DOE15_LDMOS_6X400um = 2,4mm Simulation
Minipac design
Build #8

Bhagath Talluri
15.08.2022

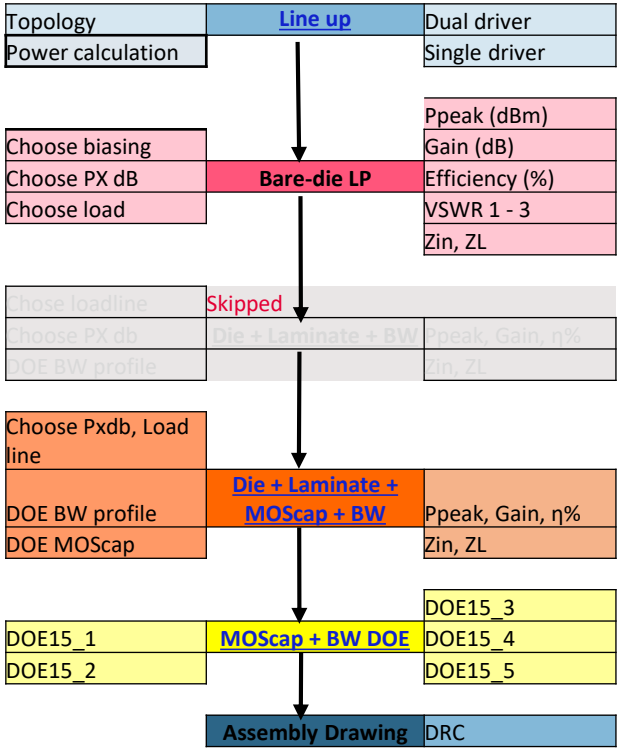
- restricted -

Contents

- Design approach
- Simulation Libraries
- LDMOS die & model
  - LDMOS model
  - Design notes
  - Cds check
- DOE setup
- Selected DOE
- ADS cell & symbols
- Acknowledgements

Design approach

- Step 1: Line up calculation with losses
- Setp 2: Obtain Main section driver power requirement
- Step 3: Choose the available LDMOS die that deliers the power
- Step 4: Design/performance criteria
  - Compressin X dB <1,
  - Px dB > 33 dBm
  - As high Gt as possible
  - As high η% as possible
- Bondwire + Moscap to improve performance
  - Select Moscap DOE



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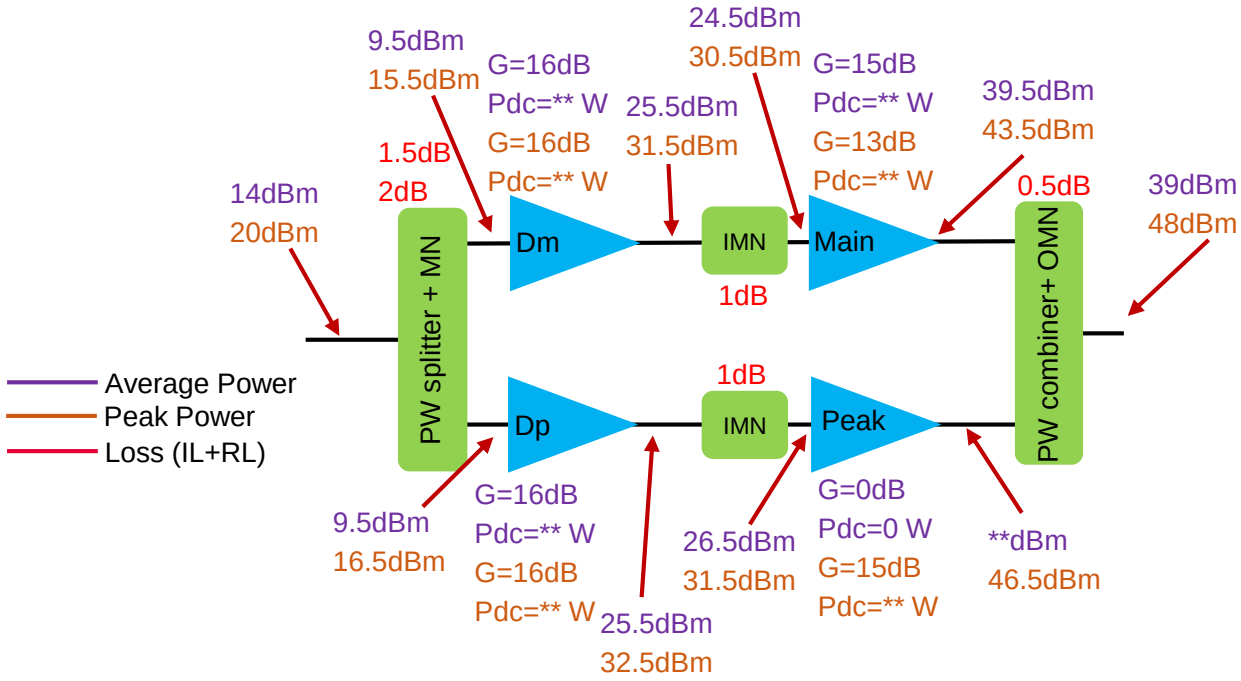
From: Dual driver Architecture-Draft (Alireza)



- Around 33 dBm expected from main section
- Intended to operate in as much linear region as possible until Pout = 33 dBm

