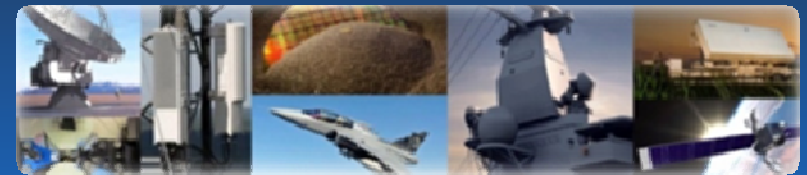


2006 – 2016 : 10 Years of ECI Projects

Rémy Leblanc - OMMIC





Introduction

2

- **Context:**
 - These projects are part of ECI program which aims at developing and qualifying in Europe components which are today only available from US and may in long-term fall under export restrictions (ITAR)
- **5 projects successfully completed:**
 - ECI1: 3 wideband mixers (AO4784)
 - ECI2: 2 Watt Ku-band amplifier (AO6070)
 - ECI2: Wideband phase shifter (6–18 GHz) (AO6184)
 - ECI2: Wideband low noise amplifier (1–45 GHz) (AO6068)
 - ECI3: Wideband LNA-MPA (12-19 GHz) (AO6854)





Introduction

3

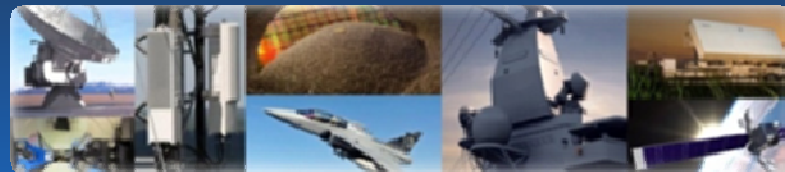
- **These 5 projects had similar structures :**
 - Collaboration TAS-F & OMMIC
 - Analyse non-European “state of the art” circuits
 - Develop new MMIC
 - **Space delta-evaluation** of MMIC process (if relevant)
 - **Space evaluation of circuit** (“new design”)
 - Make new MMIC available as **flight model** product





OMMIC

Innovating with III-V's



The Dream Team

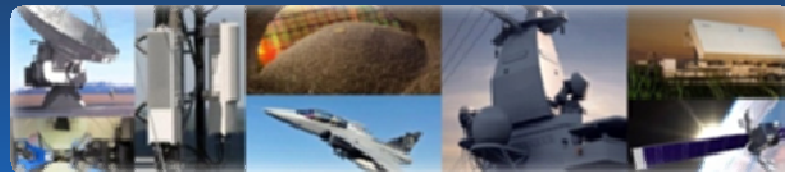
4



estec

European Space Research and Technology Centre



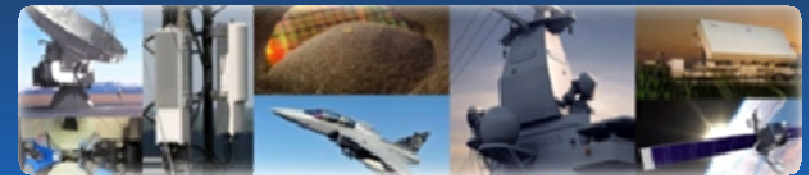


Tasks per partner

5

MMIC	Process	Design	Processing & ow Test	MMIC validation	Process evaluation
0.7-3.7 GHz Mixer	ED02AH	TAS-F	OMMIC	TAS-F	OMMIC
1.0-4.5 GHz Mixer	ED02AH	TAS-F	OMMIC	TAS-F	OMMIC
3-10 GHz Mixer	ED02AH	TAS-F	OMMIC	TAS-F	OMMIC
6-18 GHz Phase shifter	ED02AH	TAS-F	OMMIC	OMMIC	OMMIC
1-45 GHz LNA	D01PH	TAS-F (+OMMIC)	OMMIC (+Millilab)	OMMIC	OMMIC
K band 2W HPA	D01PH	TAS-F	OMMIC	TAS-F	OMMIC
K band LNA-MPA	D01PHS	TAS-F	OMMIC	TAS-F	OMMIC

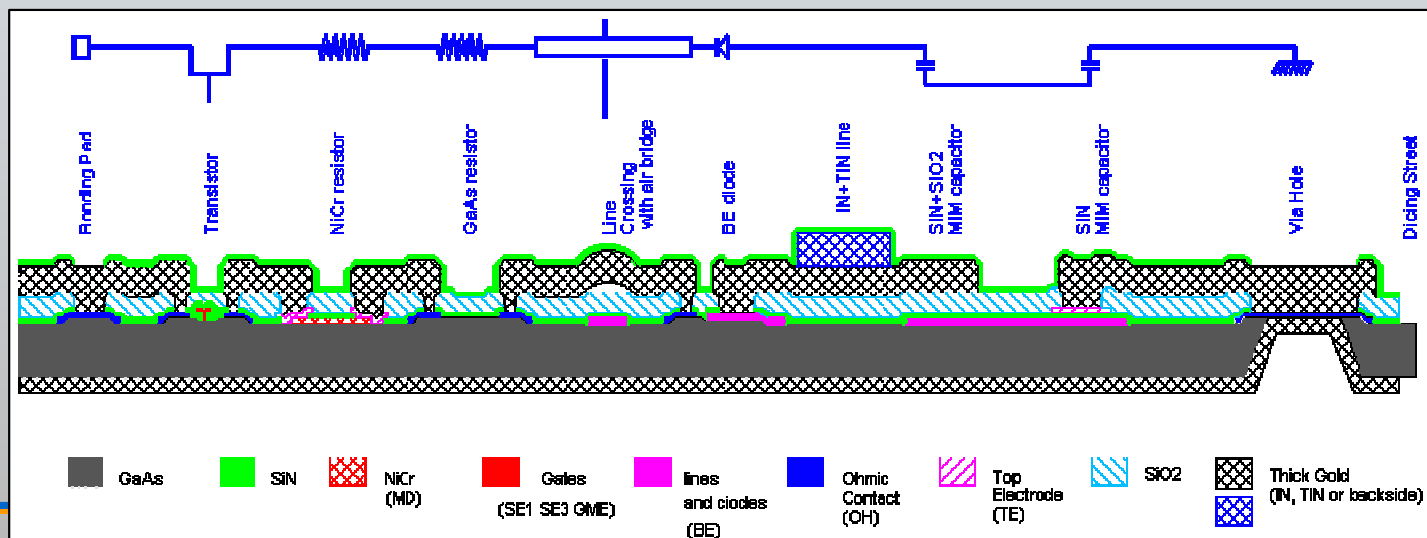


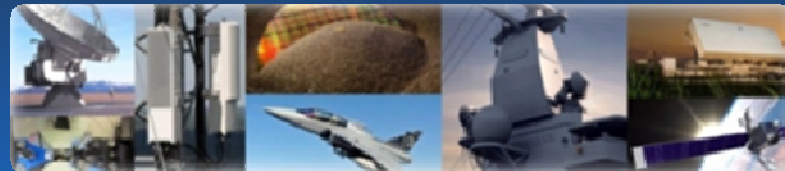


OMMIC Processes

6

- The OMMIC EPPL ED02AH, D01PH processes have been used and delta evaluations have been completed.
- A new capability of D01PH (etch stop) has been evaluated
- All processes are very similar (same passives) :
 - Via holes, full dielectric passivation, isolation and coverage
 - MIM 400pF/mm² & 50pF/mm²,
 - Res 100 or 200 Ohms.sq & 40 Ohms.sq

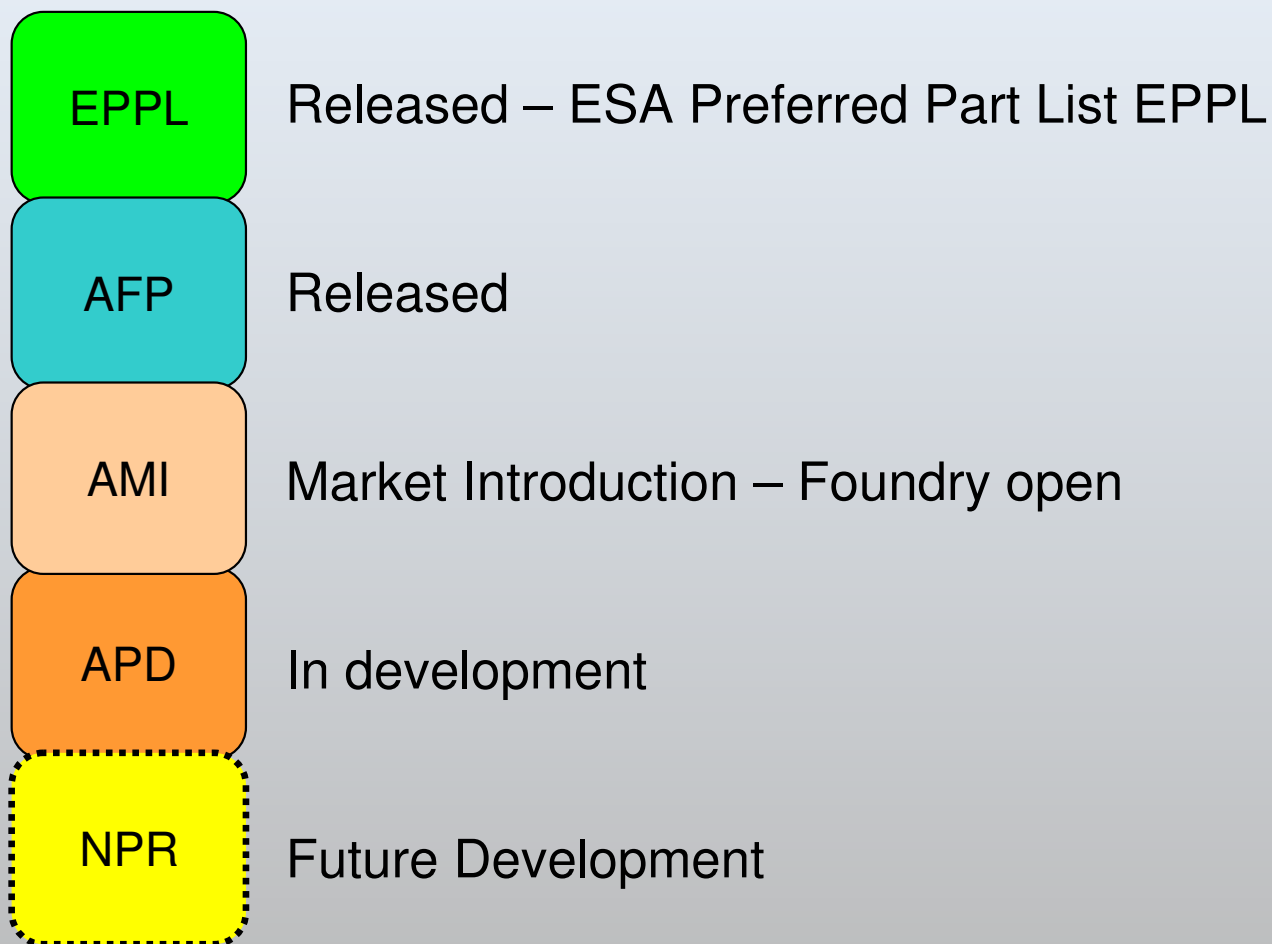


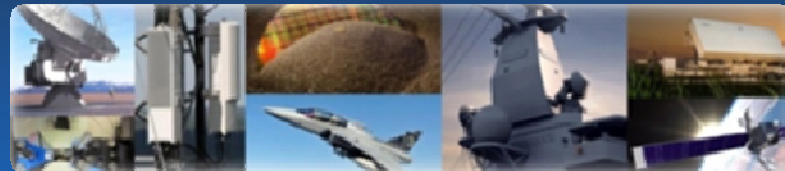


OMMIC processes

7

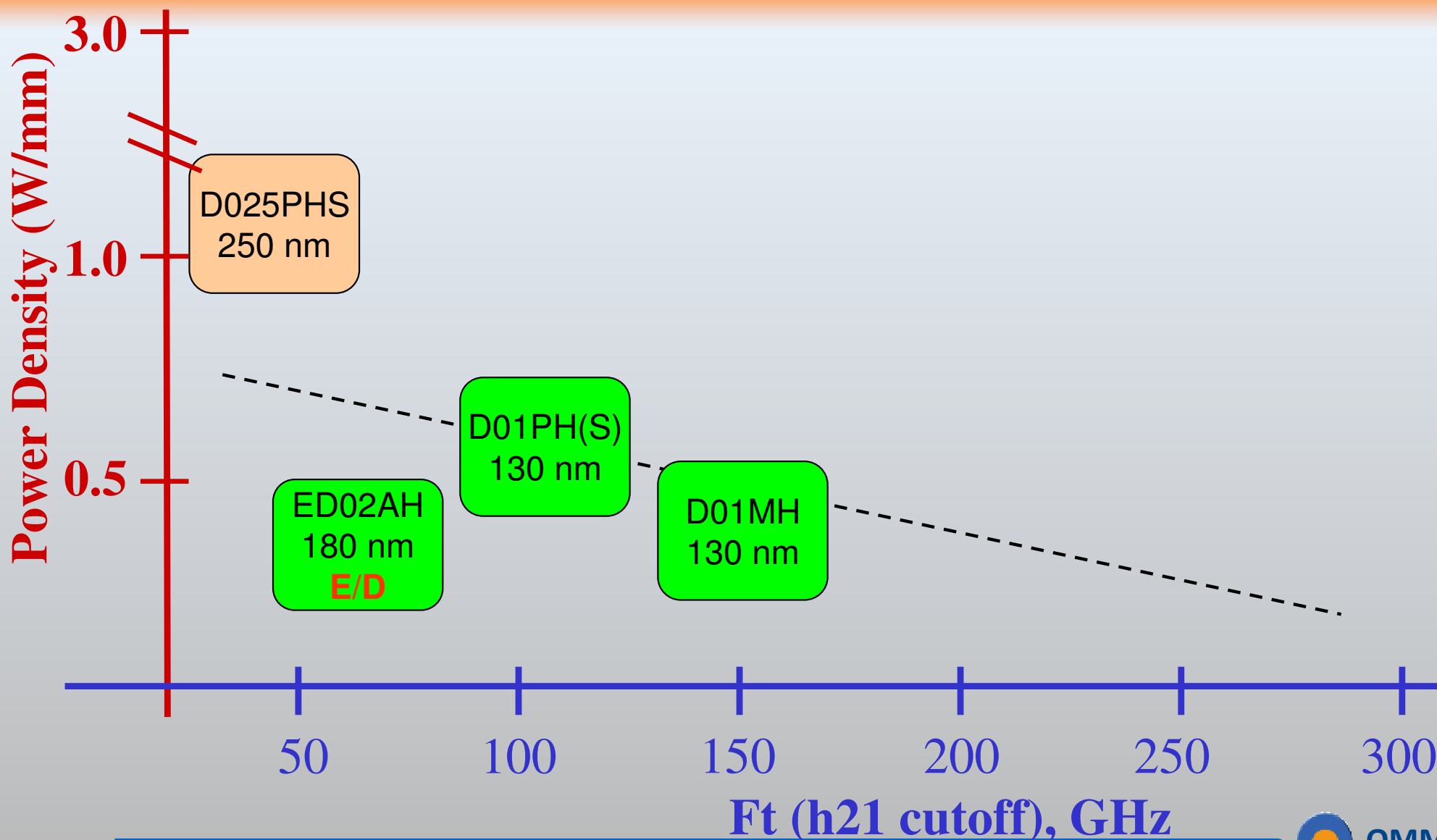
- **Process Status (simplified)**

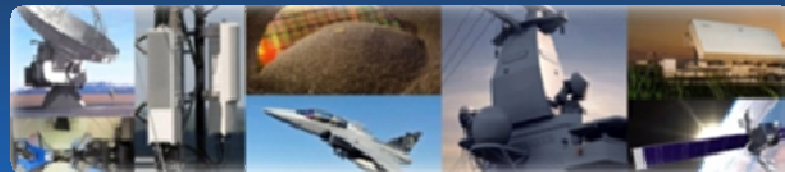




OMMIC Processes (Power)

