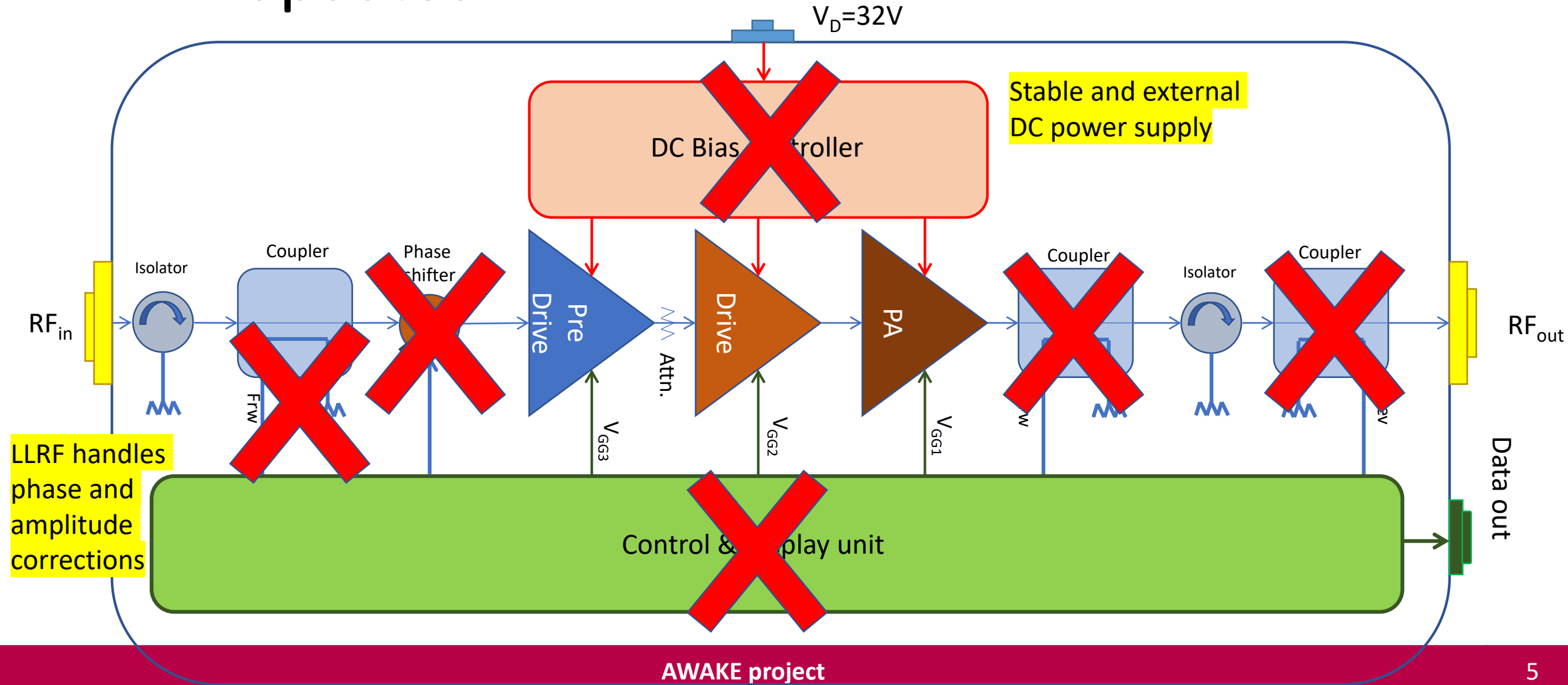
Design requirements for S band-PA

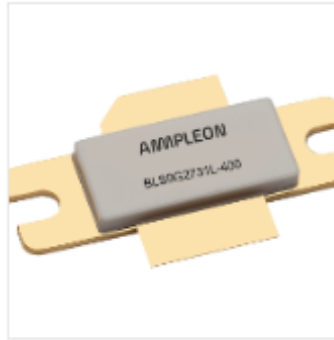
- Center frequency 3GHz
- Minimum output power 250 W (up to 500W is also allowed)
- Linearity is not an important factor as it could be compensated by LLRF
- Input power < 10 dBm (so we need at least 45 dB signal gain-31000 times)
- Pulse Repetition Frequency (PRF) $< 1\%$ with $4.5\mu\text{s}$ pulse width
- Protected against full power reflection condition

Block diagram of 250W SSPA @ 3GHz - initial




Block diagram of 250W SSPA @ 3GHz – updated





BLS9G2731L-400

[Download datasheet](#) 

[Overview](#)

[Product details](#)

[Recommended line-up](#)

[Quality](#)

[Ordering](#)

LDMOS S-band radar power transistor

400 W LDMOS power transistor for S-band applications in the frequency range from 2700 MHz to 3100 MHz

Features and benefits

- High efficiency
- Excellent ruggedness
- Designed for S-band radar applications
- Excellent thermal stability
- Easy power control
- Integrated dual sided ESD protection enables excellent off-state isolation
- High flexibility with respect to pulse formats
- Internally matched for ease of use
- Compliant to Directive 2002/95/EC, regarding Restriction of Hazardous Substances (RoHS)



Driver and Pre-driver design

BLM9D2327S-50PB; BLM9D2327S-50PBG

LDMOS 2-stage integrated Doherty MMIC

Rev. 1 — 6 April 2019

AMMPLÉON

Product data sheet

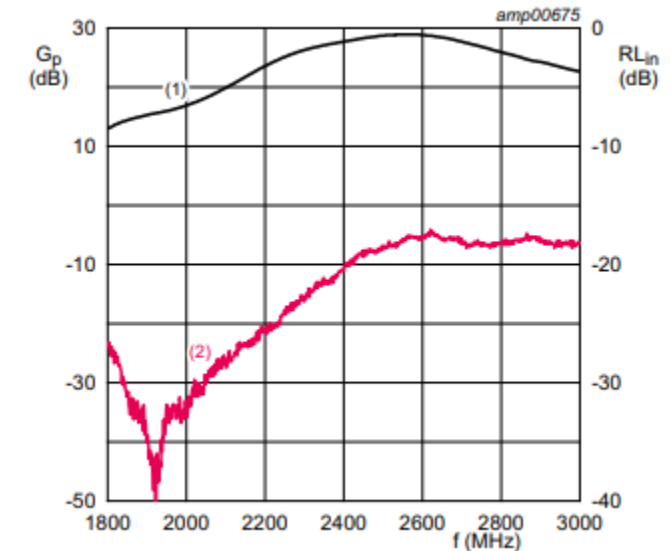


1. Product profile

1.1 General description

The BLM9D2327S-50PB(G) is a dual section, 2-stage fully integrated Doherty MMIC solution using Ampleon's state of the art GEN9 LDMOS technology. For each section, the carrier and peaking device, input splitter and output combiner are integrated in a single package. This multiband device is perfectly suited as general purpose driver or small cell final in the frequency range from 2300 MHz to 2700 MHz. Available in gull wing or flat lead outline.