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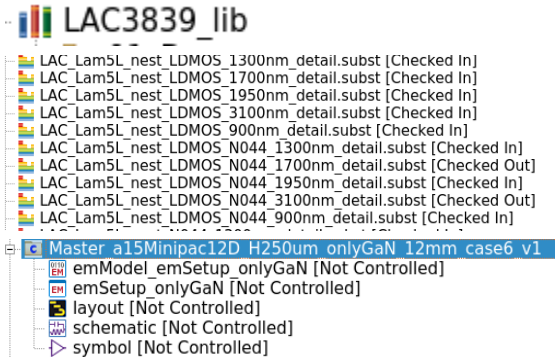
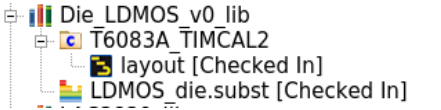
Design on laminate DOE15

- Laminate library:LAC3839_lib





	LDMOS	MOSCap
Design	Die_LDMOS_v0_lib	IC_LD8C_lib
Assembly drawing	Die_LDMOS_v0_lib	Central_v0_lib

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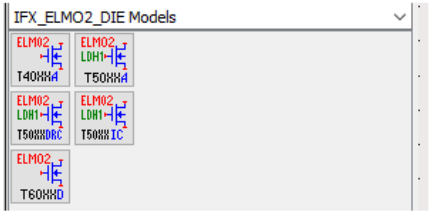
LDMOS model

LDMOS models,

- Model validation I was never involved here. I have the model itself, and we could theoretically even support and improve this in the future, but I don't have validation data or report.
- 

- You need to go to the 'ELMO2' palette (there are many palettes)
  T40xx = LD10
  T60xx = LD12 (LD10S)
  Anything marked with LH1 is 50V LDMOS – poor performance >1GHz.
  I believe the LD11 model was discontinued – and in any case for a plastic OM product we shouldn't consider LD11.

\\mucsdv534.infineon.com\RFS\PG_WI\90_TechInfo\LDMOS\PDK_Model\

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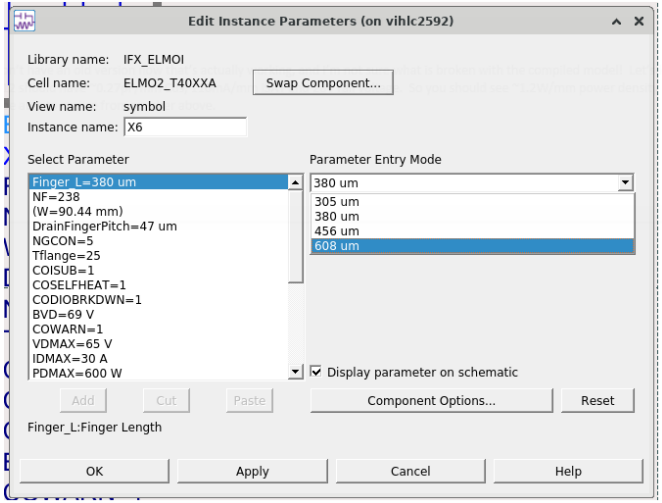
Design Notes

Right Finger length is not Available, So only 2.28 mm can be made (Interested 2.4mm)



Fab Name	Marketing Name	Comment
LD10M	LD10	Oldest run material, Sinker (no TSV) and no voids
LD10E	LD11	LD10M with 'open' voids. Not suitable for plastic
LD10S	LD12	High res+TSV and integrated capped voids for low Cds.

So if you are using LD10S, this is not the same thing as LD10.

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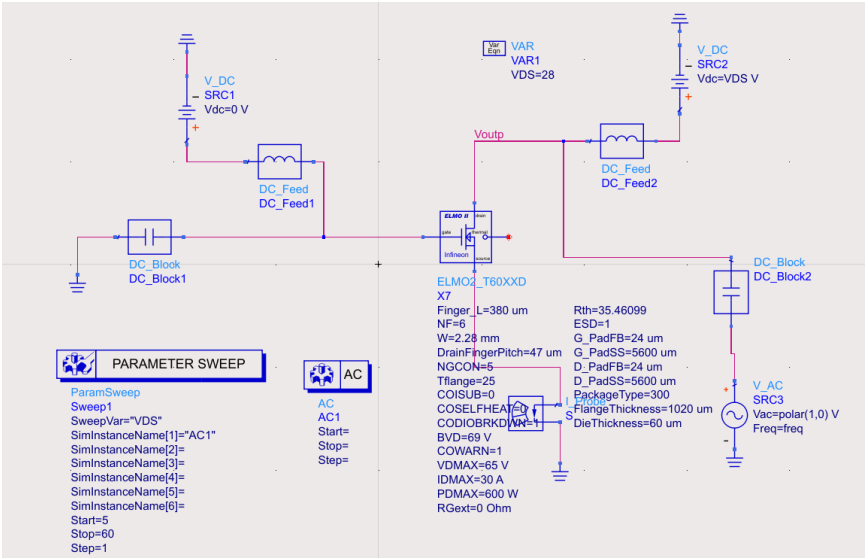
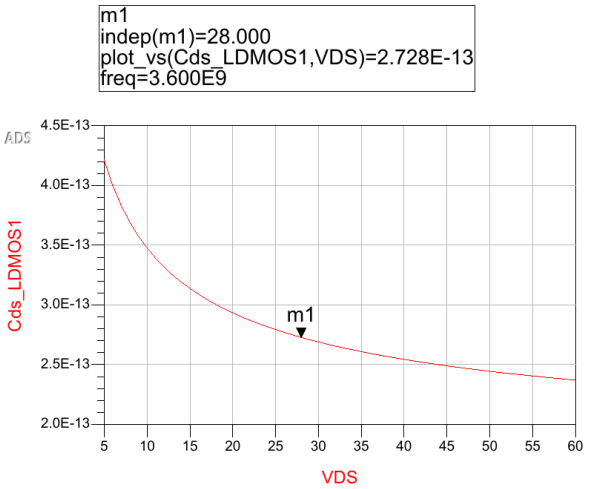
CDS checking