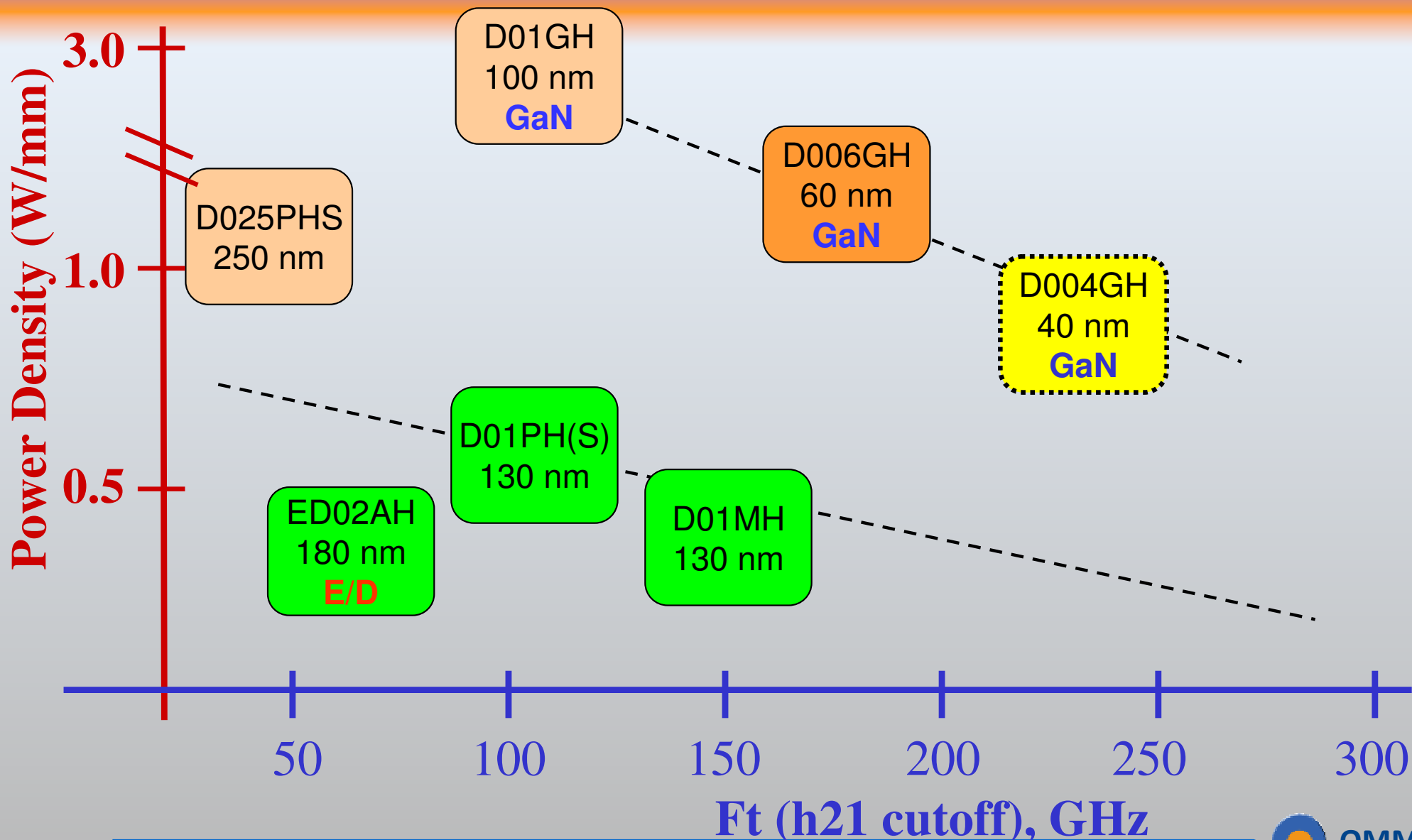
8





OMMIC Processes (Power) & GaN

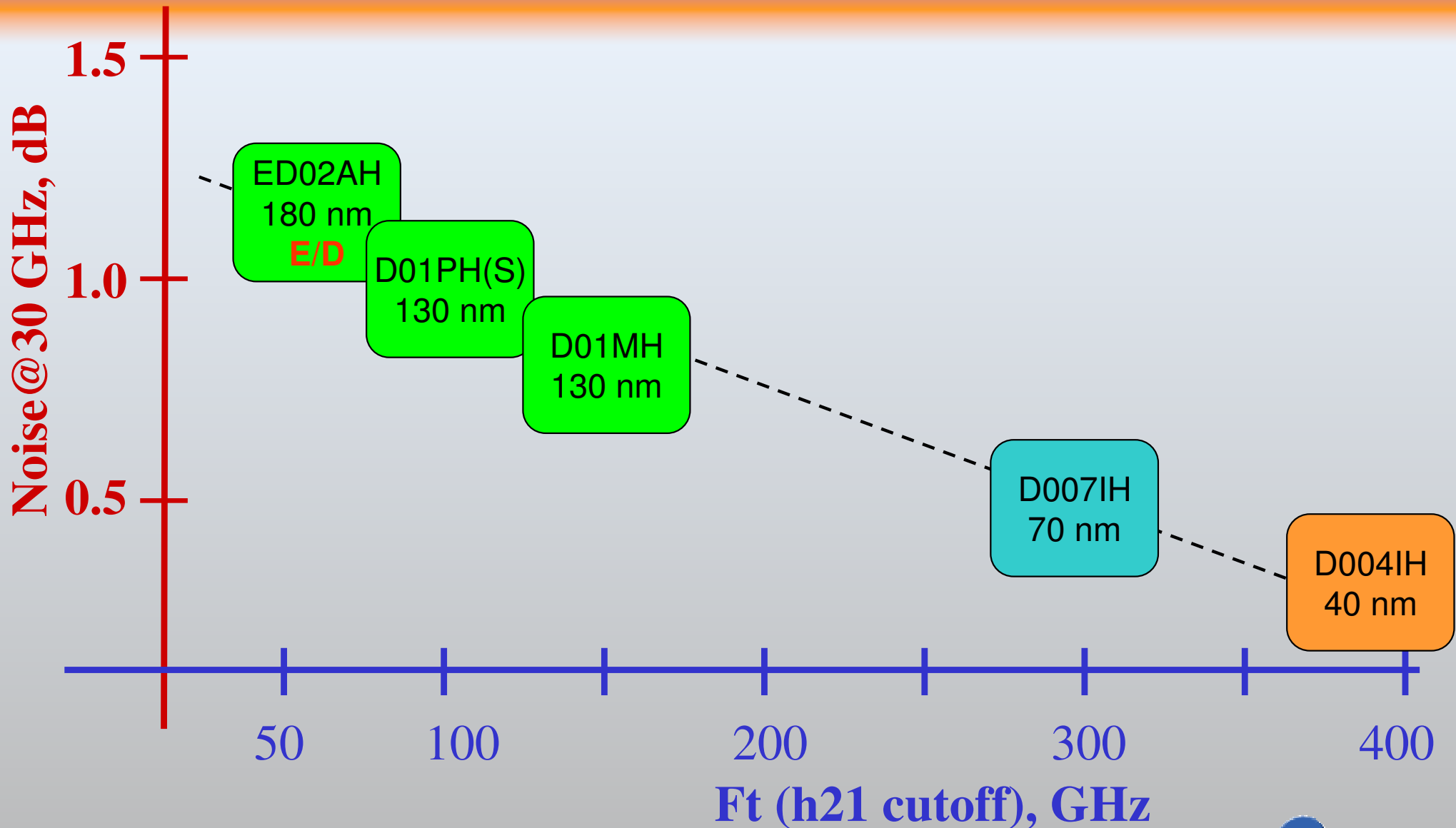
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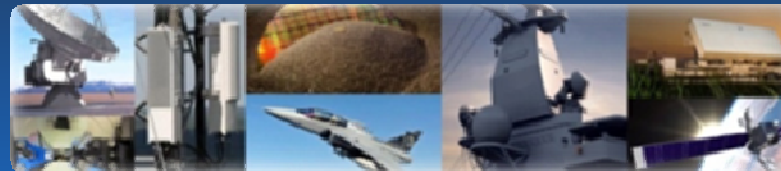




OMMIC Processes (Low Noise)

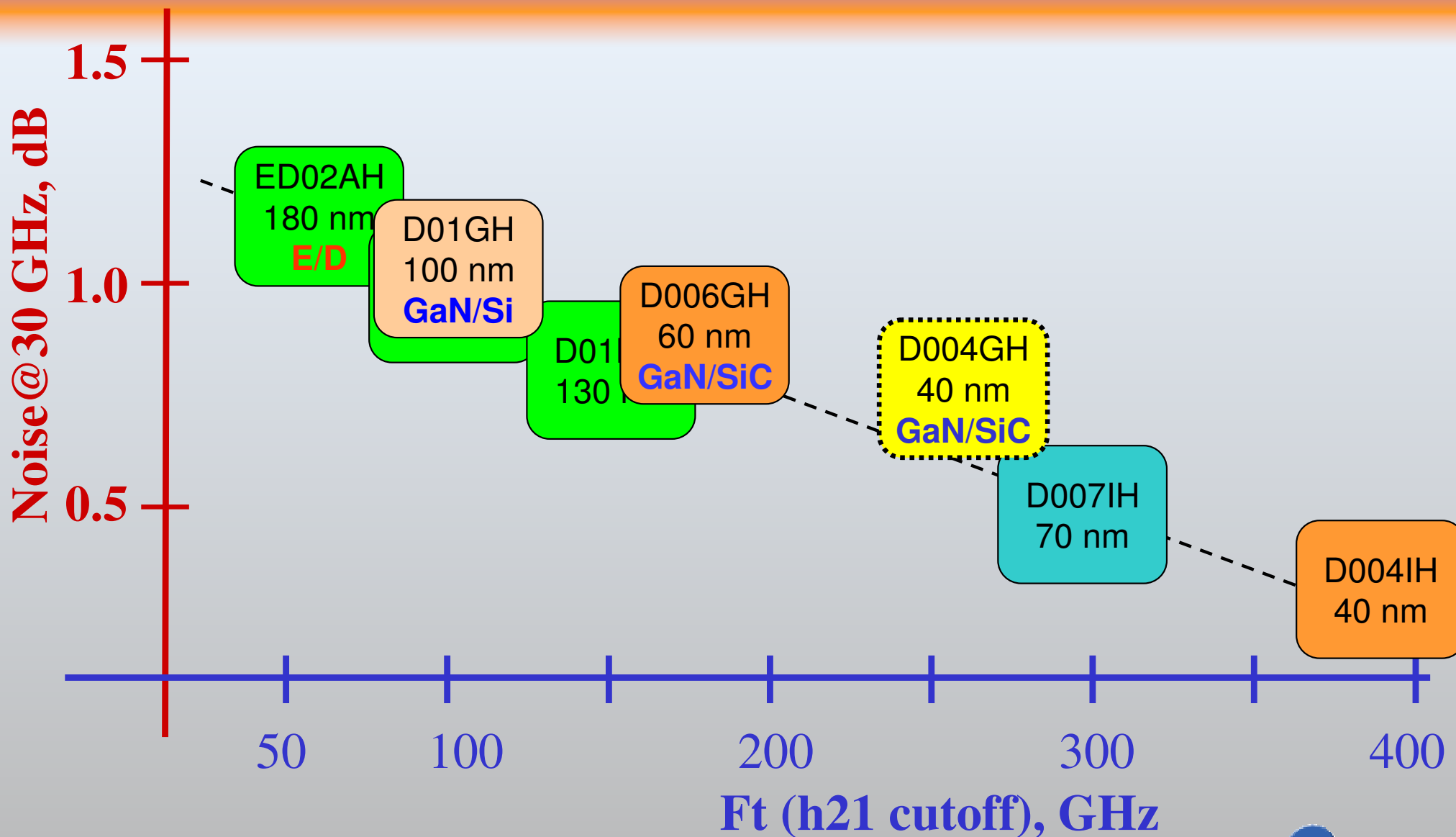
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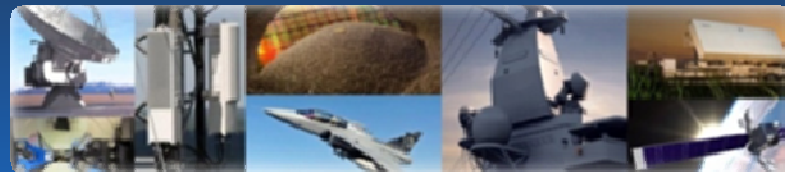




OMMIC Processes (Low Noise) & GaN

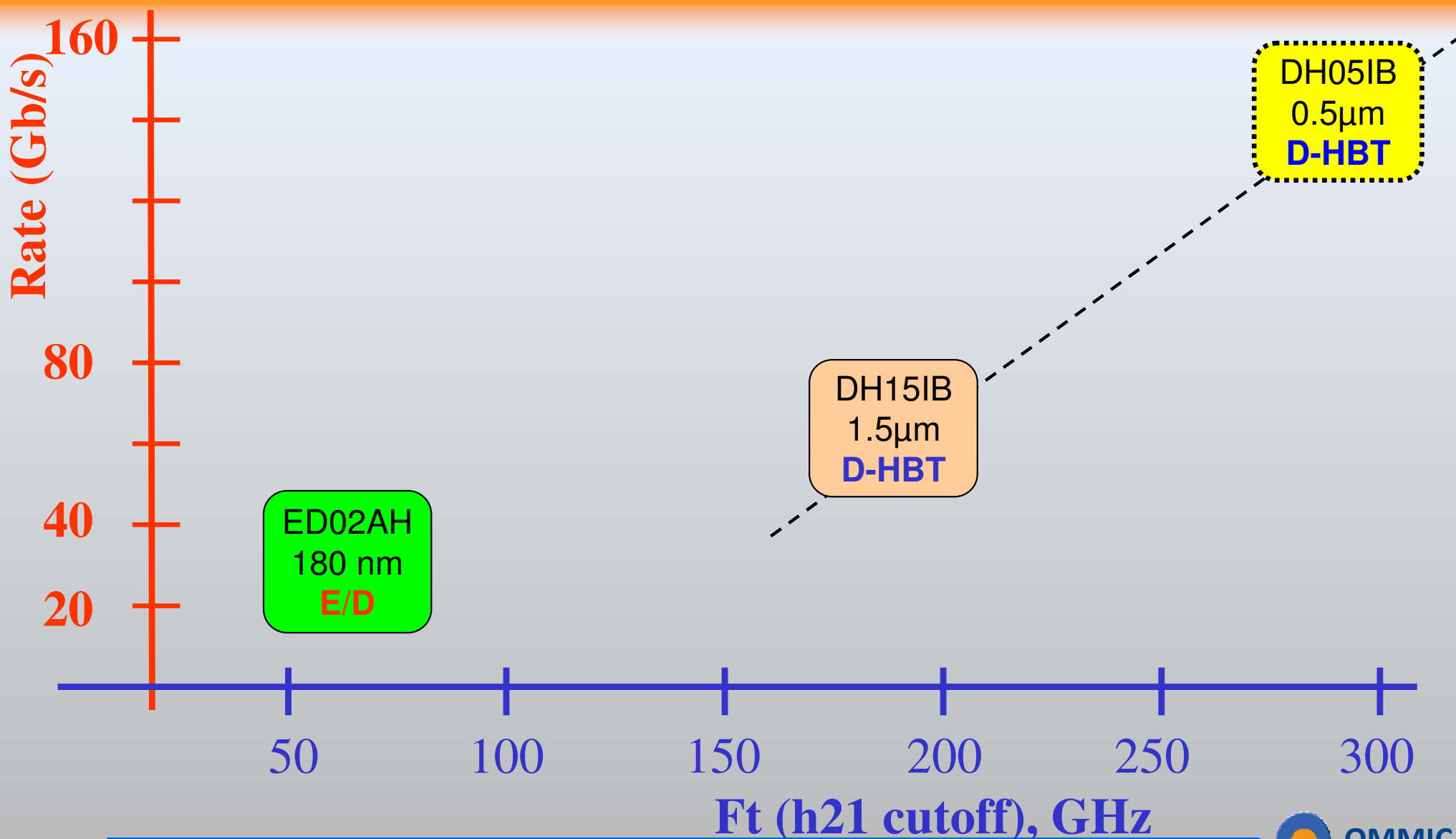
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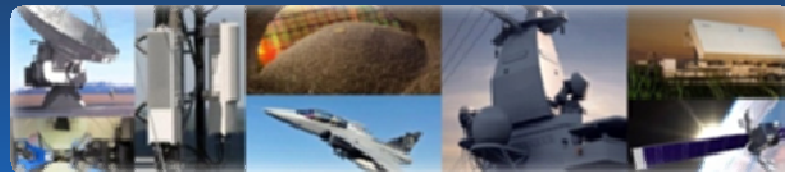




Roadmap Digital-mixed-VCO-Mixers

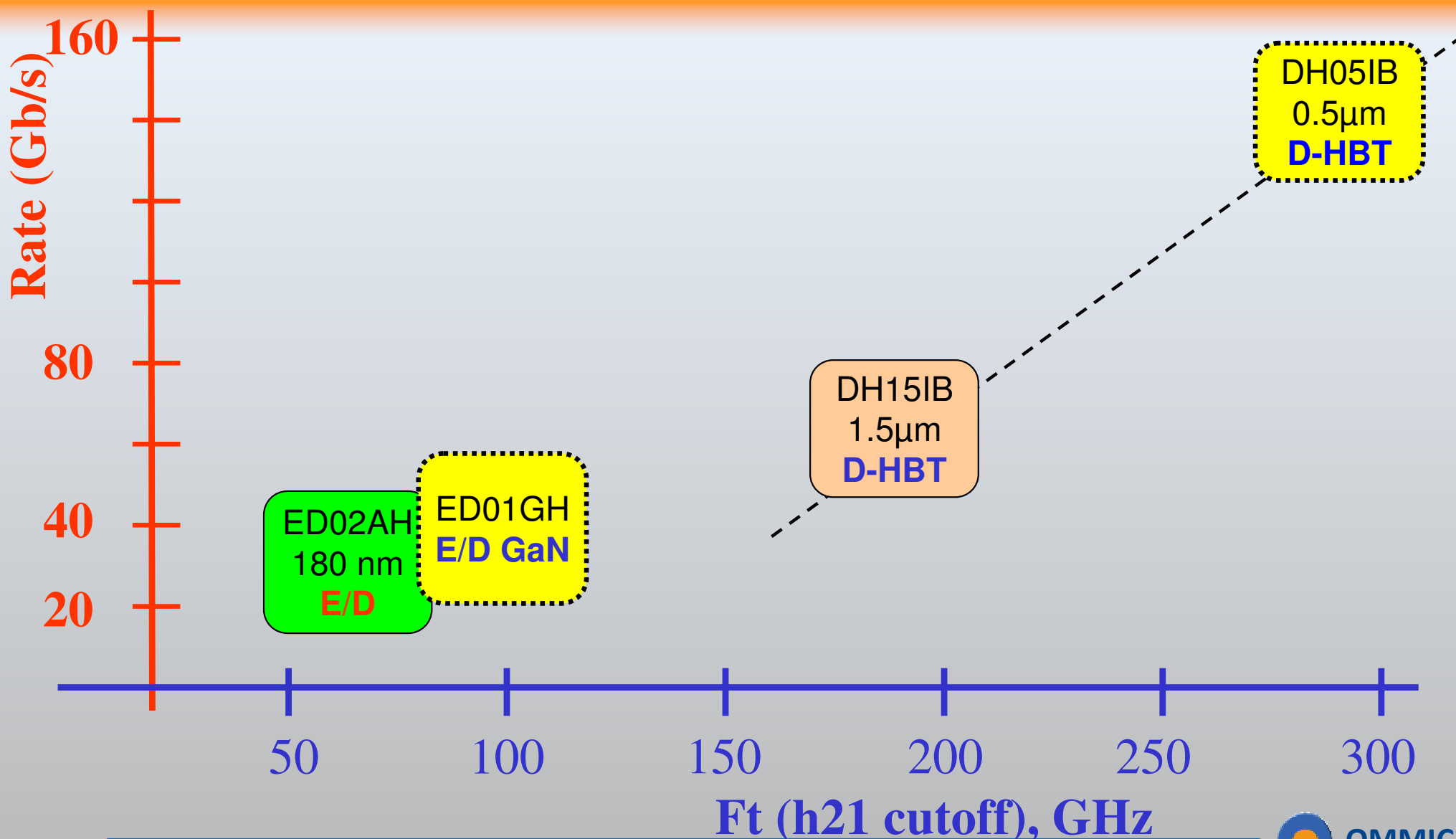
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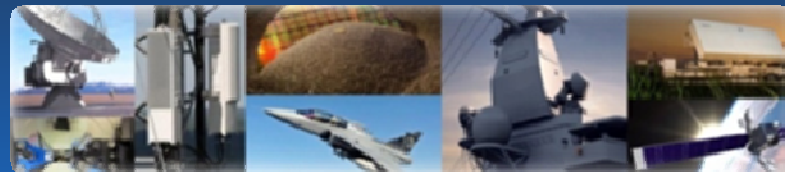