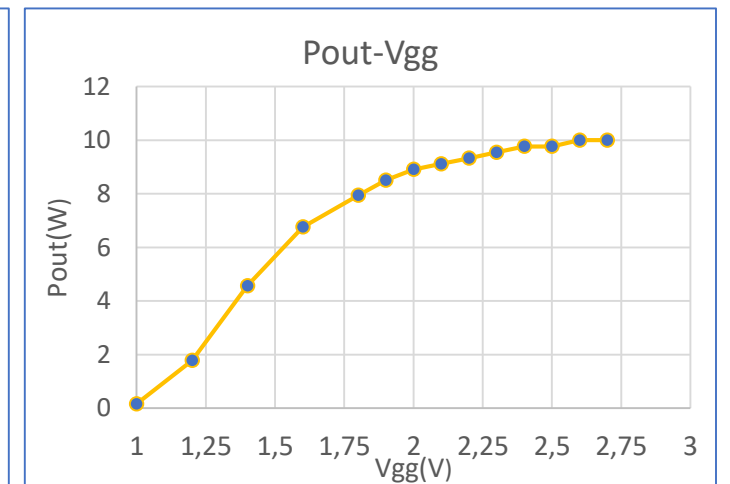
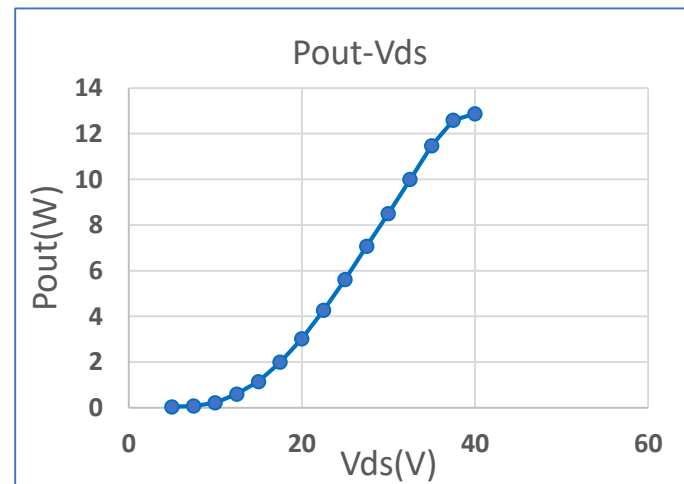
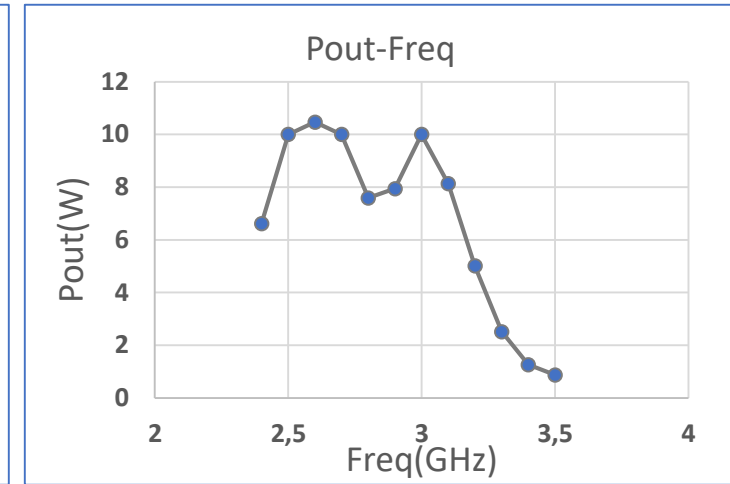
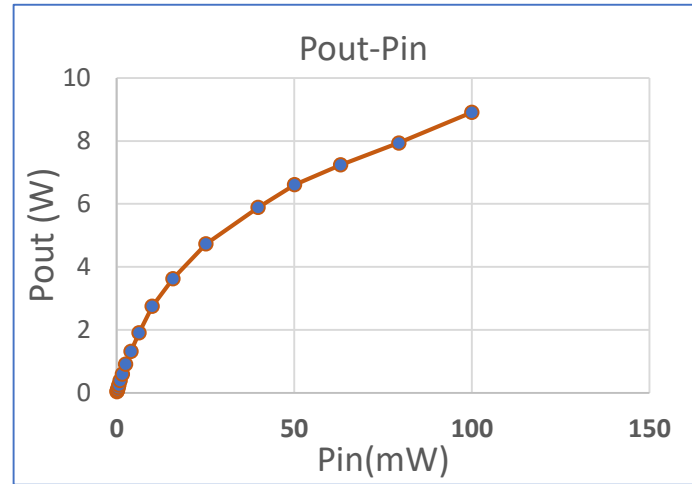
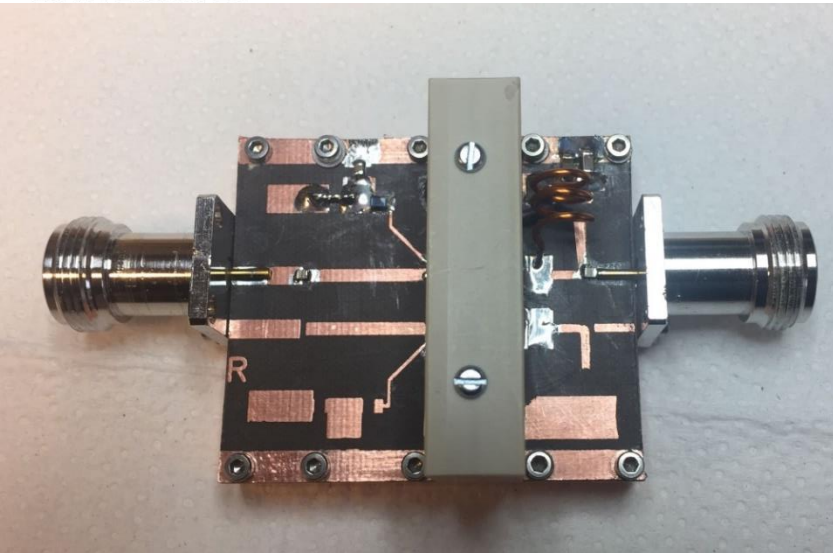
Test signal	f	V _{DS}	P _{L(M)}	G _p	η _D	ACPR _{20M}
	(MHz)	(V)	(dBm)	(dB)	(%)	(dBc)
single carrier LTE	2600	28	47.7	29.0 [1]	25.7 [1]	-39.5 [1]
				28.7 [2]	41.1 [2]	-36.2 [2]