N.B. I don't have an old version now that's actually working, and I'm not sure what is broken with the compiled model! Let's looks carefully at the results you get.
N.B. LD12 should have ~0.27pF/mm Cds, 110mA/mm ISAT and 28V rail voltage. So you should see ~1.2W/mm power density and the Cout should let you roughly estimate the load contours. If you get strange results you should be able to realise from number above.



Eqn Zout_p = Voutp/S.i

Eqn Cds_LDMOS1=1/(2*4.56*pi*AC.freq*-imag(Zout_p))



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DOE_15 variants

LDMOS_A (3x0.8mm = 2.4mm)	P_1dB	Moscap_detail_EM					Max. performace @ P1dB			Performance_@ (33,0 dBm)						Performance_@ (33,5 dBm)					
DOE_15	BW_profile	Name	RF top plate (X x Y)	Oxide thickness (µm)	Value (pF)	Freq.	MXP (dBm)	MXG (dB)	MXE (%)	Zin (Ω)	Z_L (Ω)	Pout (dBm)	Eff. (%)	Gt (dB)	IRL (dB)	Zin (Ω)	Z_L (Ω)	Pout (dBm)	Eff. (%)	Gt (dB)	IRL (dB)
DOE_15_1	BW_1q_2q	Direct				3.6 GHz	33,5	18,2	51,7	6,5 – j 0,3	2,8 + j 13,3	33,05	51,8	16,9	-25,0	6,6 – j 0,8	5,4 + j 13,8	33,5	47,8	16,0	-25,6
DOE_15_2	BW_3q_4q_5q	N9501B_V8		3100	3,53	3.6 GHz	33,8	17,7	49,9	2,8 + j 1,2	3,7 + j 15,5	32,97	50,0	16,4	-18,7	2,8 + j 1,2	4,2 + j 15,2	33,4	49,7	16,1	-17,8
DOE_15_3	BW_3q_4q_5q	N9500B_V7		3100	4,64	3.6 GHz	33,8	17,5	50,6	2,3 + j1,6	3,7 + j 15,5	33,07	50,3	16,0	-11,3	2,3 + j 1,5	4,7 + j 15,2	33,74	49,6	15,4	-10,8
DOE_15_4	BW_3q_4q_5q	N9500B_V2		1950	5,41	3.6 GHz	33,9	17,4	50,7	2,1 + j 1,8	3,7 + j 15,5	33,14	50,5	15,8	-9,8	2,0 + j 1,8	4,7 + j 15,2	33,74	49,5	15,1	-9,3
DOE_15_5	BW_3q_4q_5q	N9500B_Std		1950	6,18	3.6 GHz	34,0	17,2	50,9	1,8 + j 2,0	3,7 + j 15,5	33,25	50,9	15,5	-8,5	1,8 + j 2,0	4,2 + j 15,2	33,6	50,5	15,2	-8,2

Compression = 1, ClassAB, Moscap: Detail EM

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ADS cells and symbols

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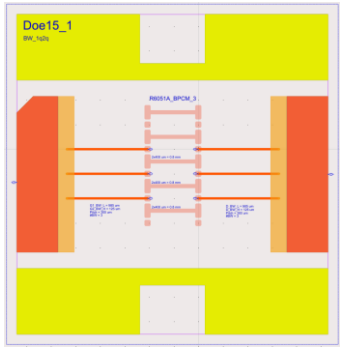

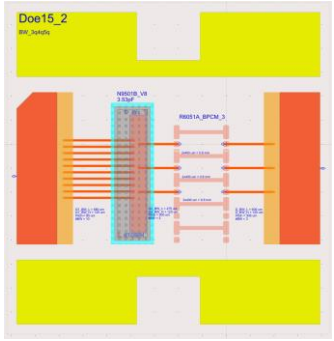

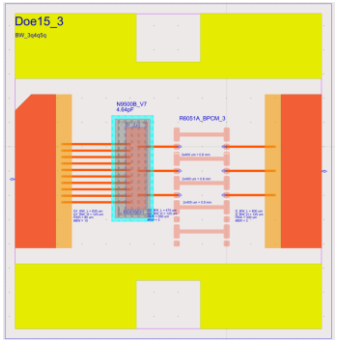

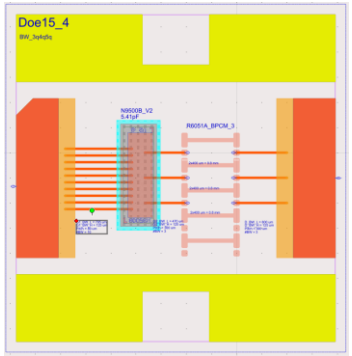

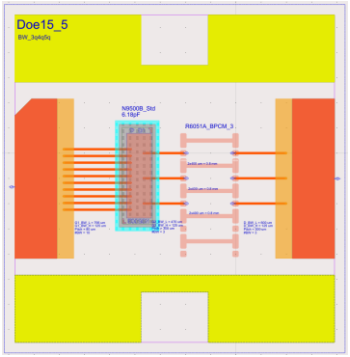

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Acknowledgements

- Theepak ShoundraBalan: Design related discussions, design review, troubleshooting and debugging.
- Fillippo Panzalo: EM layouts of Moscaps, LDMOS dies, Assembly drawing generation and review, EM simulation support.
- Jorge Texeira: Assembly design rule guidelines, drawing review, build planning, coordination and documentation.
- Shamsafar Alireza: Design review, design target discussions and guidelines.
- De Astis Giuseppe & Andrea Scarpa: Design follow up, design environment & logistic coordination.