Roadmap Digital-mixed-VCO-Mixers & GaN

13

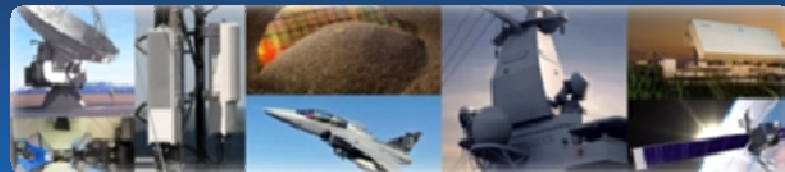




AO4784: Development and Qualification of European Microwave Monolithic Double Balanced Mixers

2006





AO4784: Double Balanced Mixers

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Non-European MMICs

HMC 128
1.8 to 5.0 GHz

HMC 129
4.0 to 8.0 GHz

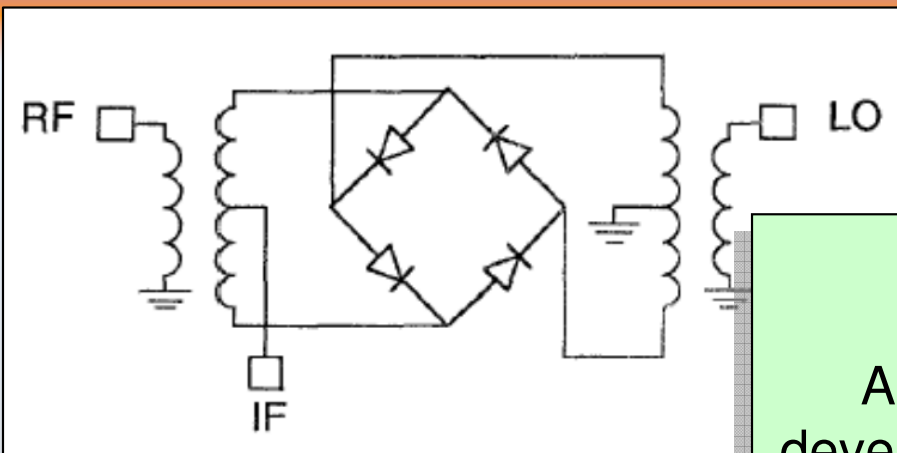
CGY2180
0.7 to 3.7 GHz

CGY2181
1.0 to 4.5 GHz

CGY2182
3.0 to 10 GHz

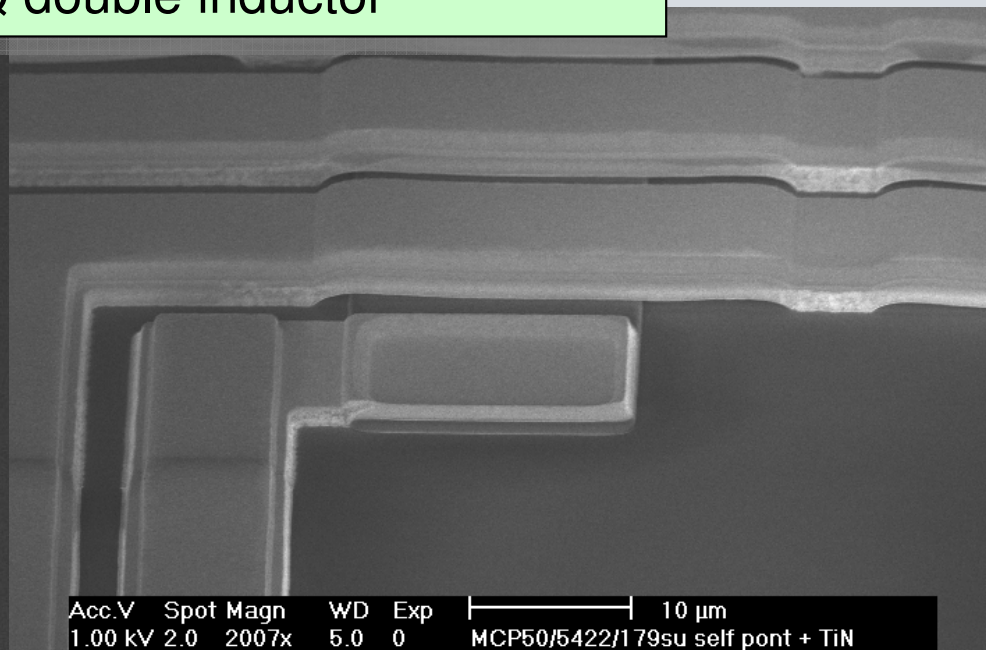
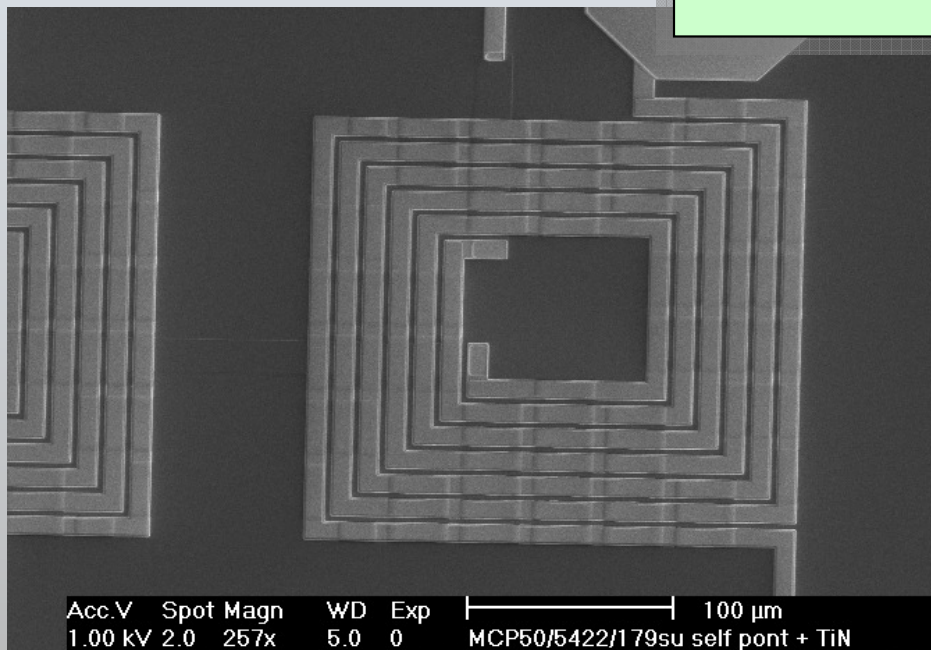
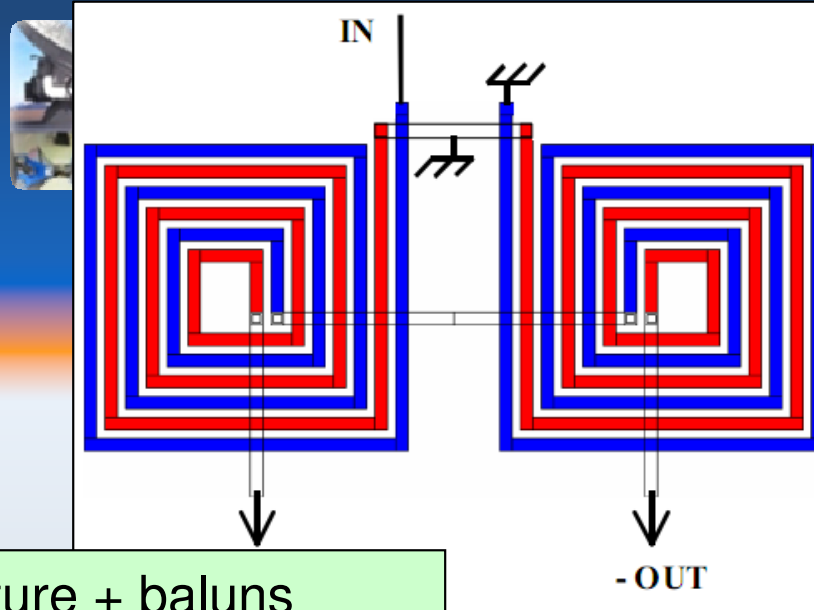


Design of the mixers



Diode ring structure + baluns

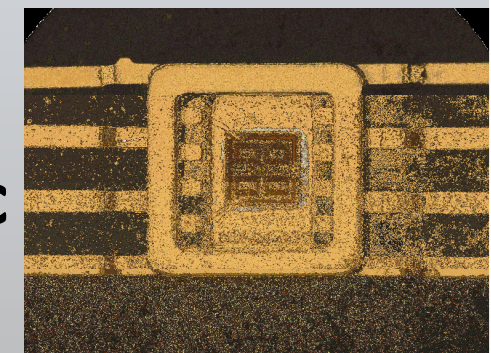
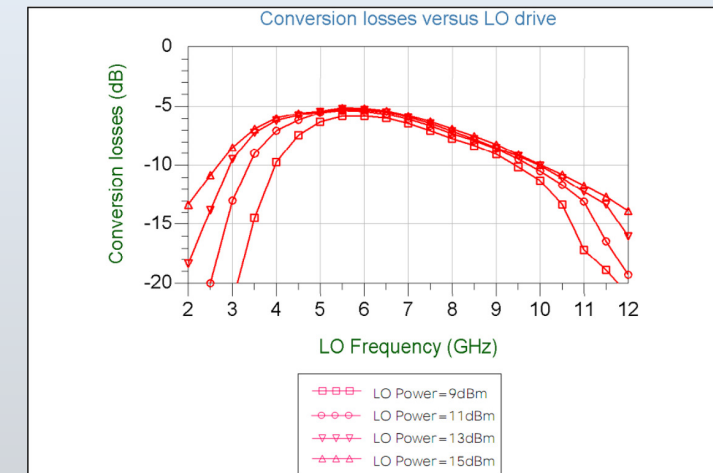
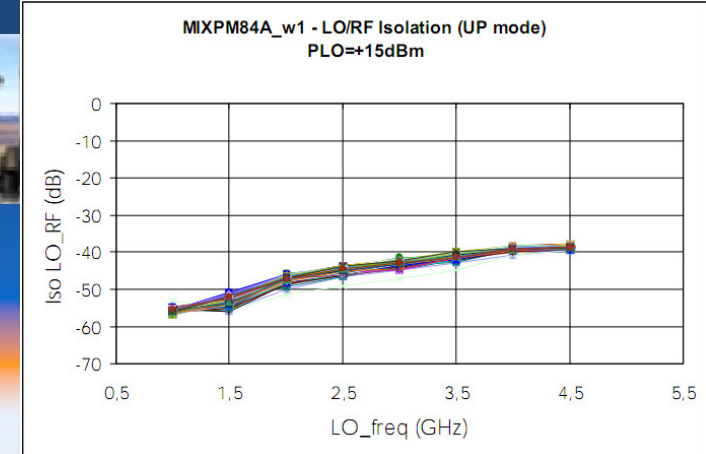
A special process step has been developed and qualified to create high Q double inductor





Summary of main performances

- Very wideband double balanced mixers
- Typical losses: 7dB
- LO-RF isolations: 35 to 60 dB
- LO-IF isolations: 32 to 45 dB
- Input P1dB: 12 dBm
- Pin to pin compatible with non european source
- Flight model available (bare die or hermetic package)

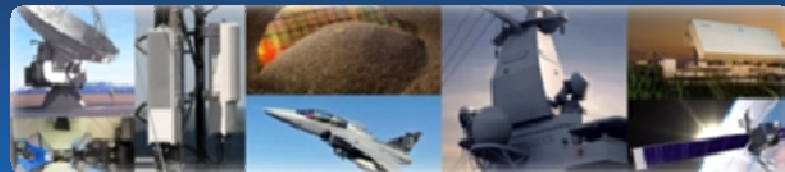




AO6184: Development And Space Validation Of A European MMIC Phase Shifter

2010

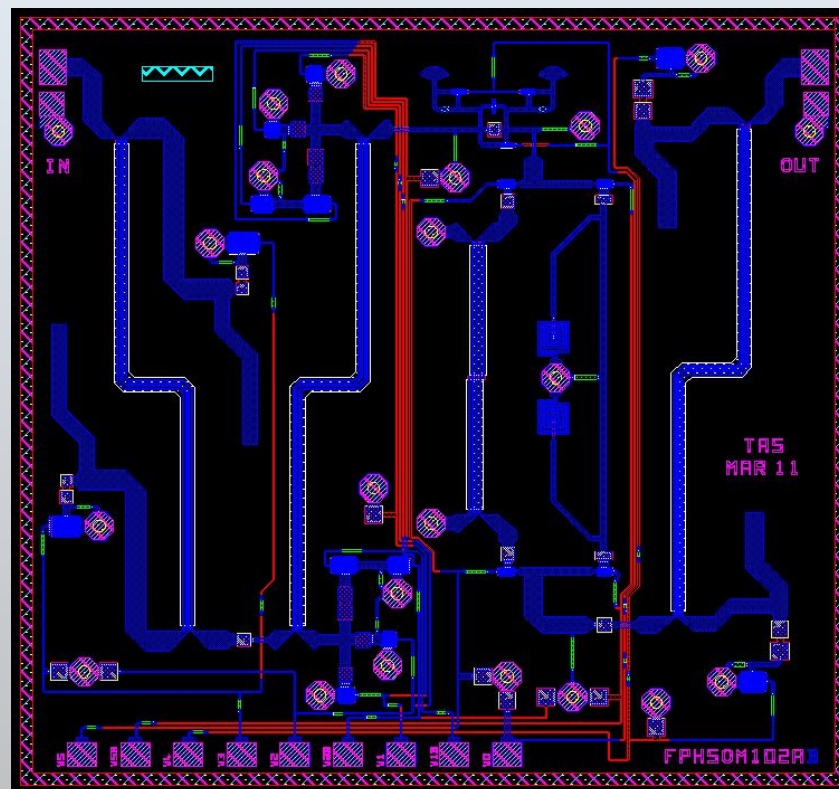
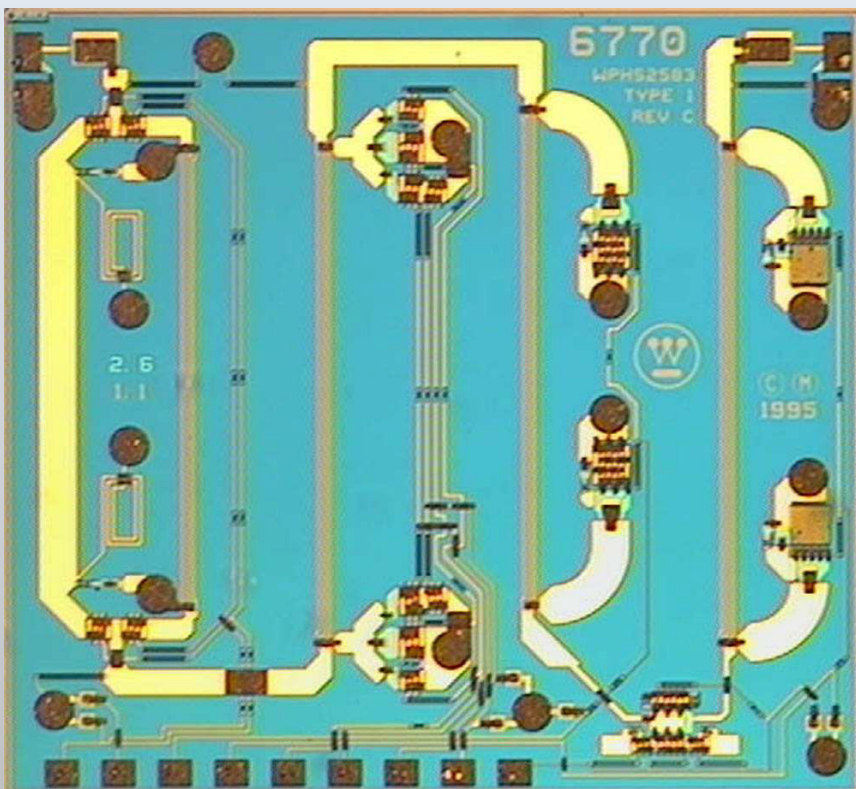