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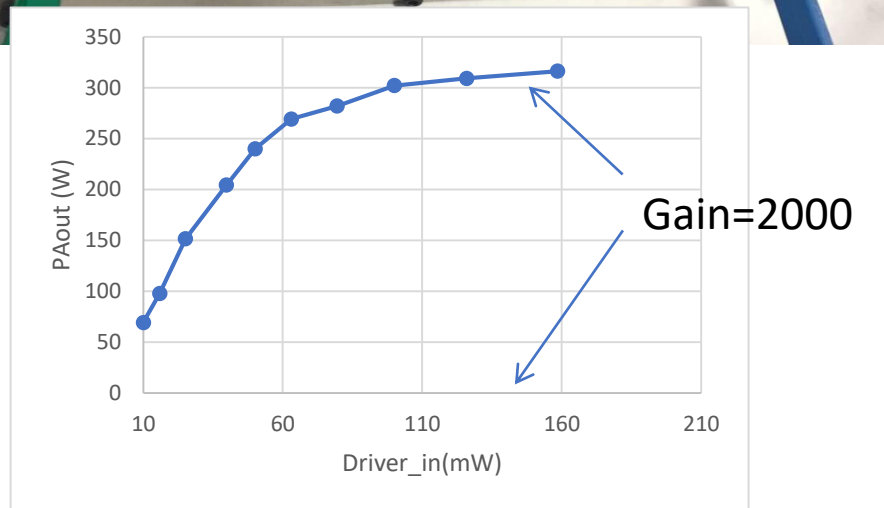
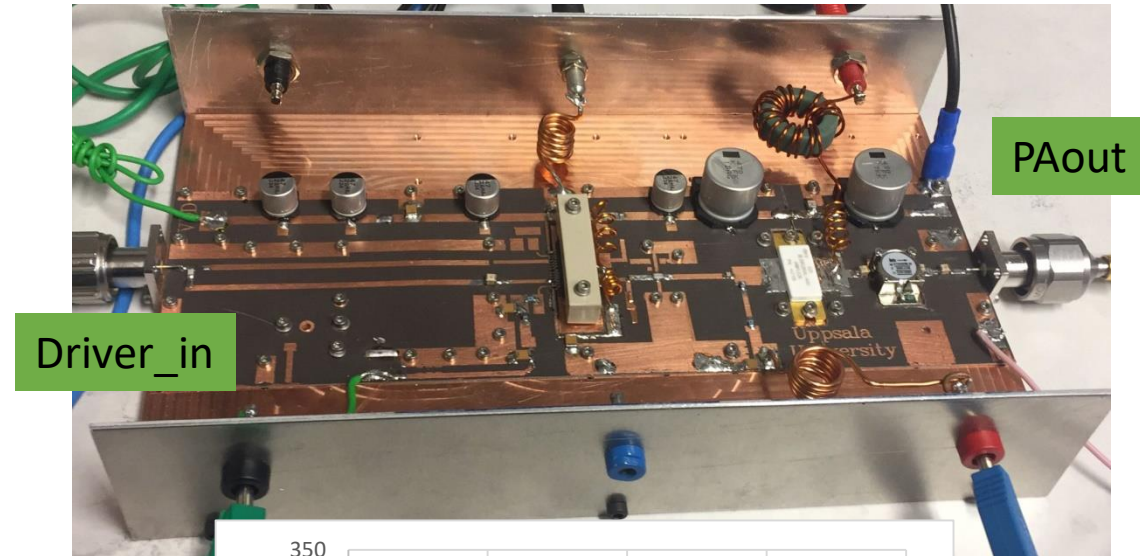
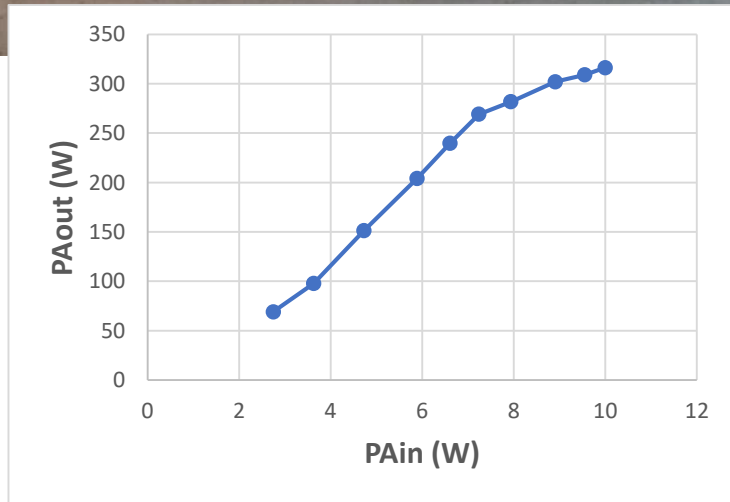
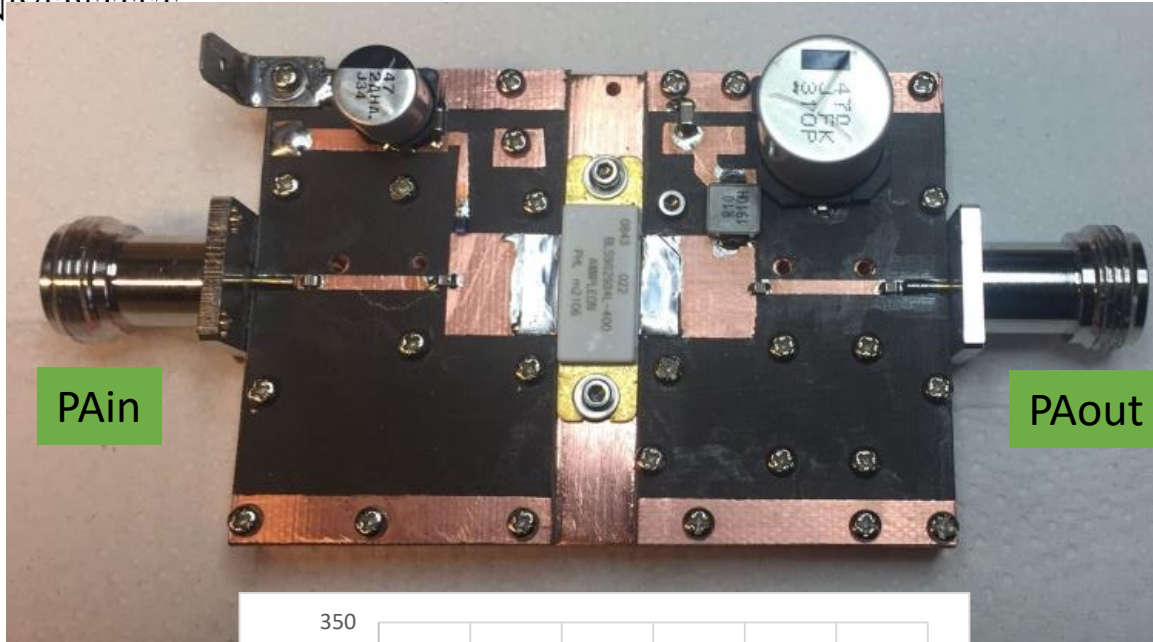
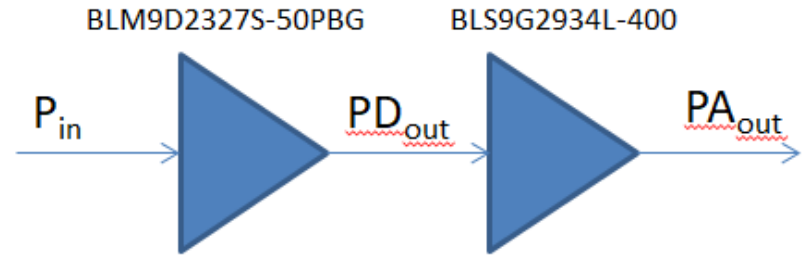
Design and characterization - Driver