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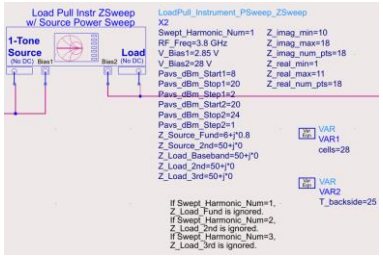
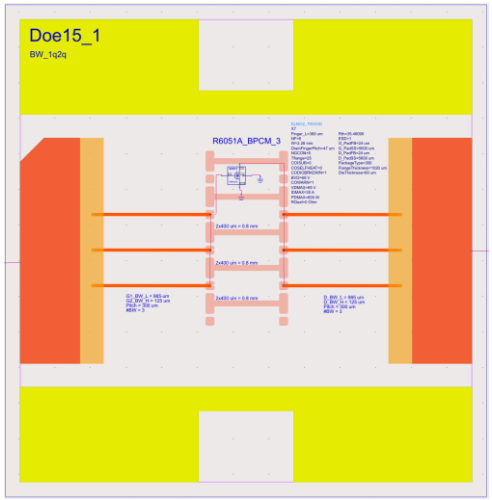
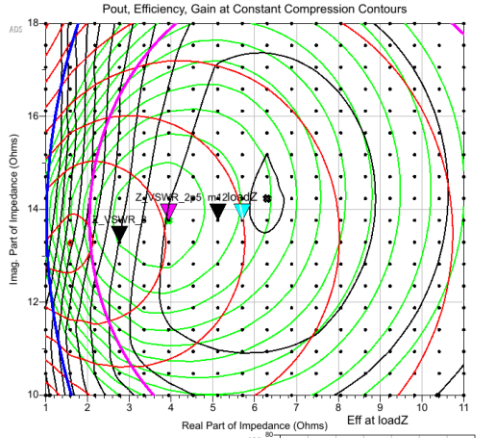
DOE15_01

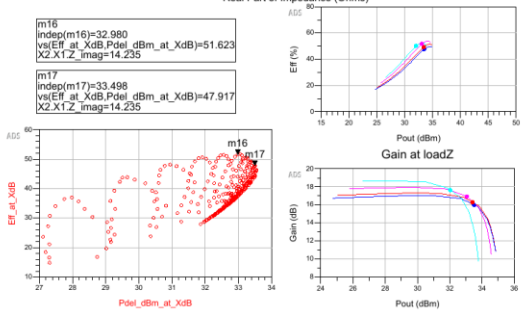
Direct
Moscap; Detailed
3,6GHz





Pout	Gt	Eff
33.5	18.2	51.7
33.0	18.0	50.0
32.5	17.0	48.0
32.0	16.0	46.0
31.5	15.0	44.0
31.0	14.0	42.0
30.5	13.0	40.0
30.0	12.0	38.0
29.5	11.0	36.0
29.0		34.0
28.5		32.0





Power Sweep Inspector

Eqn VSWRVal=5 Eqn VSWRVal1=2.5

Move Marker 'loadZ' to desired impedance point.

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = 6.29 + j14.24
VSWR=5

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = 5.12 + j13.76
VSWR=5

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
5.71 + j13.76	0.81 / 148.86	1

Pout (dBm)	Eff (%)	Gt (dB)
33.50	47.79	16.01

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-8.22	-25.64	6.55 - j0.82

✕ In plots below corresponds to this data.

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
5.12 + j13.76	0.83 / 148.93	1

Pout (dBm)	Eff (%)	Gt (dB)
33.40	49.26	16.30

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-8.42	-26.20	6.51 - j0.70

✕ In plots below corresponds to this data.

VSWR = 2.5 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.94 + j13.76	0.86 / 149.05	1

Pout (dBm)	Eff (%)	Gt (dB)
33.05	51.80	16.93

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-9.78	-25.09	6.47 - j0.28

✕ In plots below corresponds to this data.

VSWR = 3 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
2.76 + j13.29	0.90 / 150.14	1

Pout (dBm)	Eff (%)	Gt (dB)
32.03	50.20	17.65

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-11.85	-21.32	6.00 + j0.25

✕ In plots below corresponds to this data.