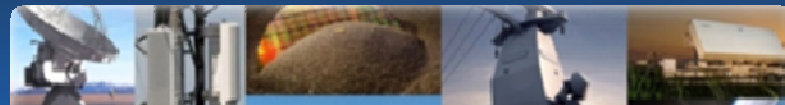


AO6184: 6-18 GHz MMIC phase shifter

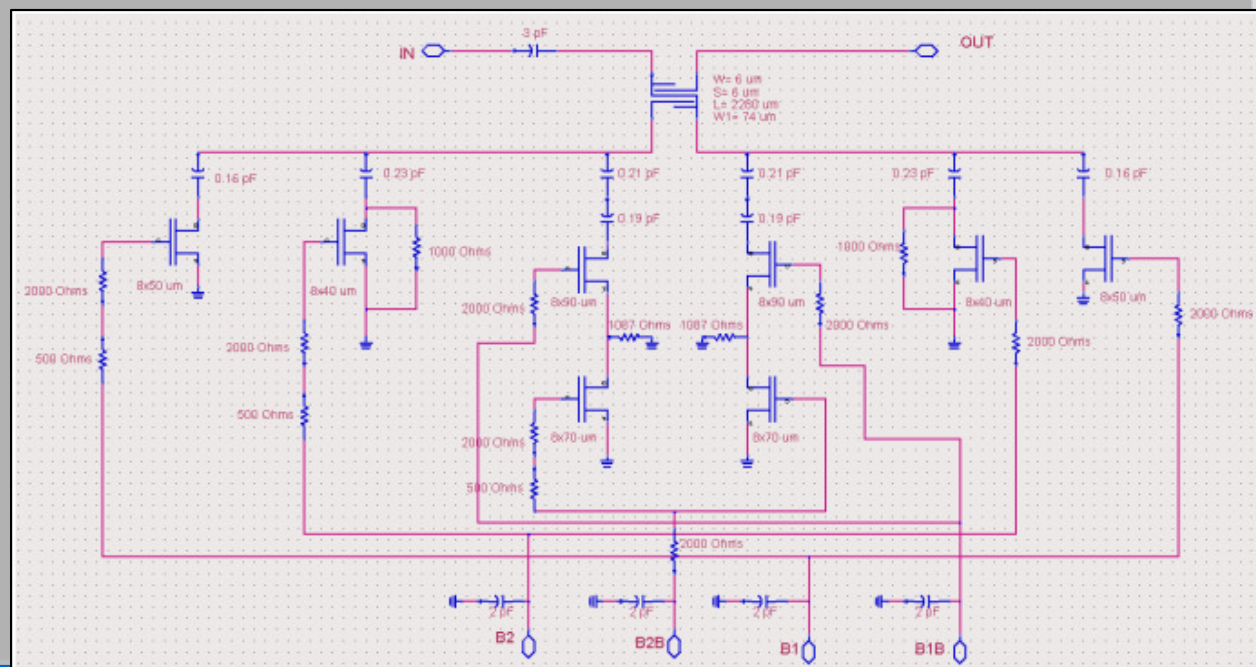
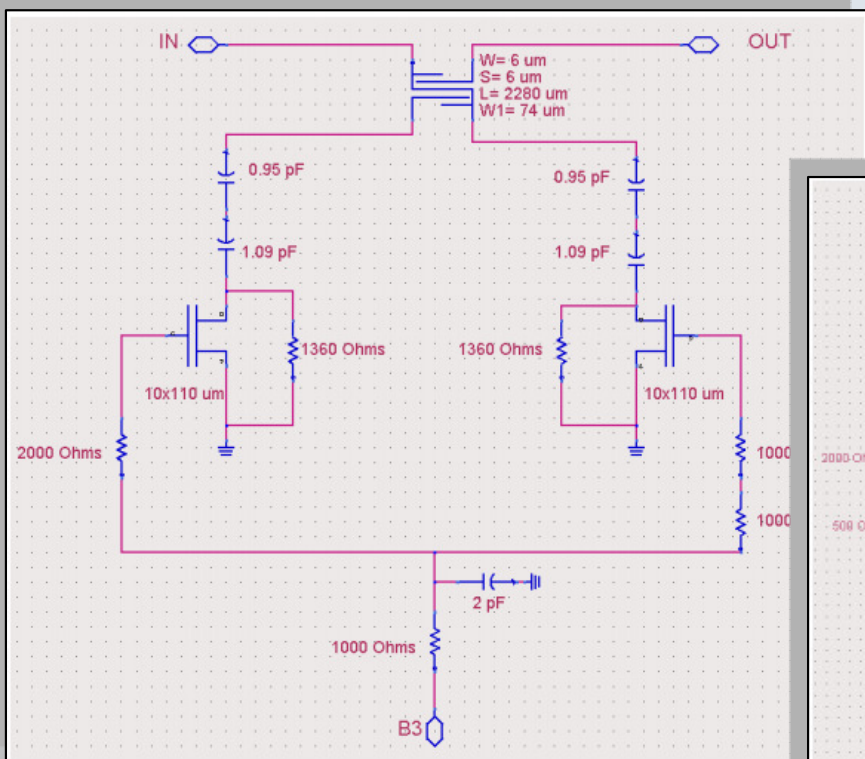
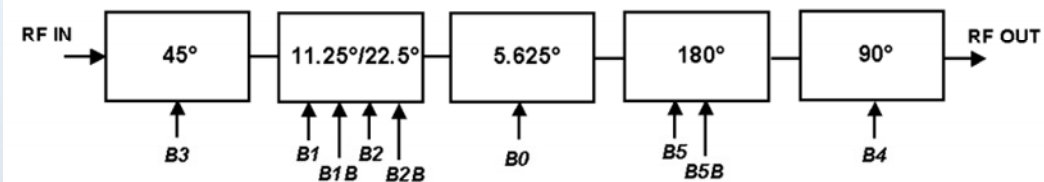
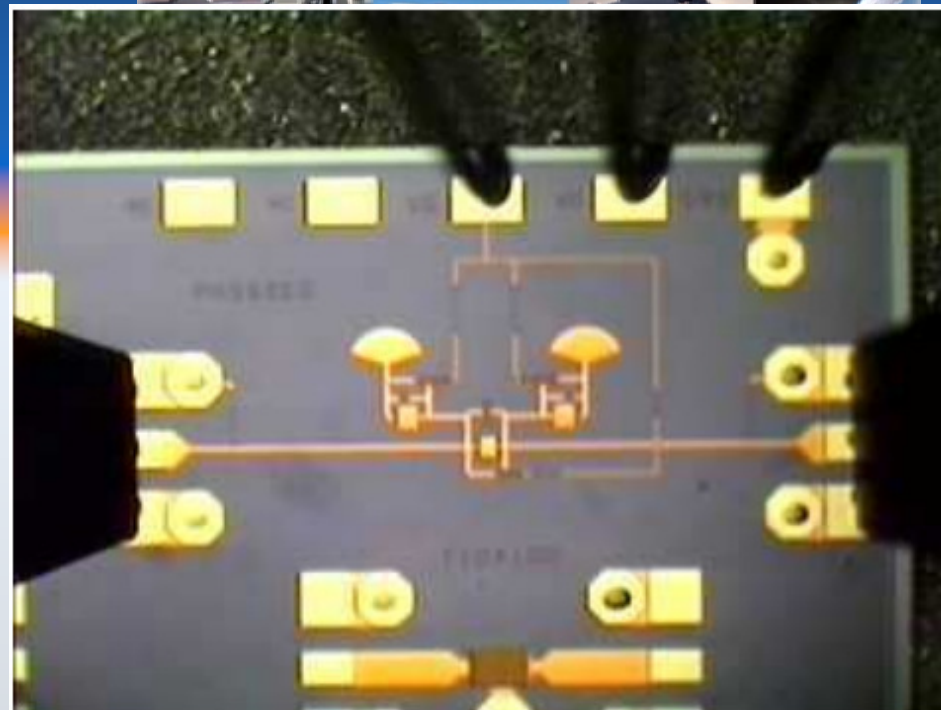
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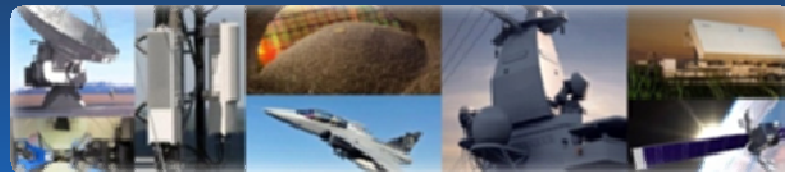
Same interfaces and chip size as the Northrop Grumman PHS2583 for a full compatibility





Phase Shifter Design



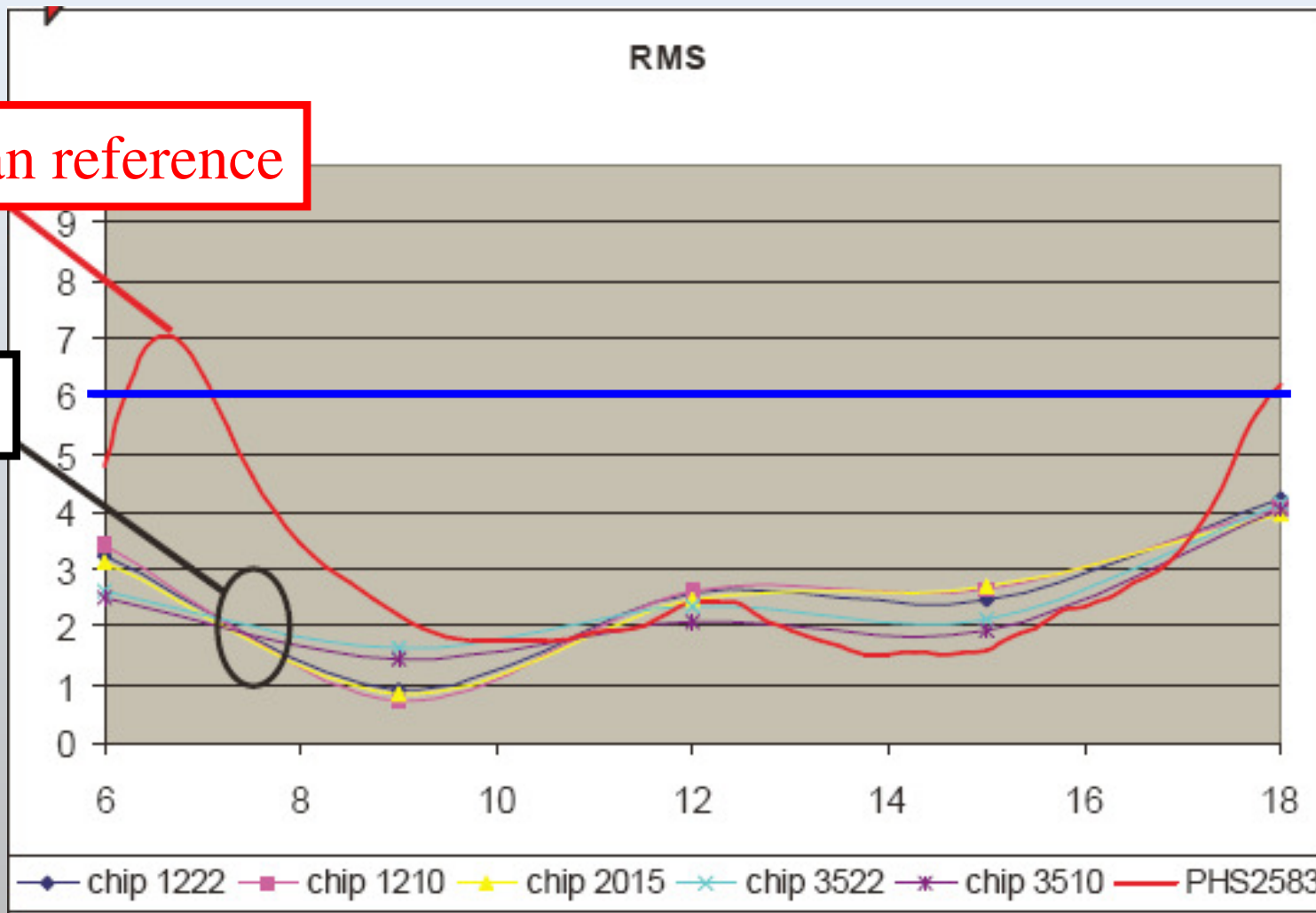


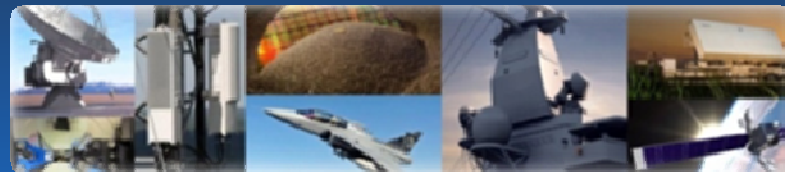
AO6184: MMIC phase shifter results

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Non-European reference

5samples





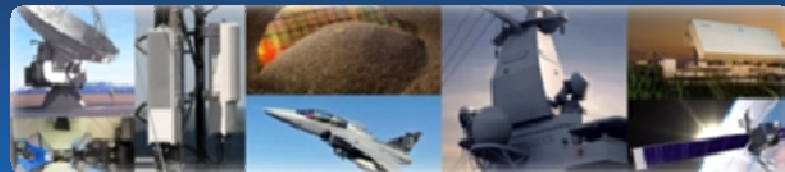
AO6184: MMIC phase shifter results

22

- 6-18GHz Phase Shifter
- 6 bits: 360°, 2.5° rms typ
- Flat losses: 13 dB
- 29 dBm Input P1dB
- 0/-3 V control
- Pin to pin compatible with non european source
- Flight model available

Parameters	Specifications	Measurements (Run iteration 2)
Frequency	6.0 – 18.0 GHz	6.0 – 18.0 GHz
Phase control range	360°	360°
Phase control resolution	6 bits (5.625° - 11.25° - 22.5° - 45° - 90° - 180°)	6 bits (5.625° - 11.25° - 22.5° - 45° - 90° - 180°)
Phase setting accuracy Typ. Midband Absolute min./Max.	< 3° RMS < 6° RMS	< 2.5° RMS < 4° RMS
Insertion Loss Typ. Midband Absolute min./Max.	9 dB < 14 dB	13.2 dB 14 dB
Insertion Loss Modulation Typ. Midband Absolute min./Max.	± 0.5 dB ± 2.1 dB	± 0.8 dB ± 1.8 dB
Return Losses (IN & OUT)	< -4 dB	< -10 dB
Input IP3	>+35dBm	Typ 29 dBm P1dB
Bias voltage	-5 V / 0 V	-3 V / 0 V
Die size	3.25 x 3.5 mm	3.25 x 3.5 mm
Current consumption	< 1 mA	< 1 mA
Control interface	9 control lines (6 are complementary)	9 control lines (6 are complementary)

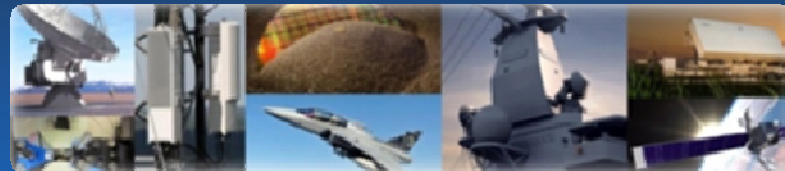




AO6070: Development and Space Validation Of A European MMIC K-band High Power Amplifier

2010

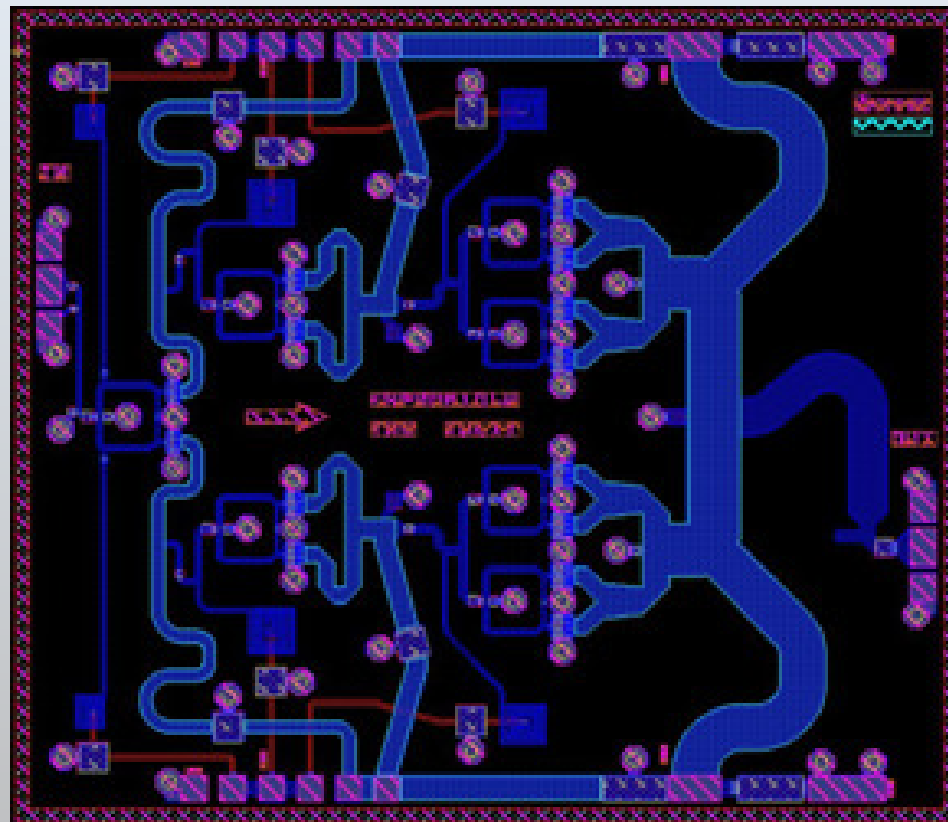
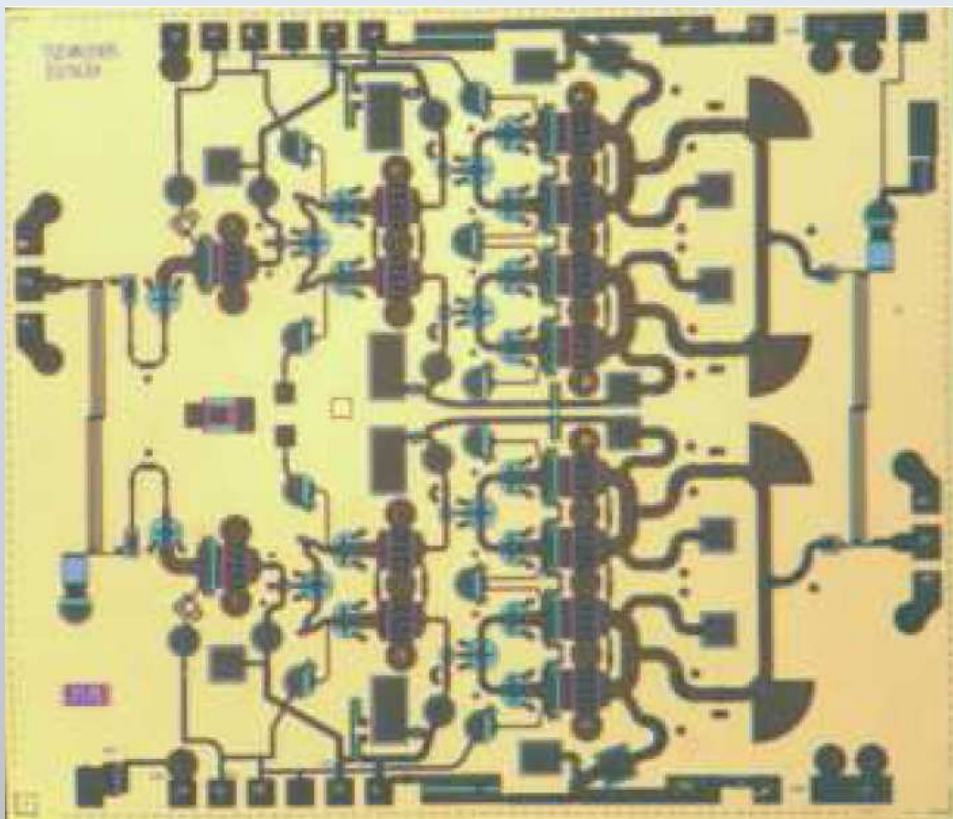