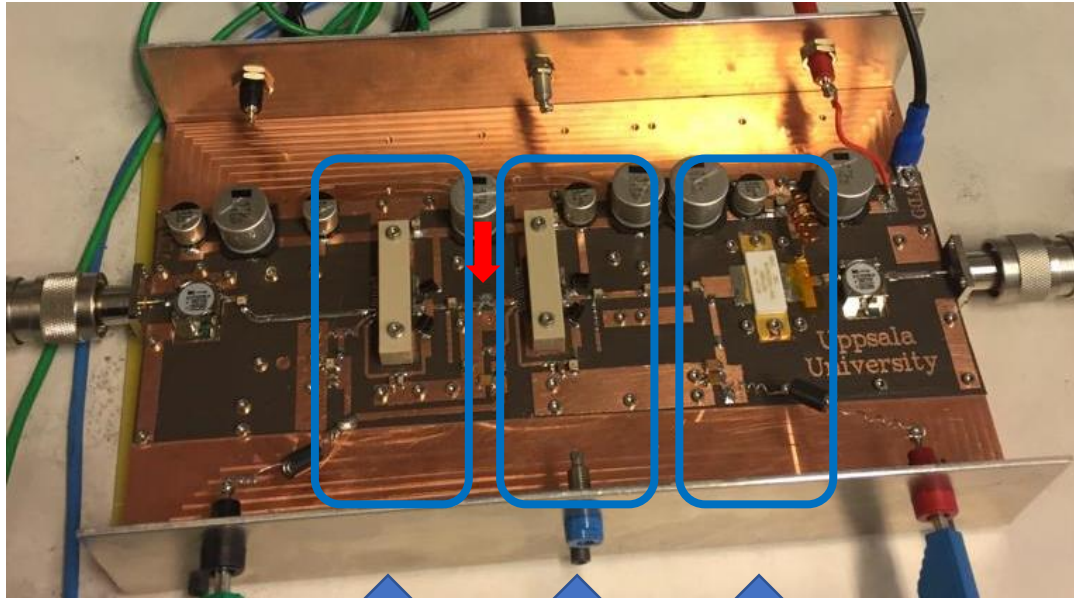
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Design and meas. of the PA