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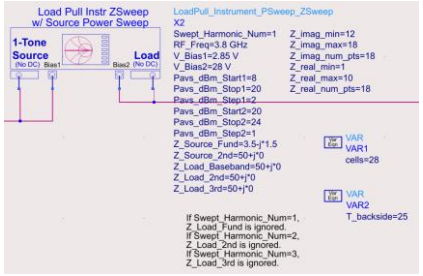
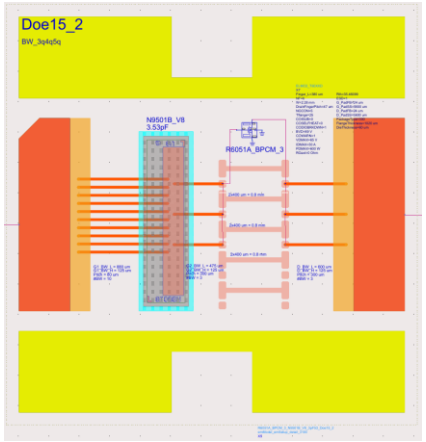
DOE15_02

C=3p53pF
Moscap: Detailed
3,6GHz





Pout	Gt	Eff
33.8	17.7	49.9
33.5	17.0	48.0
33.0	16.0	46.0
32.5	15.0	44.0
32.0	14.0	42.0
31.5	13.0	40.0
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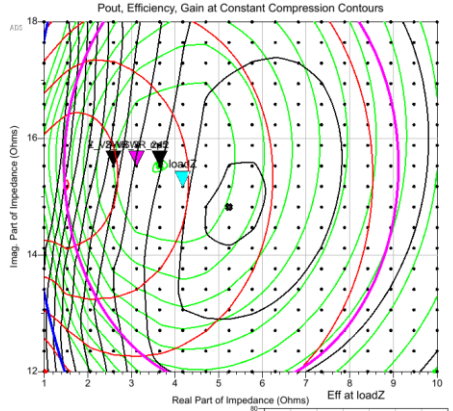
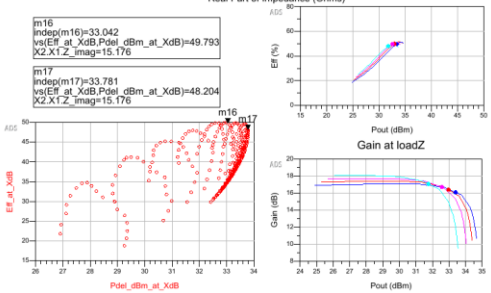
30.0		34.0
29.5		32.0
29.0		30.0





Power Sweep Inspector

Eqn VSWRVal=5 Eqn VSWRVal1=2.5

Move Marker 'loadZ' to desired impedance point.

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = VSWR=5: 5.24 + j14.82

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = VSWR=5: 3.65 + j15.53

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
4.18 + j15.18	0.86 / 146.03	1

Pout (dBm)	Eff (%)	Gt (dB)
33.40	49.72	16.07

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.65	-17.83	2.75 + j1.18

✕ In plots below corresponds to this data.

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.65 + j15.53	0.88 / 145.33	1

Pout (dBm)	Eff (%)	Gt (dB)
32.97	49.97	16.39

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.24	-18.70	2.82 + j1.20

✕ In plots below corresponds to this data.

VSWR = 2.5 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.12 + j15.53	0.89 / 145.38	1

Pout (dBm)	Eff (%)	Gt (dB)
32.57	49.80	16.70

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-8.34	-20.04	2.89 + j1.30

✕ In plots below corresponds to this data.

VSWR = 3 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
2.59 + j15.53	0.91 / 145.41	1

Pout (dBm)	Eff (%)	Gt (dB)
31.76	48.00	17.07

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-8.19	-20.94	2.92 + j1.39

✕ In plots below corresponds to this data.

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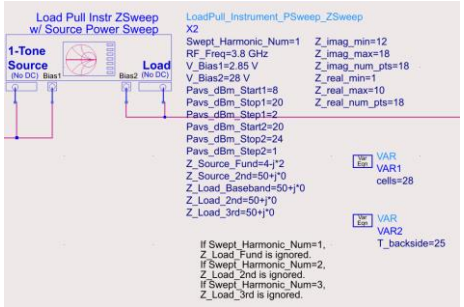
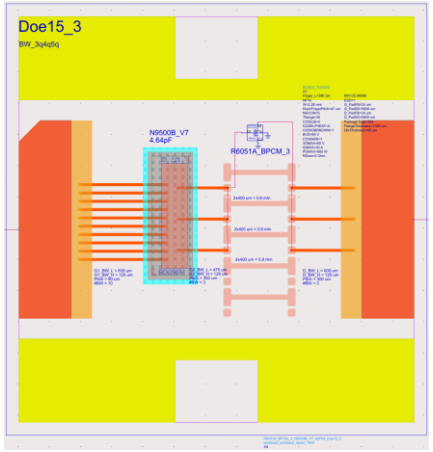
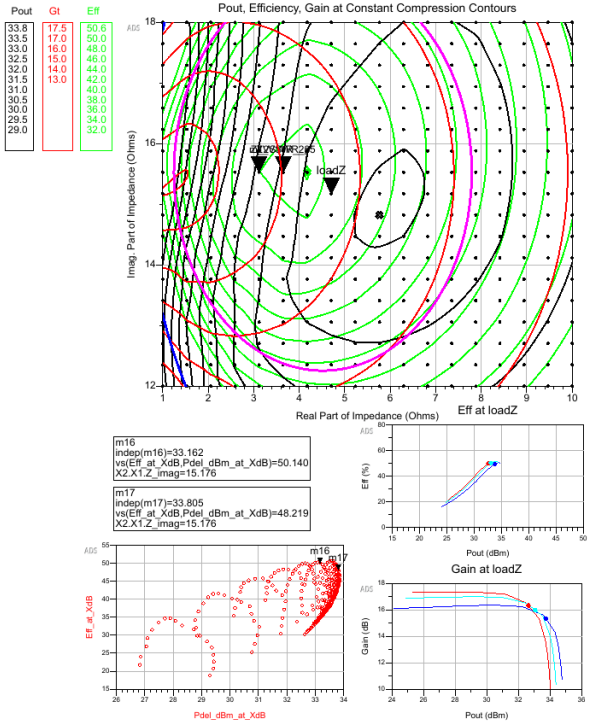
DOE15_03

C=4p64pF
Moscap: Detailed
3,6GHz







Power Sweep Inspector

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VSWR=5

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = 3.12 + j15.53
VSWR=5

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
4.71 + j15.18	0.84 / 145.97	1

Pout (dBm)	Eff (%)	Gt (dB)
33.74	49.55	15.35

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-6.78	-10.76	2.25 + j1.54

✕ In plots below corresponds to this data.