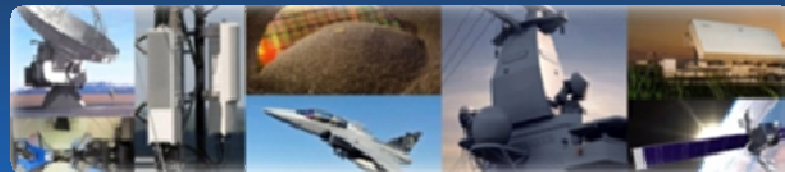


AO6070: K-band high power amplifier

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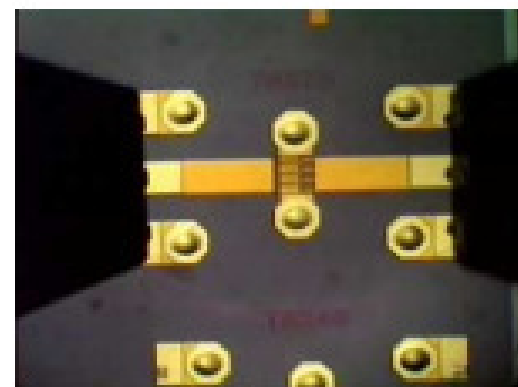
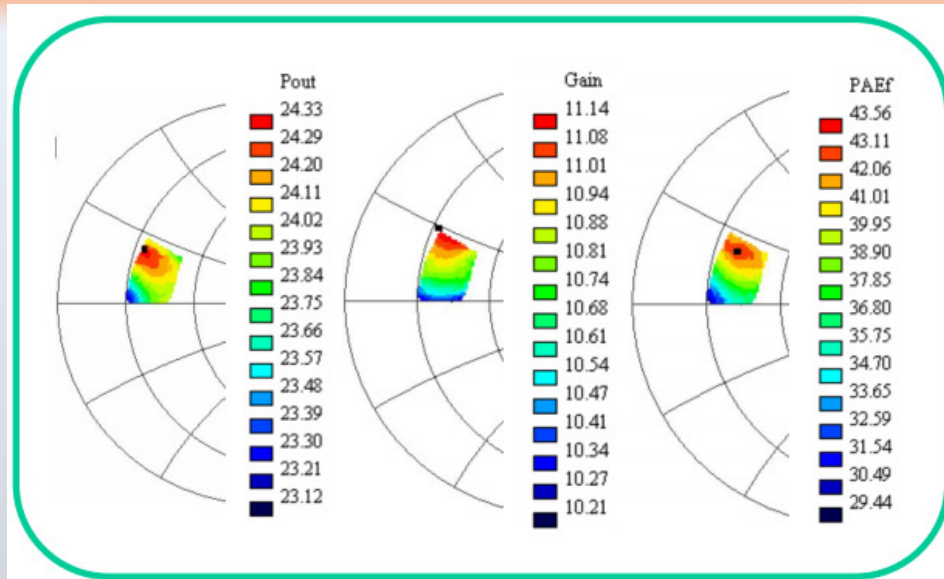
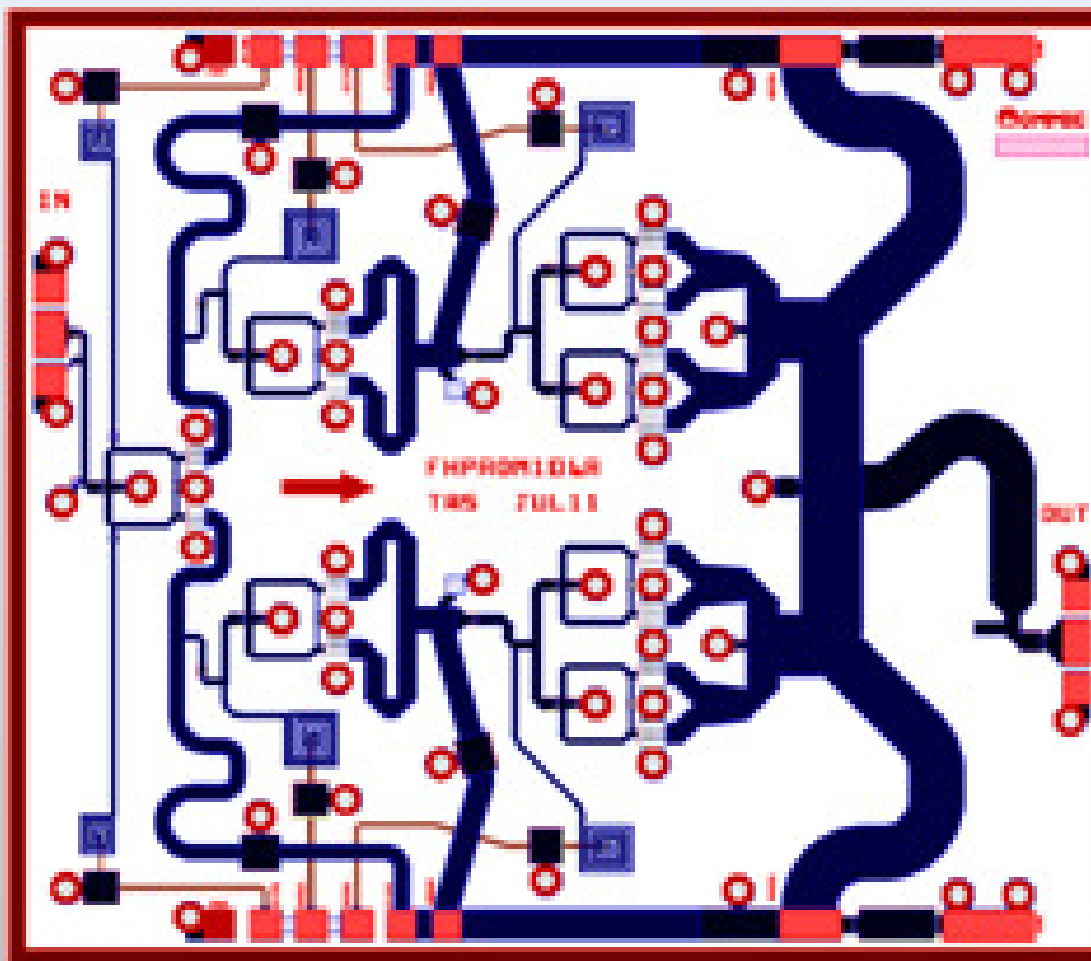
Size and pads compatible with Non European source (Triquint TGA4022)

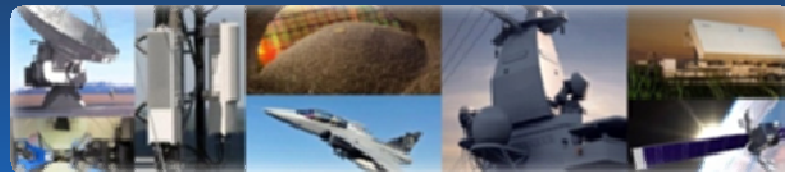




K-Band high power amplifier design

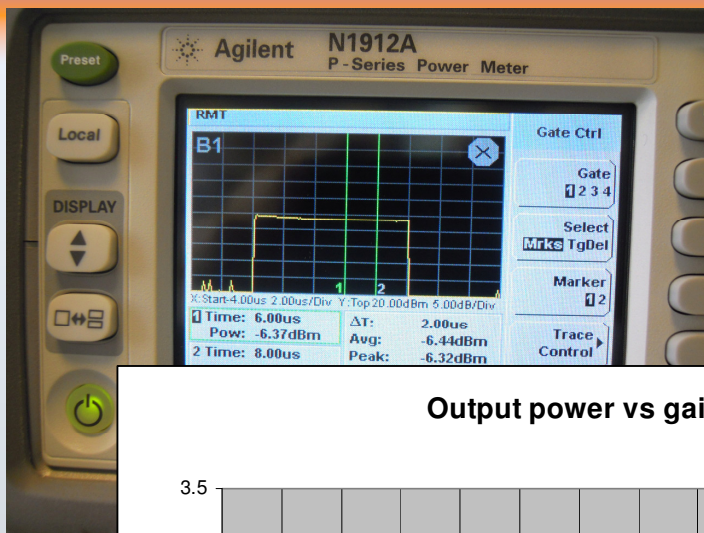
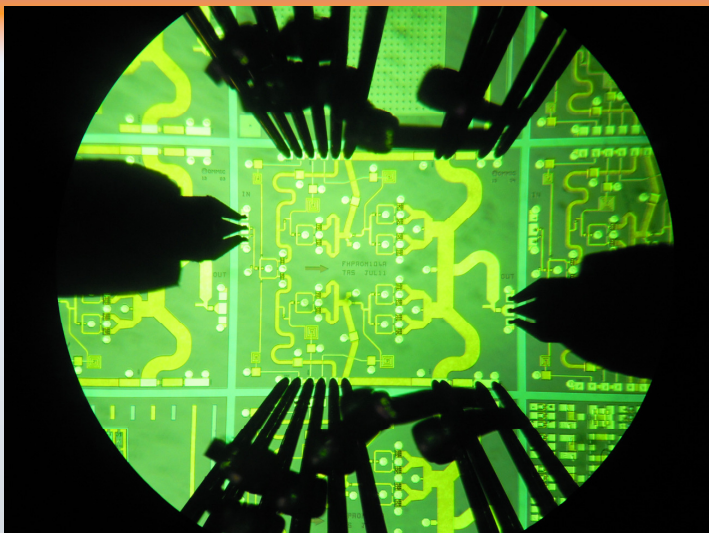
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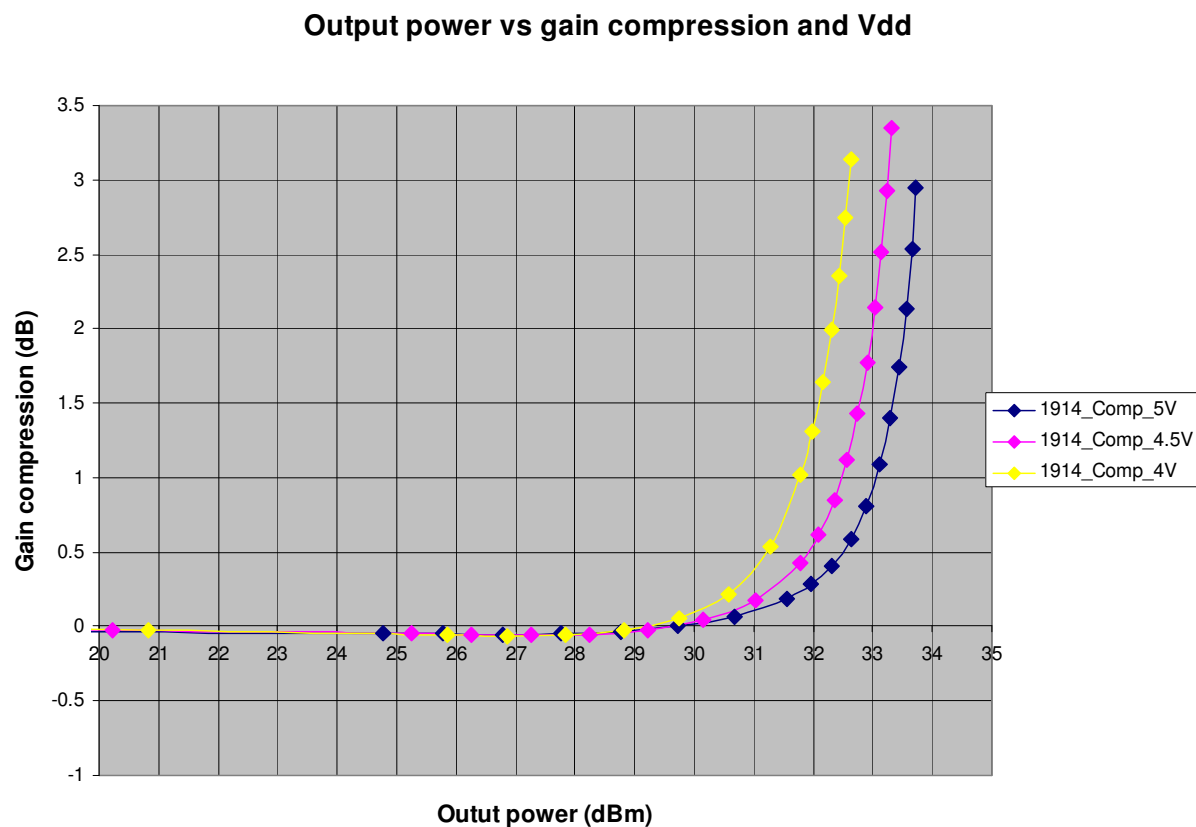
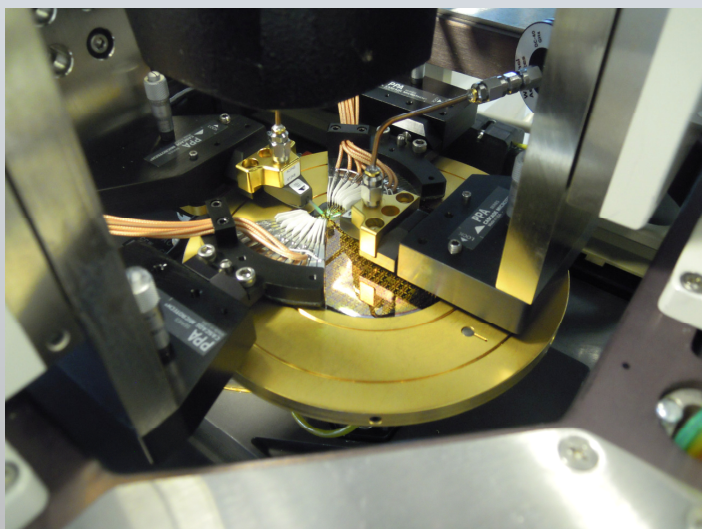


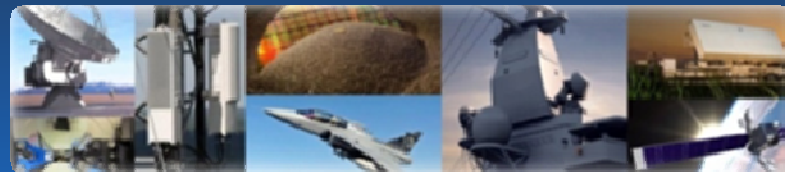
AO6070: K-band high power amplifier

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2W P1dB@5V



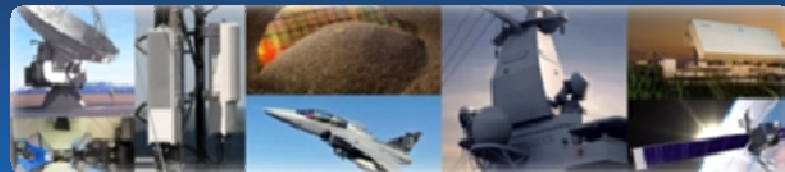


AO6070: K-band high power amplifier

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Parameter	TGA 4022 measurement	OMMIC 4V Simulation Without IP & OP bonding	OMMIC 4V On wafer Measurement	OMMIC 5V On wafer Measurement	Measurement Compliance
Frequency range (GHz)	18-23	18-23	18-23	18-23	C
Drain Voltage (V)	6 (space derated)	4	4	5	C
small signal gain (dB)	> 23 dB	>22	>23	>23	C
Input return Loss(dB)	12 (min)	10	10		NC *
Output return Loss (dB)	14 (min)	10	8		NC *
P1dB (dBm)	29 (min)	30.5 min	30.5 min	32 min	C
PAE_1dB (%)	16 (min)	21 (min)	17 min	20 min	C

- Pin to pin compatible with non european source
- Flight model available



ECI phase 2 (AO6068)