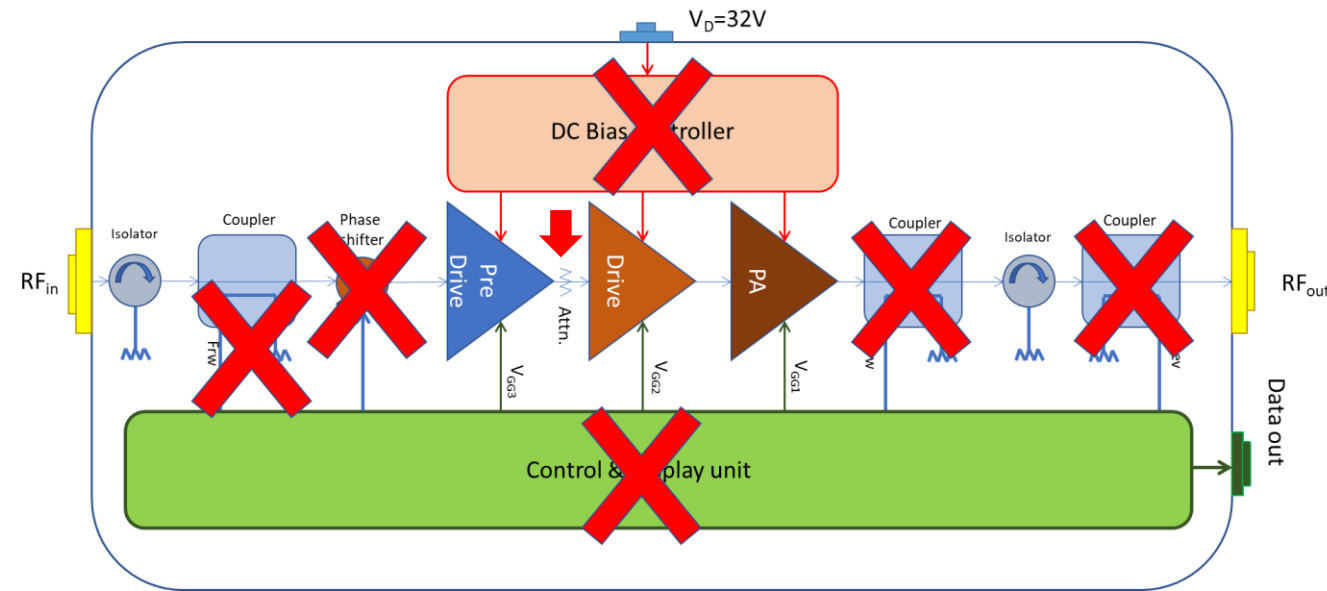
Pre-driver embedding



Pre Driver

Driver

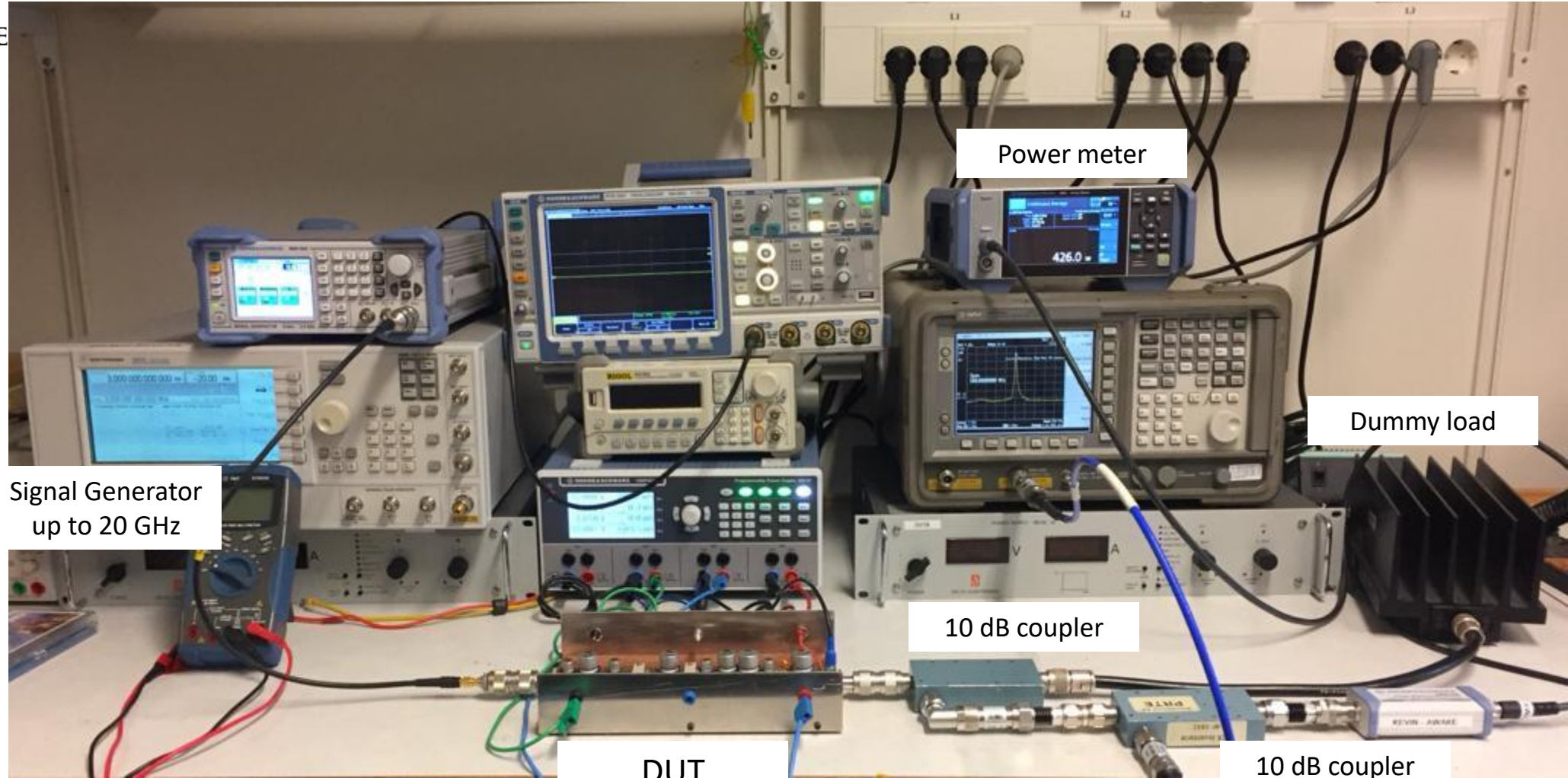
PA





Test & Measurement set-up

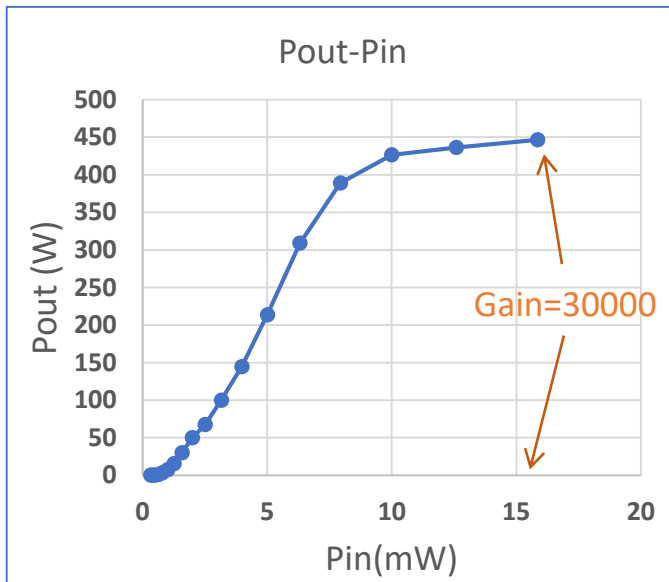
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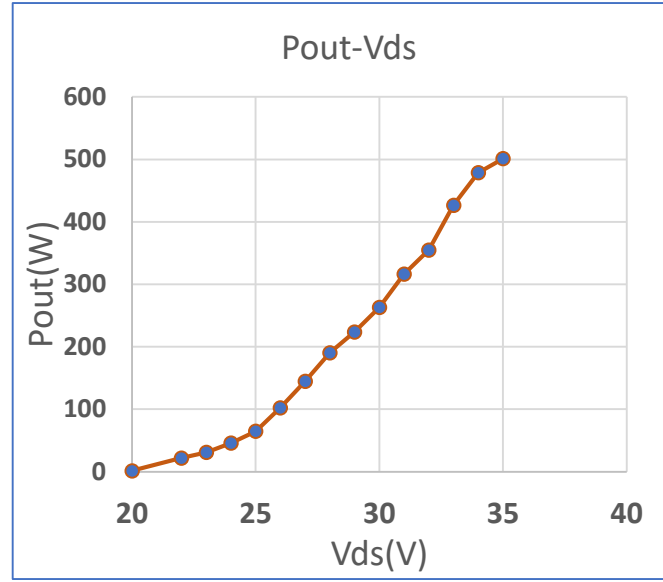