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.12 + j15.53	0.89 / 145.38	1

Pout (dBm)	Eff (%)	Gt (dB)
32.64	49.99	16.33

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-8.24	-11.71	2.38 + j1.65

✕ In plots below corresponds to this data.

VSWR = 2.5 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.65 + j15.53	0.88 / 145.33	1

Pout (dBm)	Eff (%)	Gt (dB)
33.07	50.26	15.98

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.31	-11.34	2.33 + j1.59

✕ In plots below corresponds to this data.

VSWR = 3 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.65 + j15.53	0.88 / 145.33	1

Pout (dBm)	Eff (%)	Gt (dB)
33.07	50.26	15.98

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.31	-11.34	2.33 + j1.59

✕ In plots below corresponds to this data.

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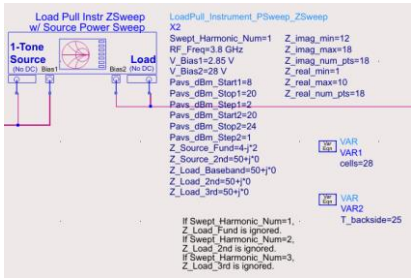
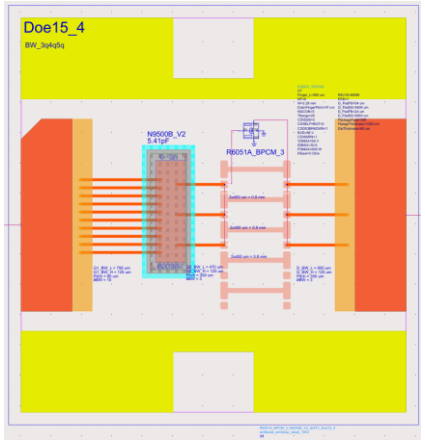
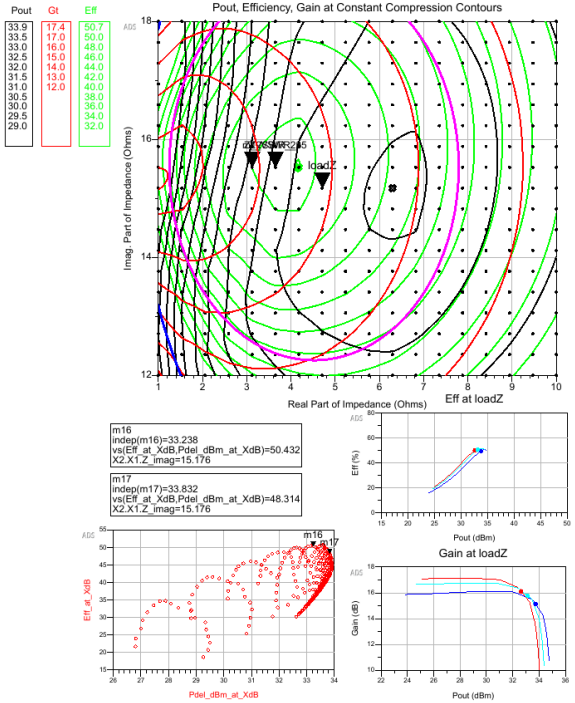
DOE15_04

C=5p41pF
Moscap: Detailed
3,6GHz







Power Sweep Inspector

Eqn VSWRVal=5 Eqn VSWRVal1=2.5

Move Marker 'loadZ' to desired impedance point.

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = VSWR=5: 6.29 + j15.18

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
4.71 + j15.18	0.84 / 145.97	1

Pout (dBm)	Eff (%)	Gt (dB)
33.74	49.53	15.12

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-6.53	-9.25	1.96 + j1.78

✕ In plots below corresponds to this data.

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = VSWR=5: 3.12 + j15.53

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.12 + j15.53	0.89 / 145.38	1

Pout (dBm)	Eff (%)	Gt (dB)
32.64	50.01	16.12

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-8.09	-9.98	2.08 + j1.86

✕ In plots below corresponds to this data.

VSWR = 2.5 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.65 + j15.53	0.88 / 145.33	1

Pout (dBm)	Eff (%)	Gt (dB)
33.14	50.52	15.76

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.41	-9.77	2.04 + j1.82

✕ In plots below corresponds to this data.

VSWR = 3 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.65 + j15.53	0.88 / 145.33	1

Pout (dBm)	Eff (%)	Gt (dB)
33.14	50.52	15.76

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.41	-9.77	2.04 + j1.82

✕ In plots below corresponds to this data.