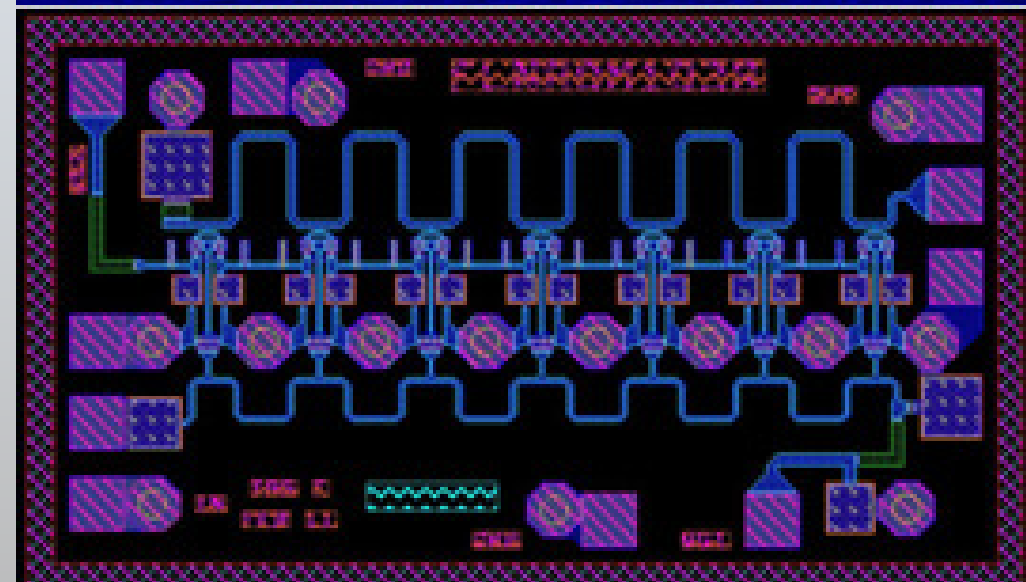
Development and space validation of a European MMIC wideband low noise amplifier

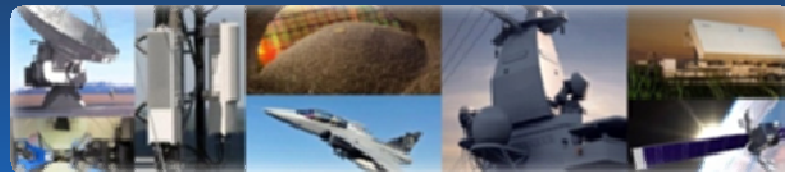
2010





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AO6068: wideband LNA

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RF CHARACTERIZATION TABLE

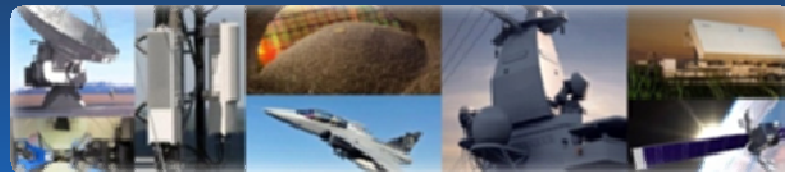
($T_A = 25^\circ\text{C}$, Nominal)

($V^+ = 5\text{V}$, $I^+ = 50\text{mA}$)

Symbol	Parameter	Test Conditions	Typ	Units	Notes
Gain	Small Signal Gain	F = 1 – 30 GHz 1 – 20 GHz	13	dB	
BW	Small Signal 3dB Bandwidth		45	GHz	
IRL	Input Return Loss	F = 1 – 30 GHz 1 – 22.5 GHz	12	dB	
ORL	Output Return Loss	F = 1 – 30 GHz	15	dB	
P1dB	Output Power @ 1dB Gain Compression	F = 1 – 25 GHz	11.5	dBm	
NF	Noise Figure	F = 1 – 40 GHz 6 - 28 GHz	3.2	dB	

Real Electrical performances of the TGA4830 (TRIQUINT)

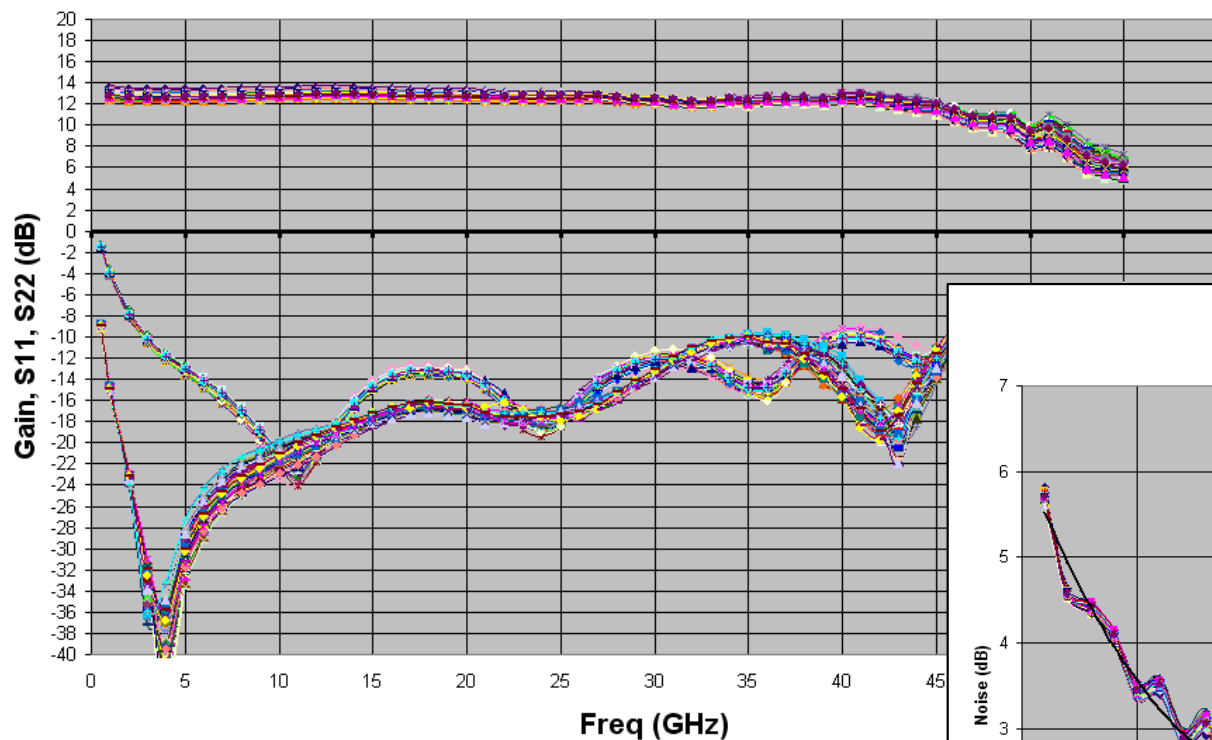




AO6068: wideband LNA main performances

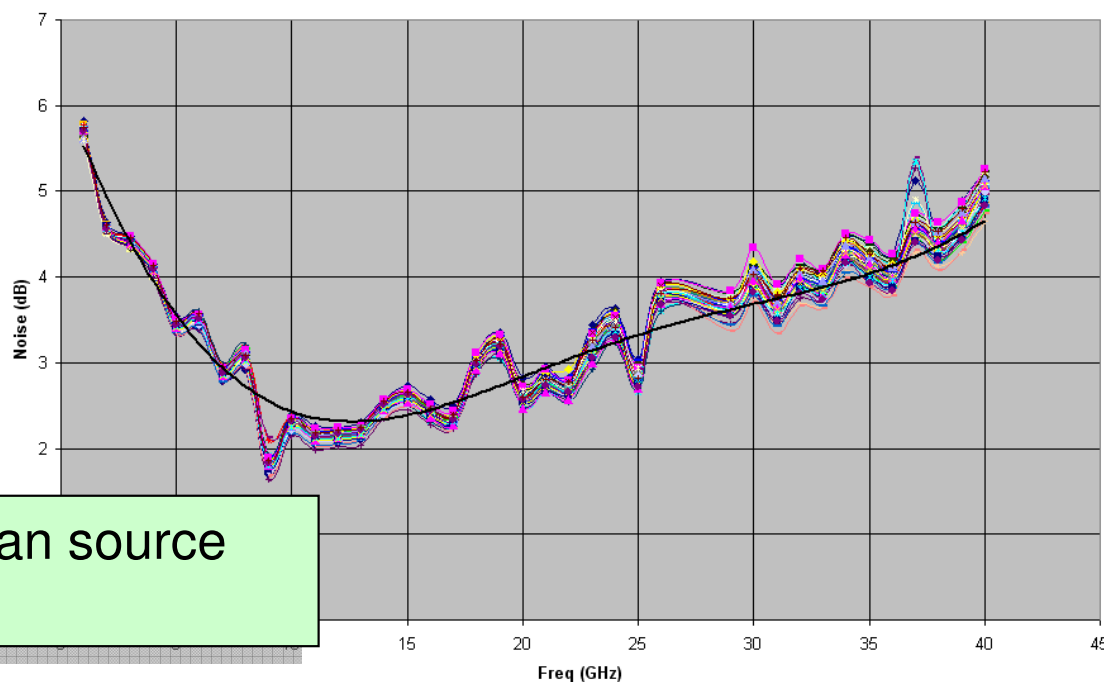
31

Wide band LNA Gain, S11 & S22

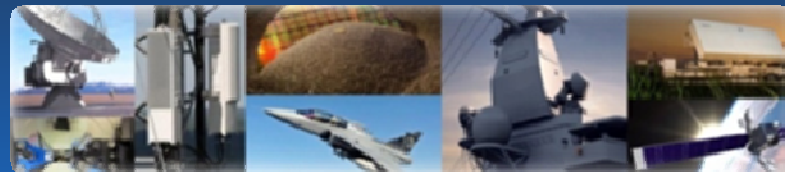


P1dB = 22dBm@35GHz

Wideband LNA NF



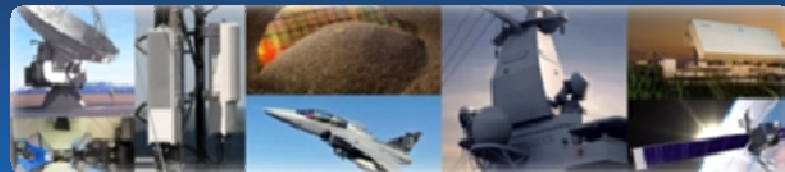
Pin to pin compatible with non european source
Flight model available



AO6854 : Development And Space Validation of A European Wide Band Amplifier

2012





AO6854 : Wide Band Amplifier

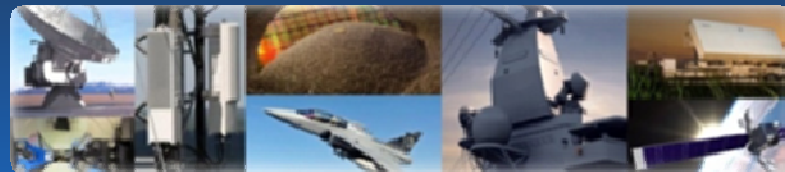
33

Reference	Freq (GHz)	Gain (dB)	NF (dB)	Output P1dB (dBm)	IP3 (dBm)
HMC342 Hittite	13 - 25	21	3.5	5	13
HMC490 Hittite	12 - 14 14 - 17	26.5 27	2.5 2	25 26	32 35
HMC516 Hittite	12 - 17	20.5	1.8	16	20
HMC565 Hittite	12 - 20	21	2.5	10	20
HMC903 Hittite	6 - 18	19	1.6	16	27
HMC-ALH216 Hittite	14 - 27	18	2.7	14	-
HMC-ALH435 Hittite	5 - 20	13	2.2	16	-
HMC-ALH476 Hittite	14 - 27	20	2	14	-
MAALGM0004 MACOM	11 - 16	14	2.9	12	23
TGA2511 TriQuint	6 - 14	20	1.3	12	24
TGA2512 TriQuint	5 - 15	27	1.4	13	24
TGA2513 TriQuint	2 - 23	17	3	16	-
TGA2513 TriQuint	14 - 18	17	4	15	-
TGA8310-SCC TriQuint	2 - 20	9	3.5	17.5	-
TGA8344-SCC TriQuint	2 - 18	19	4	16	-

- There were two MMICs in the ESA requirement.
- We have decided to develop a single circuit for both ...

	HMC903 @(12-19 GHz)	ESA requirements		Spec. submitted	
		LNA	MPA		
Freq. Range (GHz)	6 - 18	12.75 - 18.4	12 - 19	12 - 19	
NF (dB)	1.6	0.8	1.5	1.2	
Gain (dB)	19	22	20	21	
P1dB (dBm)	16	7	14	LNA application	MPA application
				7	14
IP3 (dBm)	27	15	24	15	24
Input RL (dB)	10	15	15	15	15
Output RL (dB)	15	15	15	15	15
Pdc (mW)	315	-	150 (TBD)	150	300

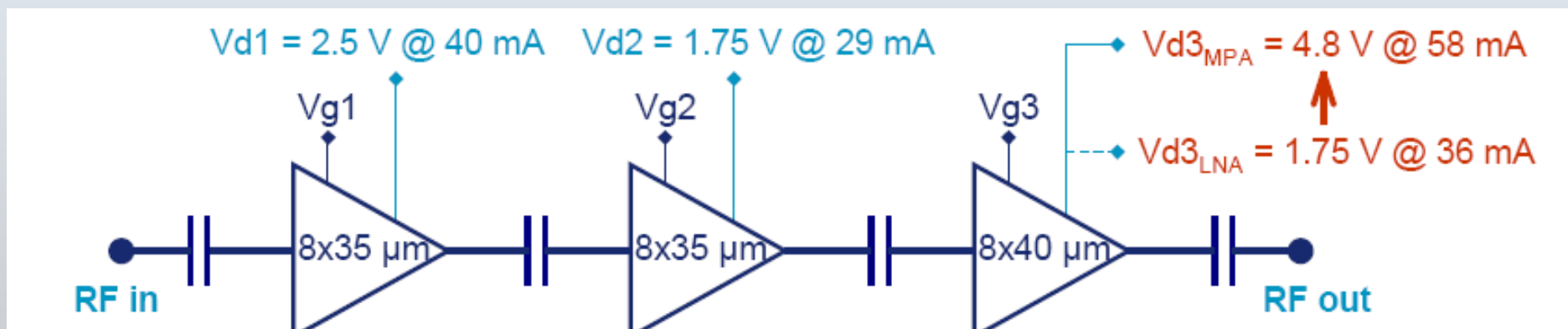




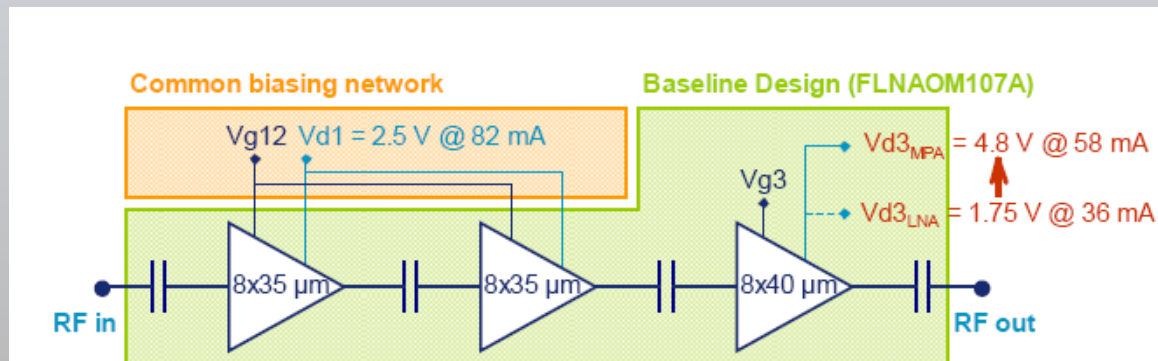
Circuit architecture

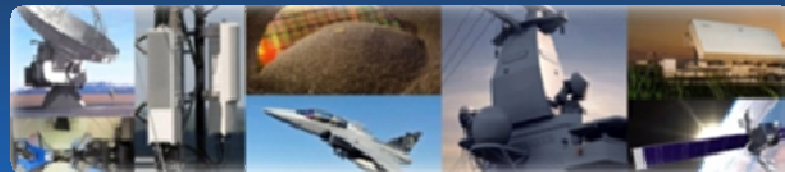
34

- MPA/LNA performances are obtained by a single circuit covering both LNA and MPA requirements by change of VDD of the last stage :



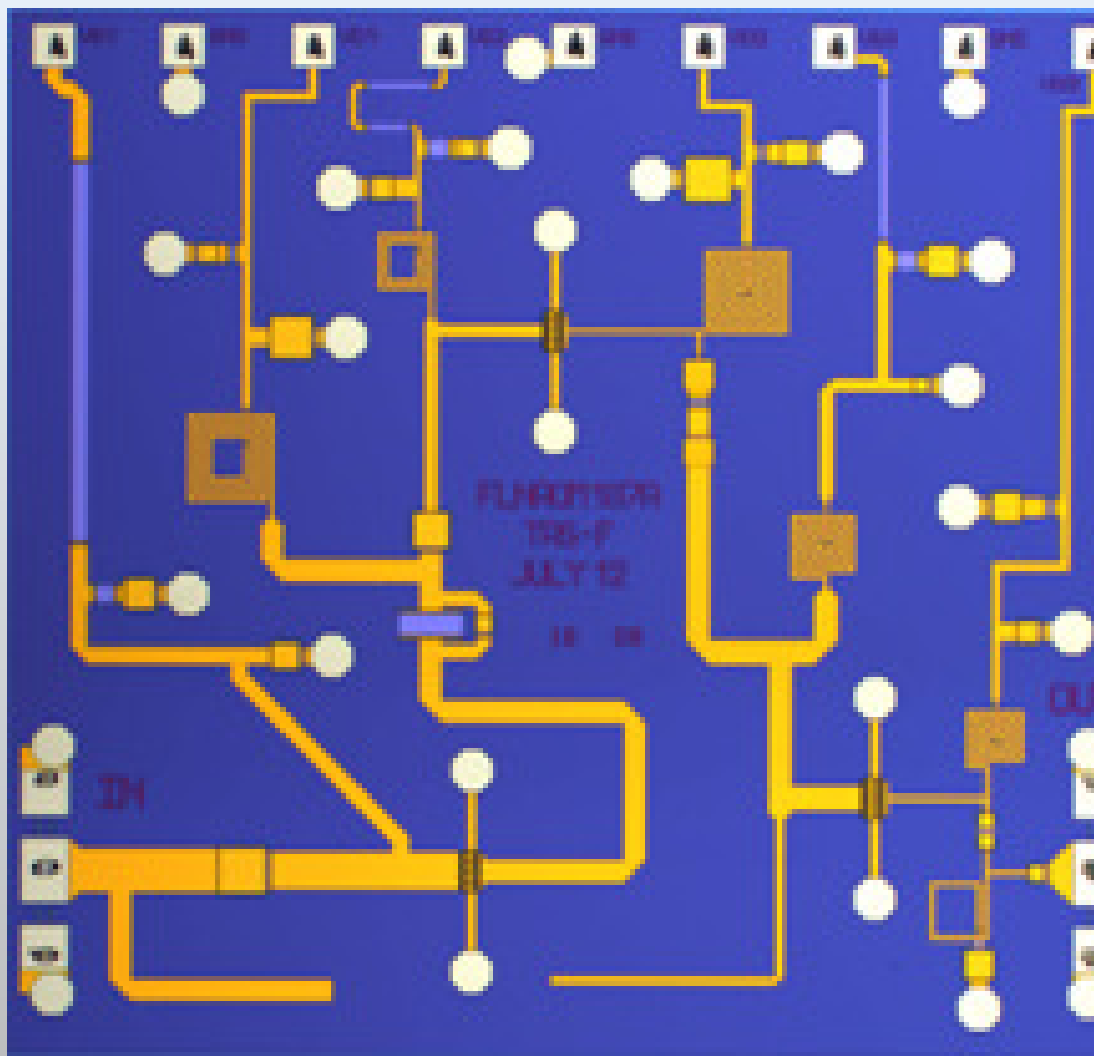
Alternate version with reduced number of pads :