Measurement results

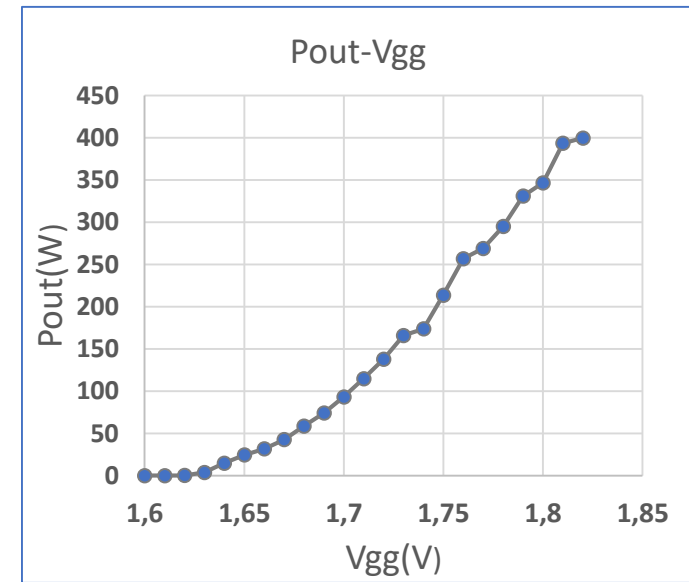
Freq 3 GHz,
Vdd=32V, Vgg=1.8V,
Pin is swept and Pout is measured