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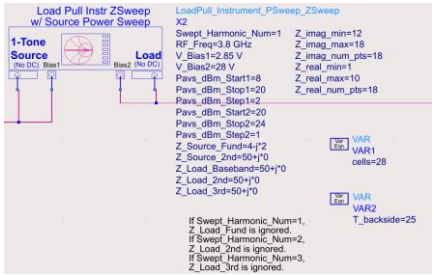
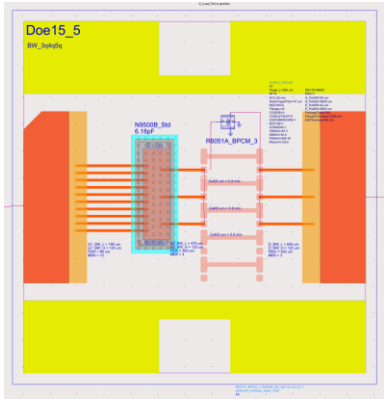
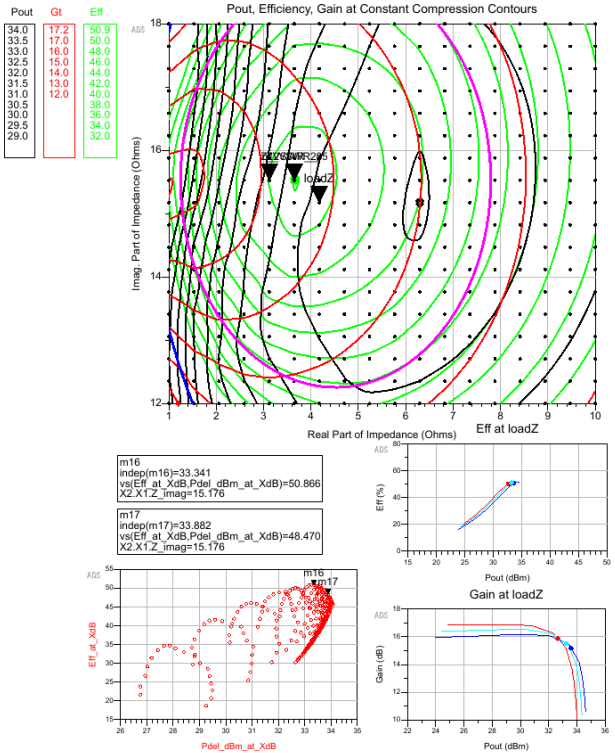
DOE15_05

C=6p18pF
Moscap: Detailed
3,6GHz







Power Sweep Inspector

Eqn VSWRVal=5 Eqn VSWRVal1=2.5

Move Marker 'loadZ' to desired impedance point.

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = 6.29 + j15.18
VSWR=5

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = 3.12 + j15.53
VSWR=5

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
4.18 + j15.18	0.86 / 146.03	1

Pout (dBm)	Eff (%)	Gt (dB)
33.60	50.49	15.17

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.40	-8.15	1.75 + j2.00

✕ In plots below corresponds to this data.

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.12 + j15.53	0.89 / 145.38	1

Pout (dBm)	Eff (%)	Gt (dB)
32.65	50.05	15.88

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-8.06	-8.59	1.83 + j2.05

✕ In plots below corresponds to this data.

VSWR = 2.5 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.65 + j15.53	0.88 / 145.33	1

Pout (dBm)	Eff (%)	Gt (dB)
33.25	50.94	15.51

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.72	-8.51	1.82 + j2.01

✕ In plots below corresponds to this data.

VSWR = 3 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.65 + j15.53	0.88 / 145.33	1

Pout (dBm)	Eff (%)	Gt (dB)
33.25	50.94	15.51

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.72	-8.51	1.82 + j2.01

✕ In plots below corresponds to this data.

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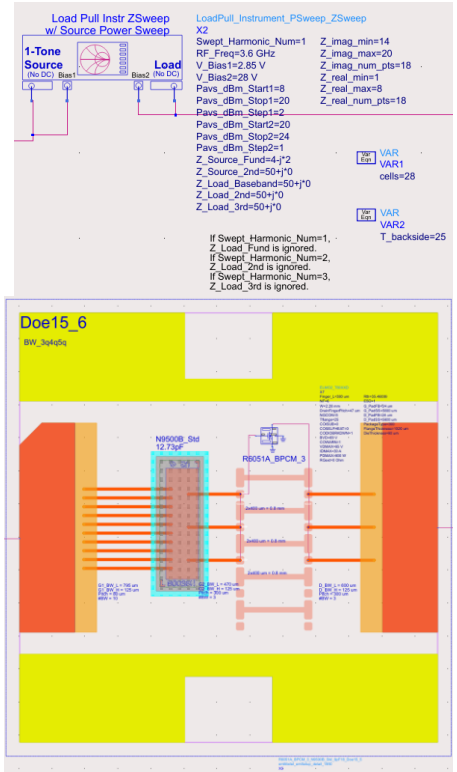
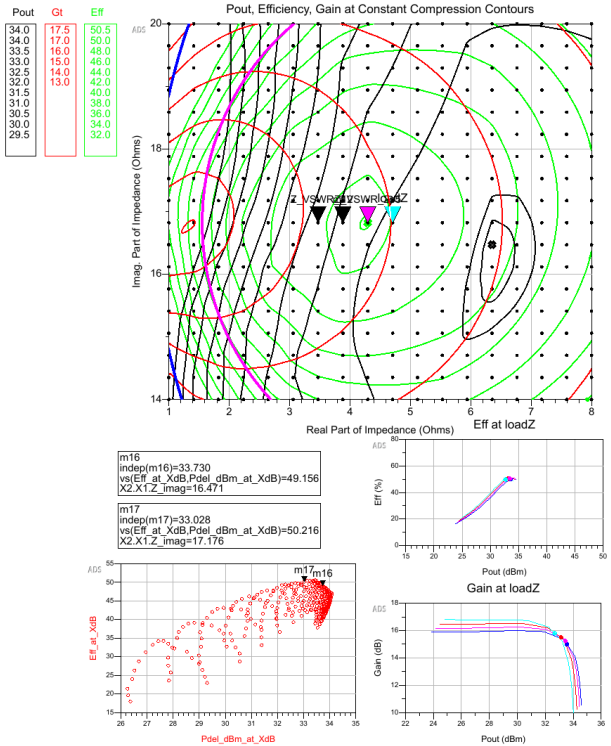
DOE15_06