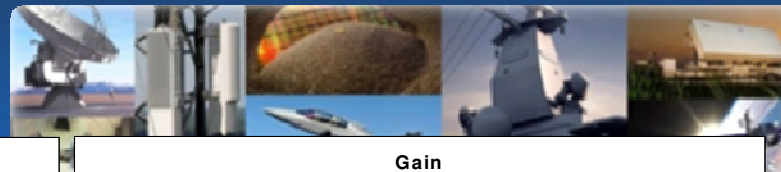




AO6854 : European Wide Band Amplifier

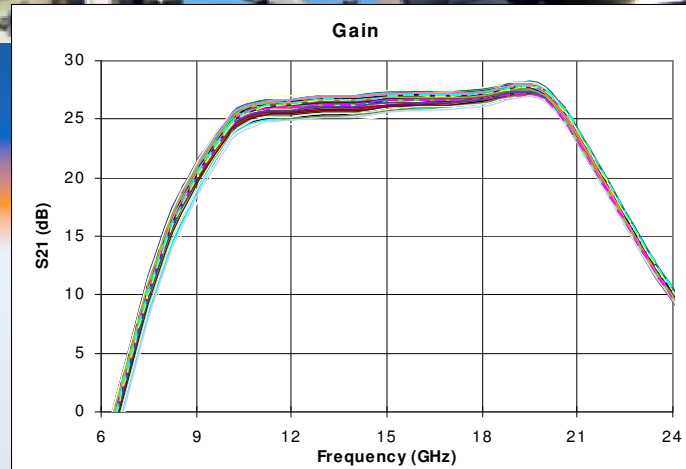
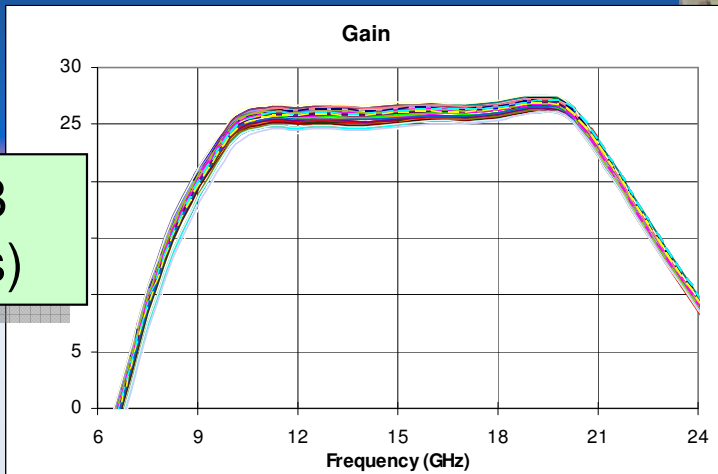
35



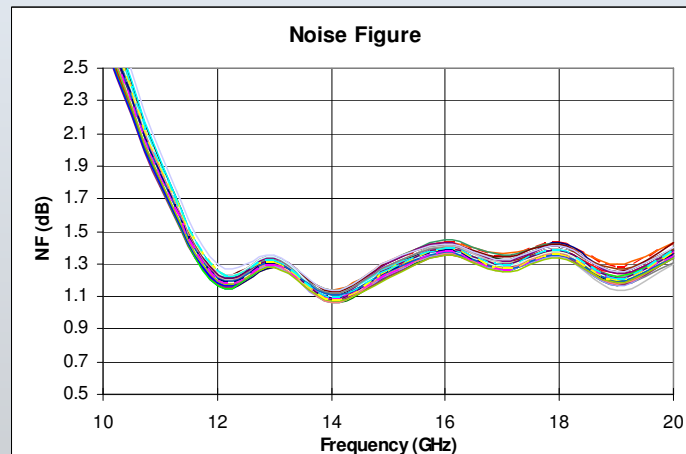
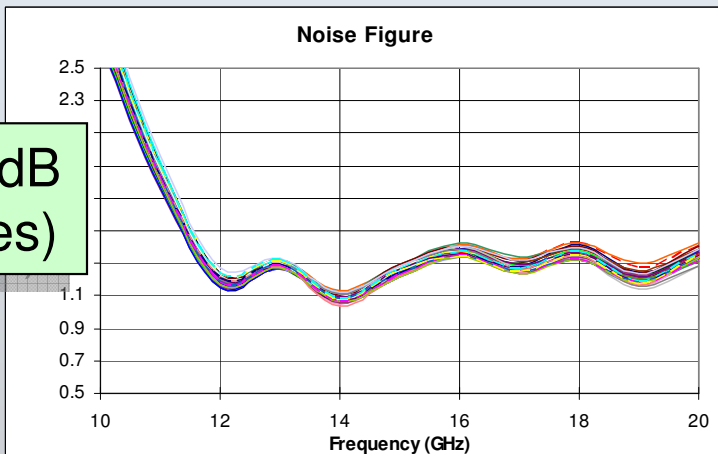


Results

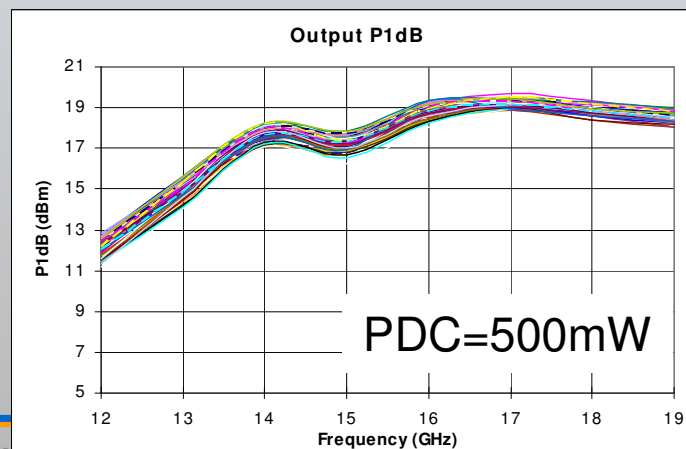
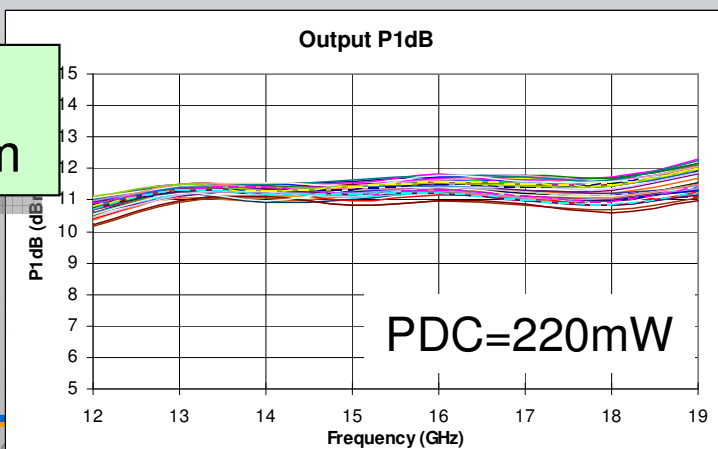
Gain: 25 dB
(both modes)



Noise: 1.2 dB
(both modes)



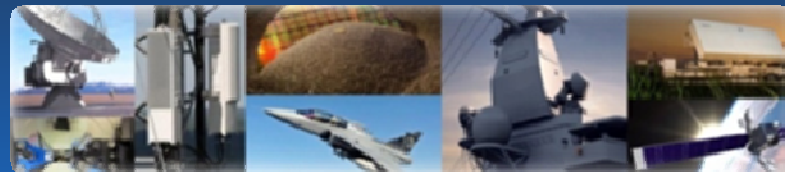
LNA P1dB: 11 dBm
MPA P1dB: 13-19 dBm





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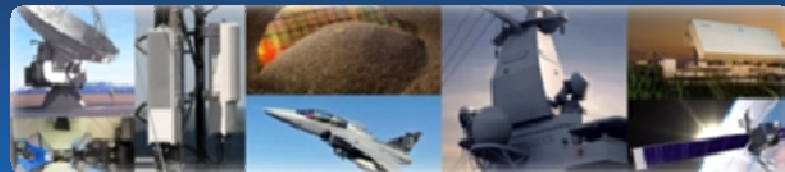
Innovating with III-V's



Conclusion



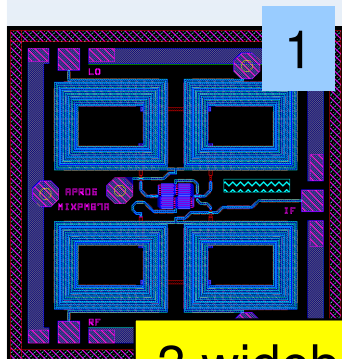
OMMIC



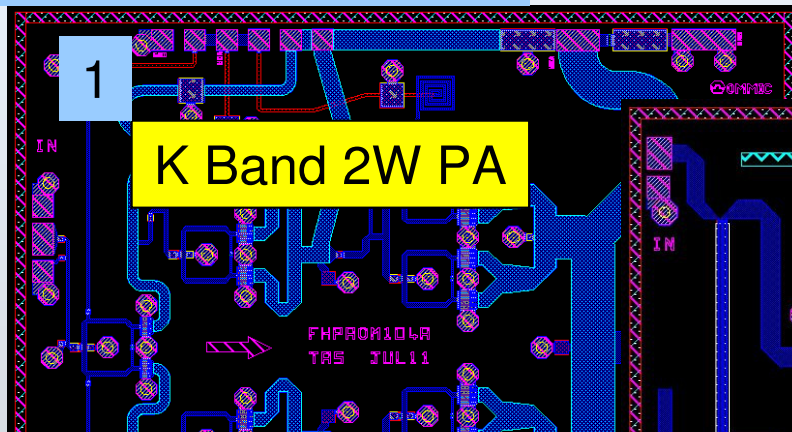
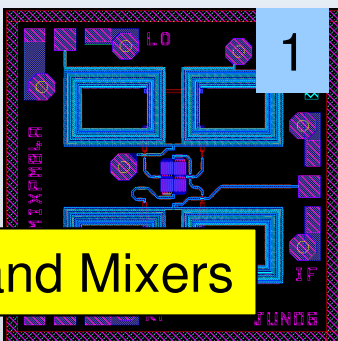
7 MMICs designed, fabricated, tested and evaluated

38

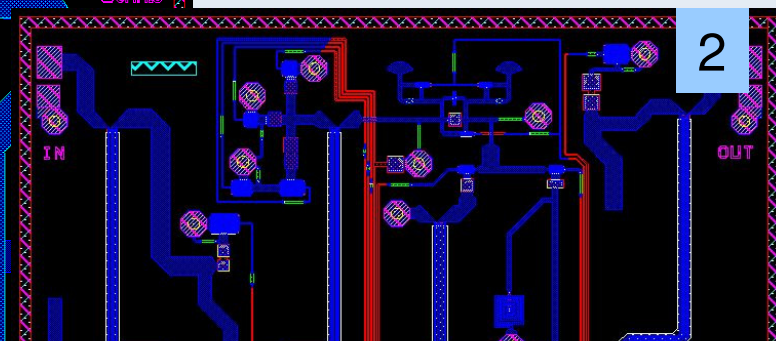
Number of design iterations



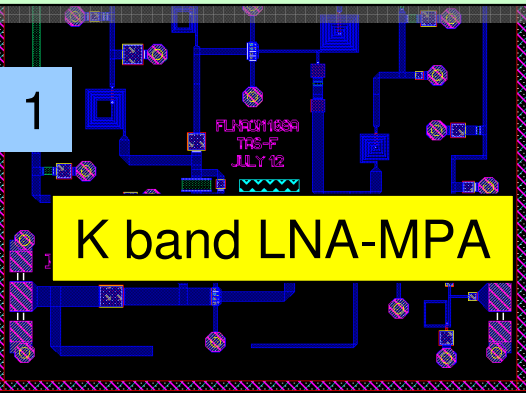
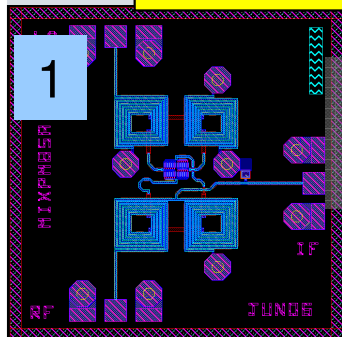
3 wideband Mixers



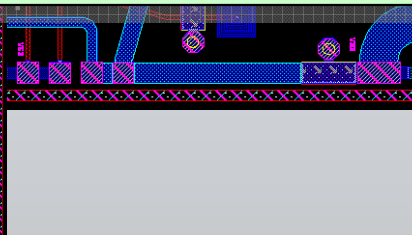
K Band 2W PA



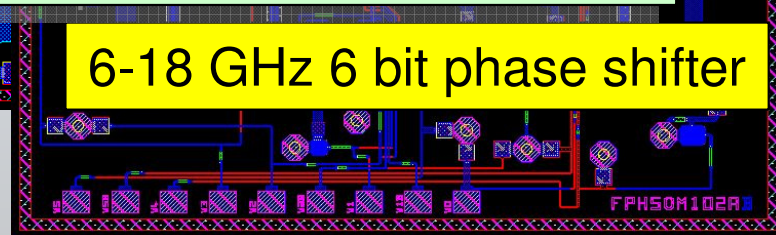
6-18 GHz 6 bit phase shifter



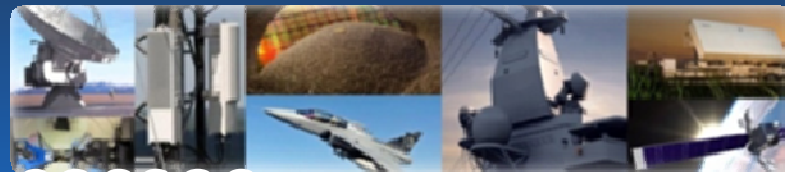
K band LNA-MPA



1 to 45 GHz LNA



Measurements have shown that all 7 circuits are (at least) state of the art as compared with non European sources