Freq 3 GHz,
Pin=8dBm, Vgg=1.8V,
Vds is swept and Pout is measured

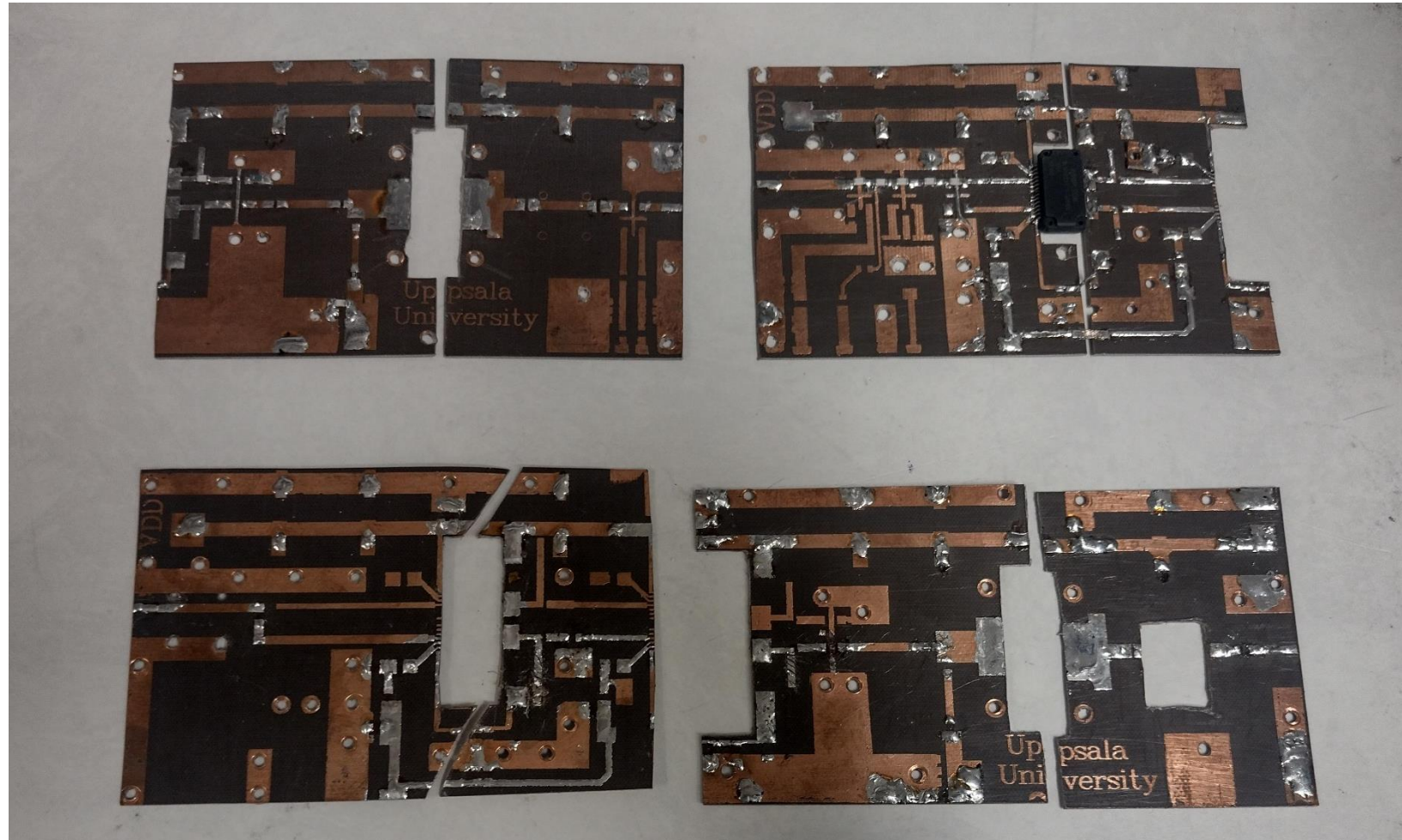


Freq 3 GHz,
Pin=8dBm, Vdd=32V,
Vgg is swept and Pout is measured



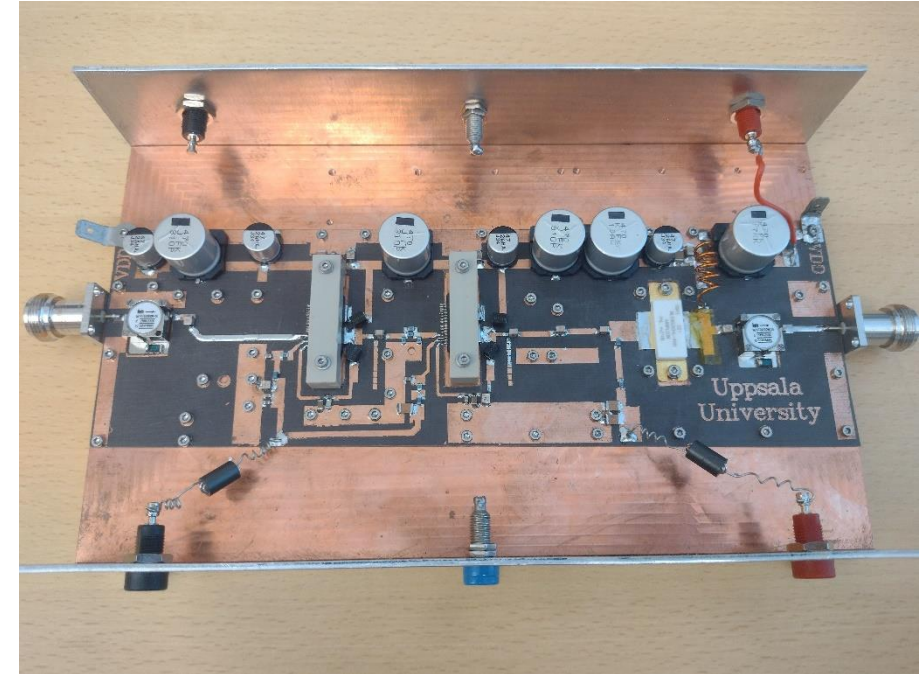
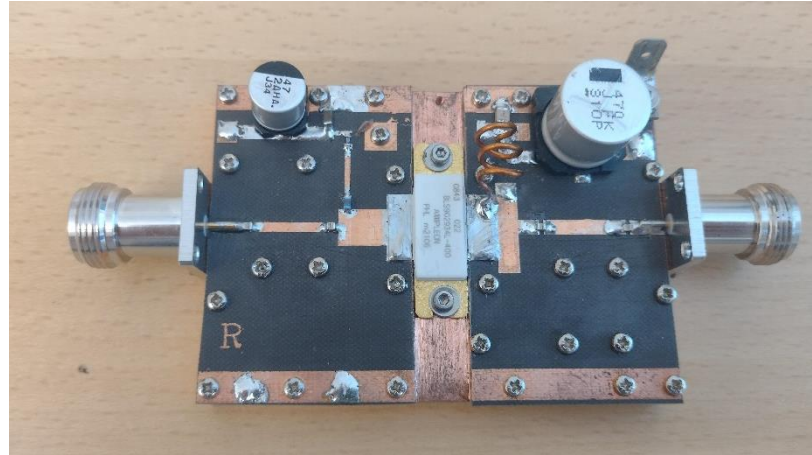
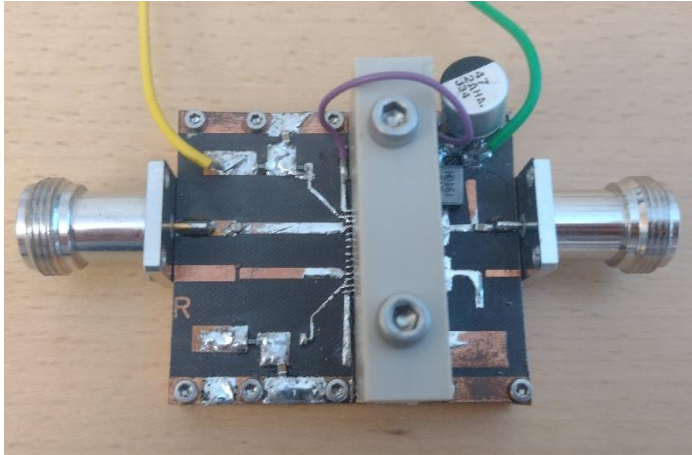
- ➡ Using this data, LLRF can be further developed to tune the amplitude of the output signal
- ➡ For the phase we need a VNA.

Development process - iterative





Development process - results



Remaining – next steps:

- Box design and related simulations
- Final measurement simple
- Final measurement with LLRF
- Field test at CERN