C=12p73pF
Moscap: Detailed
3,6GHz





Power Sweep Inspector

Eqn VSWRVal=5 Eqn VSWRVal=2.5

Move Marker 'loadZ' to desired impedance point.

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = 6.35 + j16.47
VSWR=5

VSWR Locus of Points selector is located on Constant Compression Loadpull page.

VSWR Locus center Impedance = 3.88 + j16.82
VSWR=5

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
4.71 + j16.82	0.84 / 142.53	1

Pout (dBm)	Eff (%)	Gt (dB)
33.56	49.96	14.98

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-5.44	-7.65	1.74 + j1.16

✕ In plots below corresponds to this data.

Summary of Performance at Compression

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.88 + j16.82	0.87 / 142.62	1

Pout (dBm)	Eff (%)	Gt (dB)
33.13	50.44	15.49

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.15	-7.94	1.79 + j1.22

✕ In plots below corresponds to this data.

VSWR = 2.5 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
4.29 + j16.82	0.86 / 142.58	1

Pout (dBm)	Eff (%)	Gt (dB)
33.44	50.58	15.23

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-6.47	-7.82	1.77 + j1.19

✕ In plots below corresponds to this data.

VSWR = 3 point DATA

Marker Impedance	Marker Gamma	Reference Compression Level (dB)
3.47 + j16.82	0.88 / 142.66	1

Pout (dBm)	Eff (%)	Gt (dB)
32.68	49.81	15.79

AMPM (dBm)	IRL (dB)	Zin (Ohm)
-7.43	-7.98	1.79 + j1.25

✕ In plots below corresponds to this data.

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Power calculation: Asymmetric Doherty

Specification				
Project	**Frequency-Range (MHz)**	**P3dB (dBm)**	**P3dB (W)**	**PAR**
PAM 2.0+	3400 - 3800	47,4	54,95	8,4
		Pavg (dBm)	**Pavg (W)**	
		39	7,94	

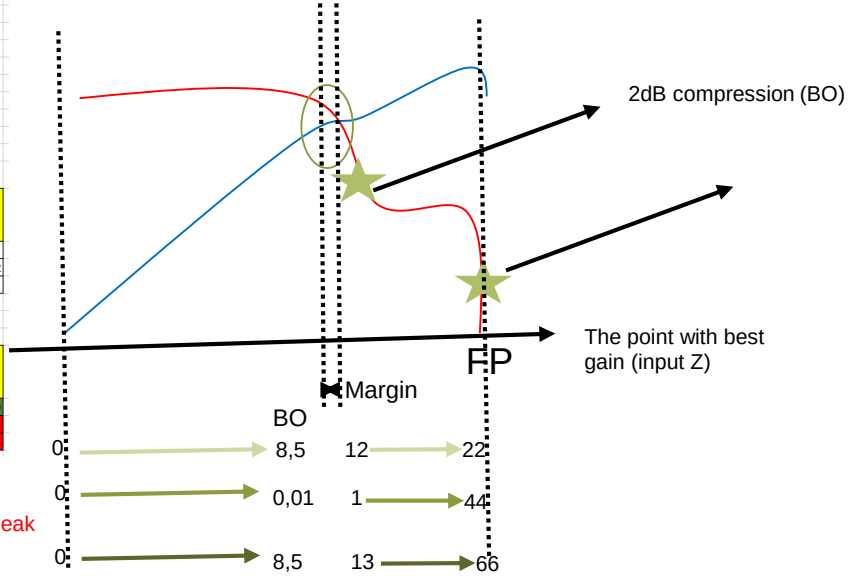
Doherty Topology	**Remark**	**Ratio**	**Main (W)**	**Peak (W)**
2-way asymmetric	To maximize efficiency	2	18,32	36,64

Estimation including loss

	Required power (W)	**Required power (dBm)**	**Loss (dBm)**	**Total required power (dBm)**	**Total required power (W)**	**Ratio**	**Total power (W)**	**Total power (dBm)**
Main	18,32	42,63	0,8	43,43	22,02			
						3,01	**66,07**	**48,2**
Peak	36,64	45,64	0,8	46,44	44,05			

	Total output power (dBm)	**PAR**	**Power @ MXE (dBm)**	**Margin (dB)**	**Power @ MXE (dB**	**Power @ MXE (W)**	**MXP (W)**	**MXP(dBm)**
	48,2	8,4					66,07	48,20
Main			39,8	1,00	40,80	12,02	22,02	43,43
Peak			Peak_start_ideal		Peak_start	0,01	44,05	46,44

Required power from peak



- Maximize Gain
  - Main section gain as high as possible while maintaining Power @ MXE
  - Peak section gain as high as possible while maintaining MXP

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