(Delta) space evaluation of 3 processes

Validation of documented process changes

39

- ED02AH, D01PH, D01PHS

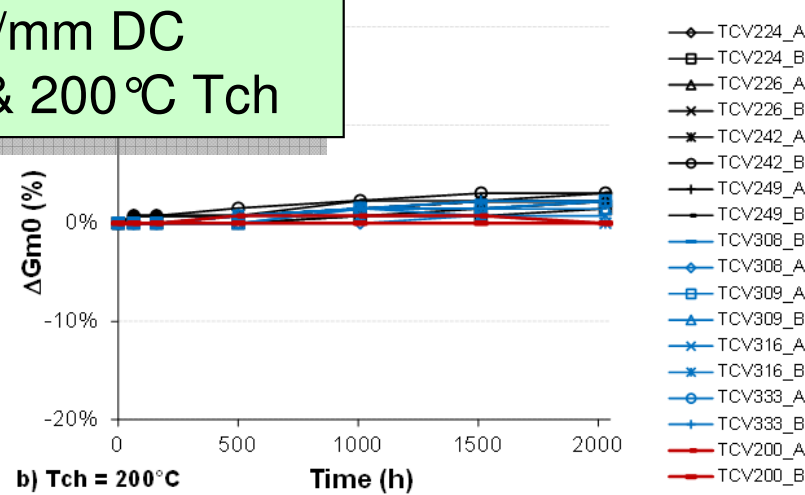
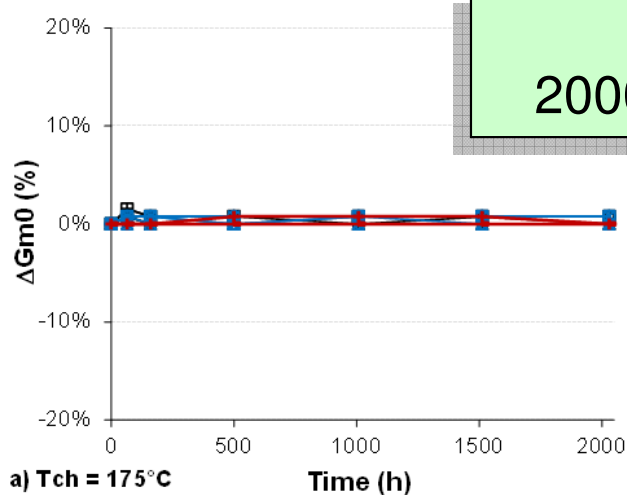
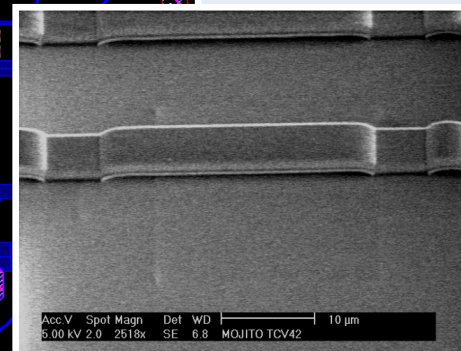
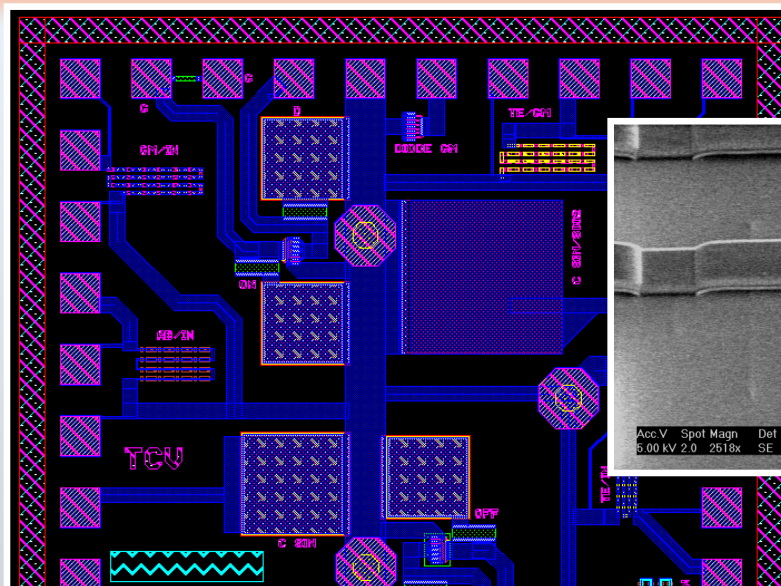
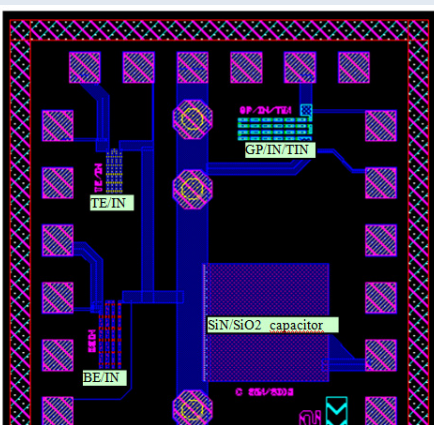
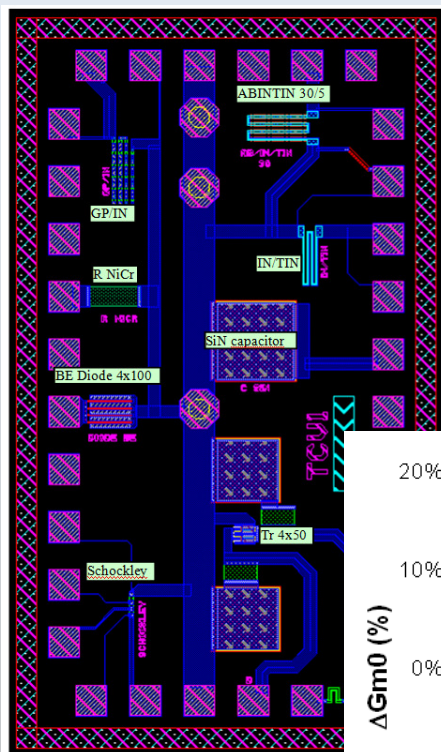
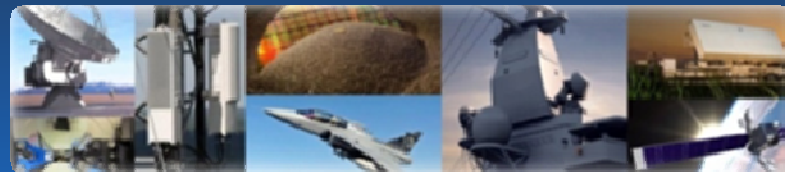


Figure 5.31 - Drift of G_{m0} in DC Life-test at T_{ch} = a) 175°C and b) 200°C

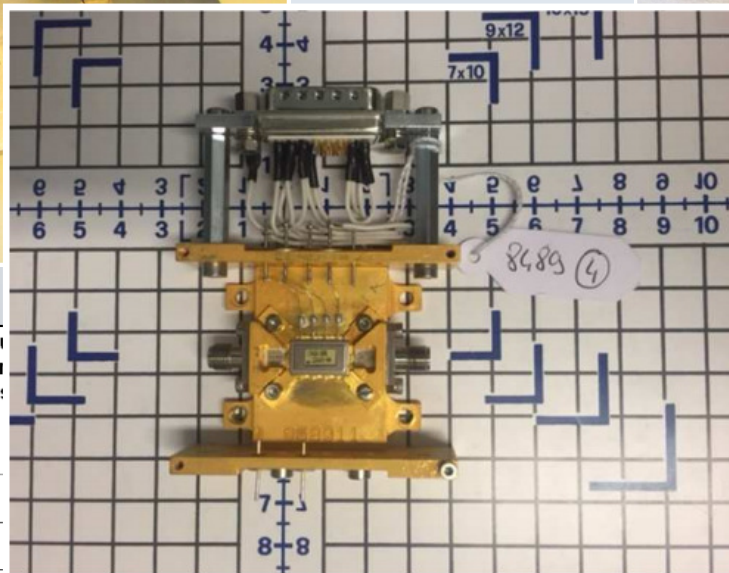
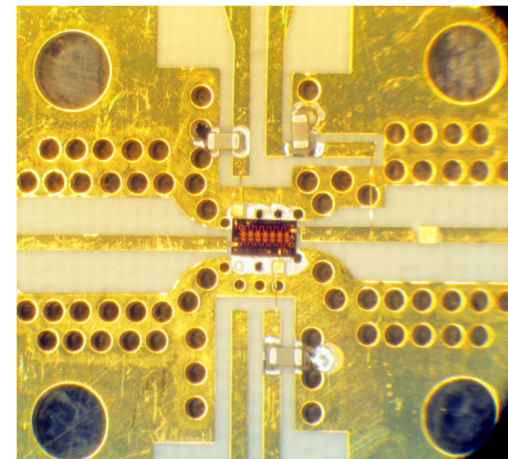
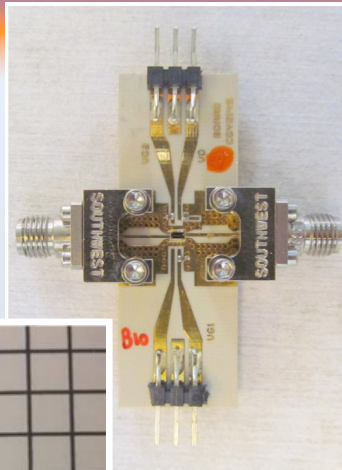
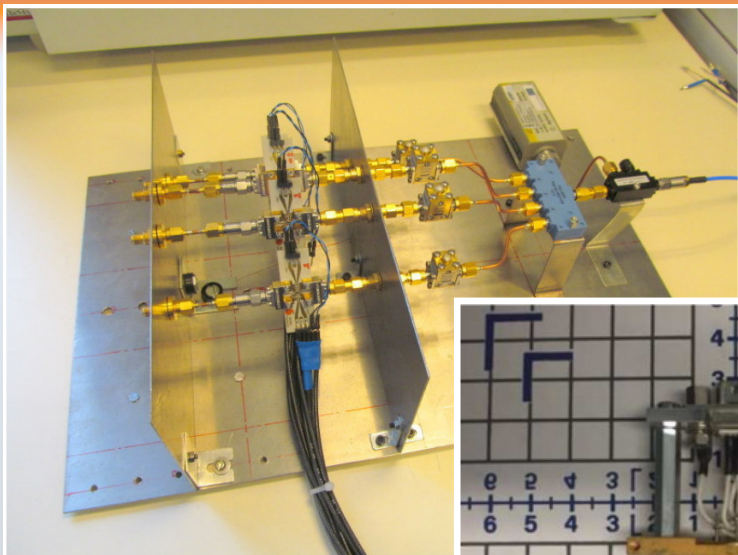


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Space validation of the 7 MMICs



DC life tests
RF life tests
Tests versus temperature

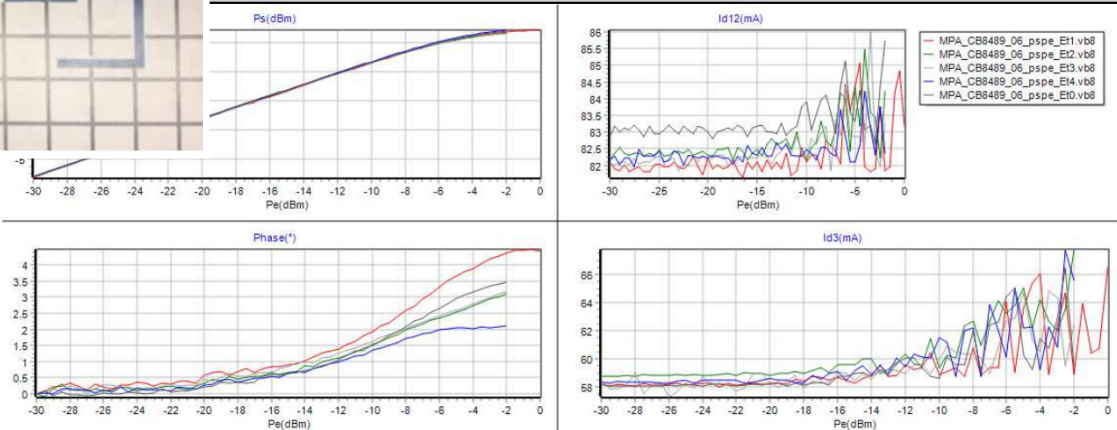
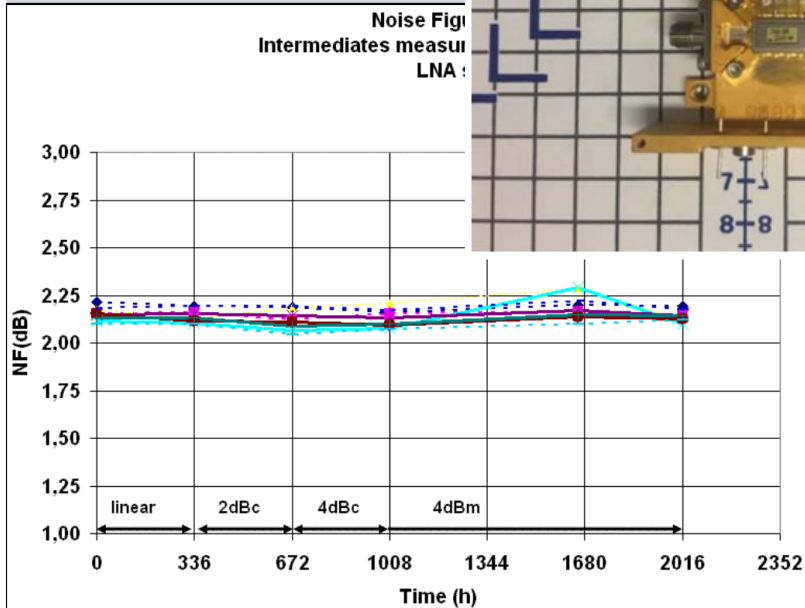
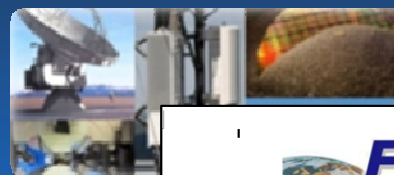


Figure 233 : Dynamic measurements @ 15 GHz : initial, intermediates and final measurements - life test RF



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Data sheets ...



PRODUCT DATASHEET

Version 1.0

CGY2181UH/C1 1 - 4.5 GHz Double Balanced Mixer

DESCRIPTION

The CGY2181UH is a high performance GaAs based Double Balanced Mixer MMIC with on chip RF and LO baluns.

The CGY2181UH covers the frequency range of 1 GHz to 4.5 GHz with a conversion loss of typically 7 dB. On-chip baluns provide excellent rejection of LO to RF and IF paths. High dynamic range is provided by the passive mixer configuration. This device can be used in GPS, Telecommunication, Radar, EW and Instrumentation applications.

The die is manufactured using OMMIC's 0.18 μ m gate length PHEMT Technology. The MMIC uses gold bonding pads and backside metallization and is fully protected with Silicon Nitride passivation to obtain the highest level of reliability. This technology has been evaluated for Space applications and is on the European Preferred Parts List of the European Space Agency.

APPLICATIONS

- GPS Systems
- Radar
- Telecommunication
- Instrumentation

FEATURES

- RF and LO Range : 1 GHz to 4.5 GHz
- IF Range : DC - 2.5 GHz
- Conversion Loss : 7 dB
- LO to RF Isolation : 45 dB
- LO to IF Isolation : 32 dB
- Input P1dB : 13 dBm
- Small Chip Size 1.5 mm x 1.5 mm
- Tested, Inspected Known Good Die (KGD)
- Samples available
- Demonstration Boards available
- Space and MIL-STD also available

PRELIMINARY DATASHEET

CGY2135UH/C1 8-23 GHz 33dBm Power Amplifier

FEATURES

- Operating Range : 18 GHz to 23 GHz
- P_{out} : 31.2 dBm @ 20.5GHz
- P_{sat} : 32.3 dBm @ 20.5GHz
- PAE : 20.2 % @ 20.5GHz @ P_{out}
- Gain : 25.4 dB @ 20.5 GHz
- Power Supply : 4.0 V
- 50 Ohms Input and Output matched

Preliminary DATASHEET

Rev 0.1

CGY2145UH 0.5-45GHz Wide Band Amplifier

PRODUCT DATASHEET

Version 1.0

MONOLITHIC MICROWAVE INTEGRATED CIRCUIT (MMIC) GaAs PHEMT D01PH

PROCESS FROM OMMIC,

BASED ON TYPE CGY2145UH BARE DIE (LOW NOISE WIDE BAND AMPLIFIER)

ESCC Detail Specification No.901x/yyy

All 7 circuits are available as commercial or flight model products



Page 1 of 20

MONOLITHIC MICROWAVE INTEGRATED CIRCUIT (MMIC) GaAs PHEMT ED02AH

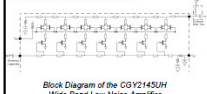
PROCESS FROM OMMIC,

BASED ON TYPE CGY2173UH BARE DIE (6-BIT 6GHZ-18GHZ PHASE SHIFTER)

ESCC Detail Specification No.901x/yyy

Page 1 of 15

- P_{out} = 18 dBm at 20GHz
- NF = 2.9 dB at 20GHz
- N_{Fmin} = 1.8 dB at 9GHz
- Chip size = 1850 x 1060 μ m
- Tested, Inspected Known Good Die (KGD)
- Space and MIL-STD Available



Block Diagram of the CGY2145UH Wide Band Low Noise Amplifier

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Instrumentation

Website: www.ommic.com

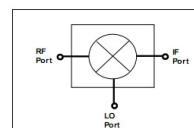
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Instrumentation

Revision: 15/01/2016
Website: www.ommic.com

FEATURES

- RF and LO Range : 3 GHz to 10 GHz
- IF Range : DC - 3 GHz
- Conversion Loss : 7 dB
- LO to RF Isolation : 60 dB
- LO to IF Isolation : 45 dB
- Input P1dB : 12 dBm
- Small Chip Size 1.5 mm x 1.5 mm
- Tested, Inspected Known Good Die (KGD)
- Samples available
- Demonstration Boards available
- Space and MIL-STD also available



Block Diagram of the Mixer

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Instrumentation

CGY2173UH/C2 6-bit 6GHz-18GHz Phase Shifter

FEATURES

- Operating Range : 6 GHz to 18 GHz
- Insertion Loss : 13 dB at 12 GHz
- Phase Shift Range = 360°
- RMS Phase Error = 4° @ 12 GHz
- Input P1dB = +27 dBm @ 12 GHz
- S_{11} & S_{22} < -12 dB @ 12 GHz (All states)
- 0/-3V Control Lines
- Chip size = 3250 x 3500 μ m
- Tested, Inspected Known Good Die (KGD)
- Space and MIL-STD Available
- Developed and Evaluated for Space in the frame of ESA European Component Initiative



Block Diagram of the 6-Bit 6-18 GHz Phase Shifter

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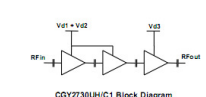
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PRELIMINARY DATASHEET

CGY2730UH/C1 Dual mode LNA/MPA Amplifier

FEATURES

- RF Frequency Range : 12 to 19 GHz
- Gain is 23dB and NF 1.4dB for both mode
- Output P1dB is 11dBm with power consumption of 270mW for LNA mode
- Output P1dB is 17dBm @ 17GHz with power consumption of 520mW for MPA mode
- 50 Ohms Internally matched ; RL is better than -6dB and ORL better than -8dB for both mode
- Device Available
- Tested, Inspected Known Good Die (KGD)



Block Diagram of the CGY2730UH/C1

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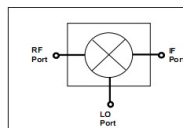
PRODUCT DATASHEET

Version 1.0

CGY2180UH/C1 1-4.5 GHz Double Balanced Mixer

FEATURES

- RF and LO Range : 0.7 GHz to 3.7 GHz
- IF Range : DC - 1.7 GHz
- Conversion Loss : 7 dB
- LO to RF Isolation : 35 dB
- LO to IF Isolation : 35 dB
- Input P1dB : 12 dBm
- Small Chip Size 1.5 mm x 1.5 mm
- Tested, Inspected Known Good Die (KGD)
- Samples available
- Demonstration Boards available
- Space and MIL-STD also available



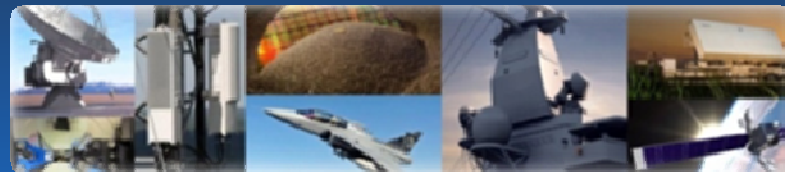
Block Diagram of the Mixer

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Thank you !