X band solid state power amplifier

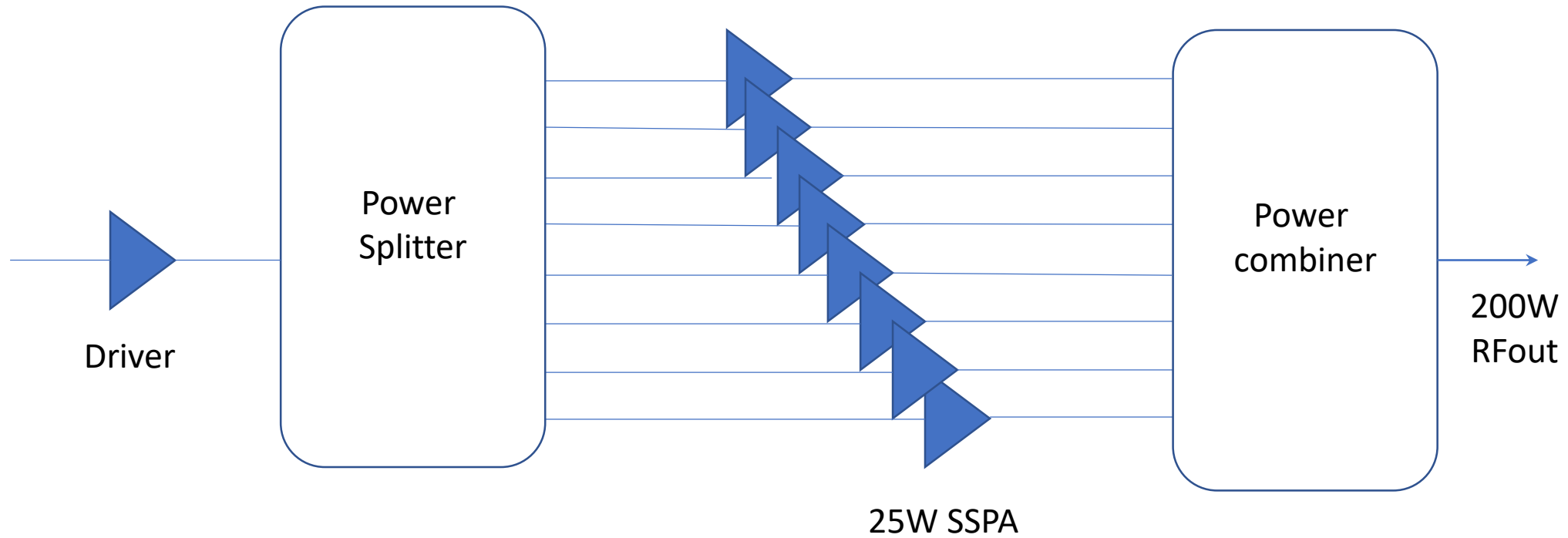
- 200 W @ 12GHz
- 1.6 kW @ 12GHz



SSPA @ 12 GHz – available transistors

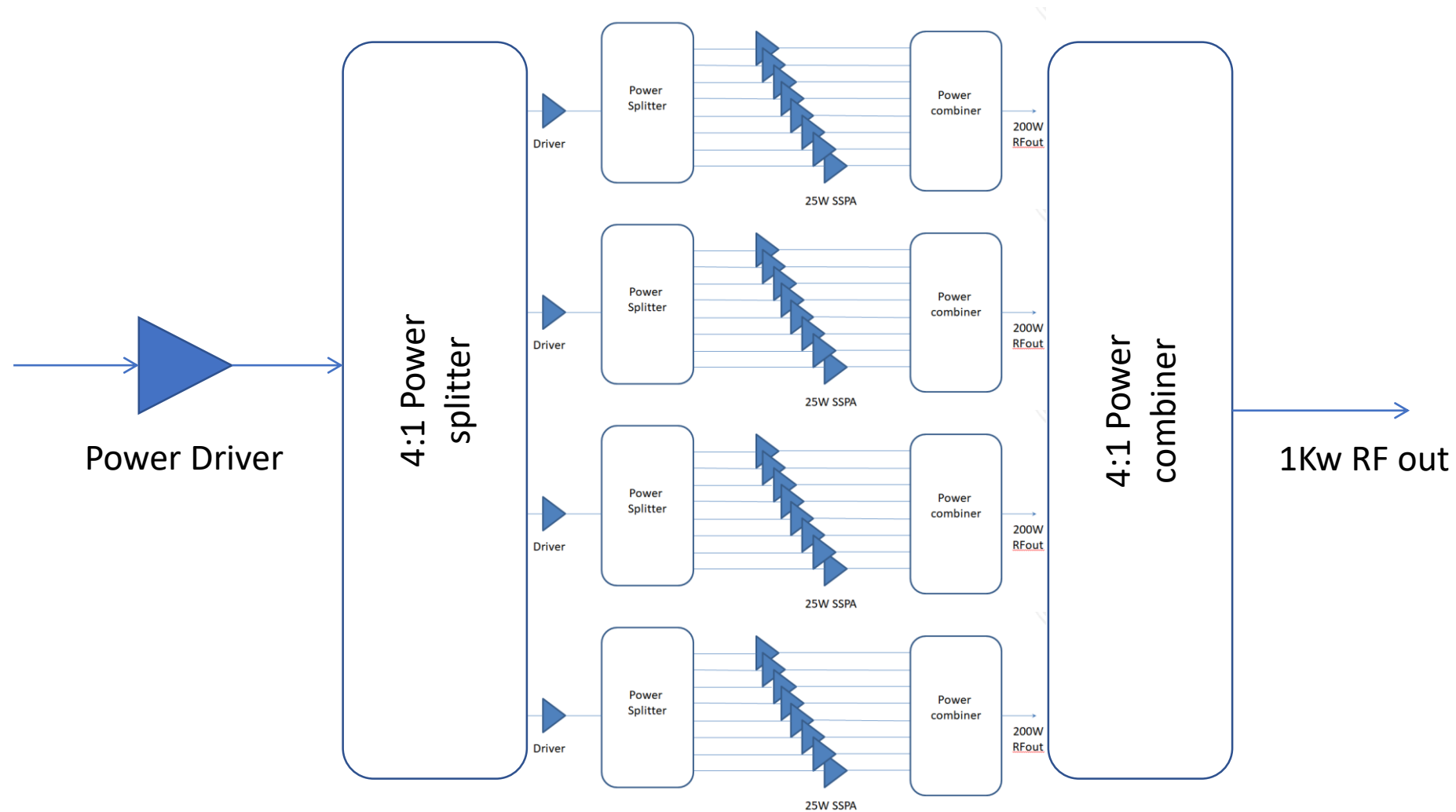
NO.	Part number	Company	F (min)- F(max)	Pout (sat)	Package	Match//U nmatch
1	TGA2590-CP	Qorvo	6-12 GHz	30 W	Flange	
2	TGA2590	Qorvo	6-12 GHz	30 W	Die	
3	FMM5061VF	Eudyna	9.5-13.3 GHz	2 W	Flange	
4	P1006-BD	Mimi Asia	8.5 – 11GHz	10 W	Die	
5	MB6.0018G434820	Elite	6-18 GHz	20 W	Connectorized	
6	TGF2979	Qorvo	DC-12 GHz	25 W	plastic package	
7	TGF2978	Qorvo	DC-12 GHz	20 W	plastic package	
8	QPD1022	Qorvo	DC-12 GHz	10 W	plastic package	
9	TGM2635-CP	Qorvo	8-11 GHz	100 W	Flange	Matched
10	QPM1021	Qorvo	10-12 GHz	100 W	Flange	Matched
11	CGHV96100	Cree	8-9.6 GHz	100W	Flange	Matched
12	CGHV1F025	Cree	DC-15GHz	25W	plastic package	

SSPA configuration





1kW X-band SSPA





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Equipment needed



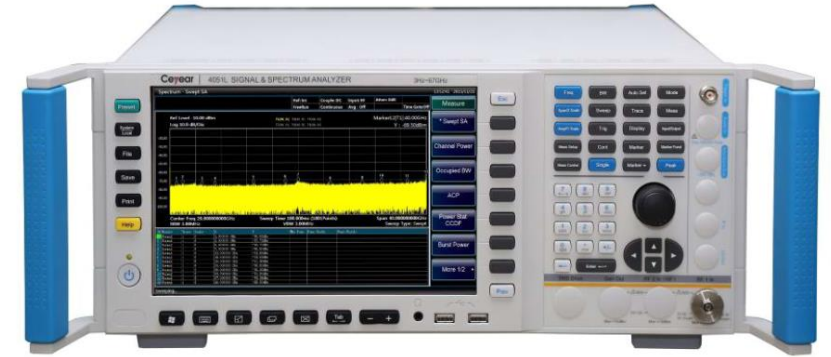
M5180 2-Port 26.5GHz VNA – 20 k€



3dB-6dB-10dB-20dB



350W-WA67 FIXED ATTENUATOR



SA Ceyar 4051 Series – 50 k€

Questions ?