APPLICATION NOTE

MITSUBISHI ELECTRIC
Silicon RF Power Semiconductors

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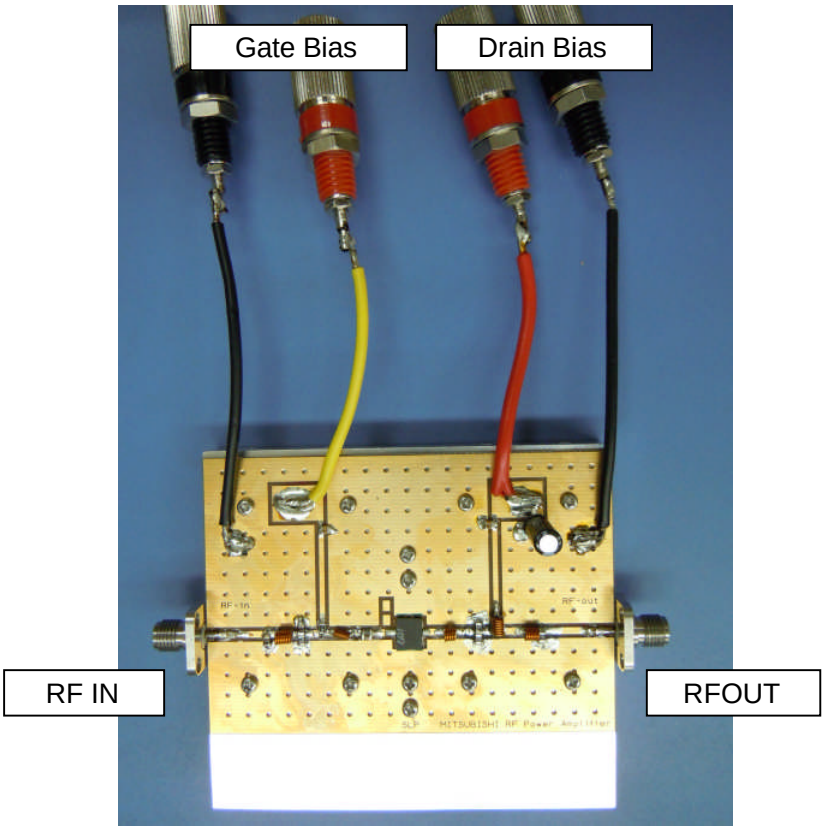
(Taking charge of Silicon RF by MIYOSHI Electronics)

SUBJECT: RD04HMS2 single-stage amplifier with f=135-175MHz evaluation board

Features:

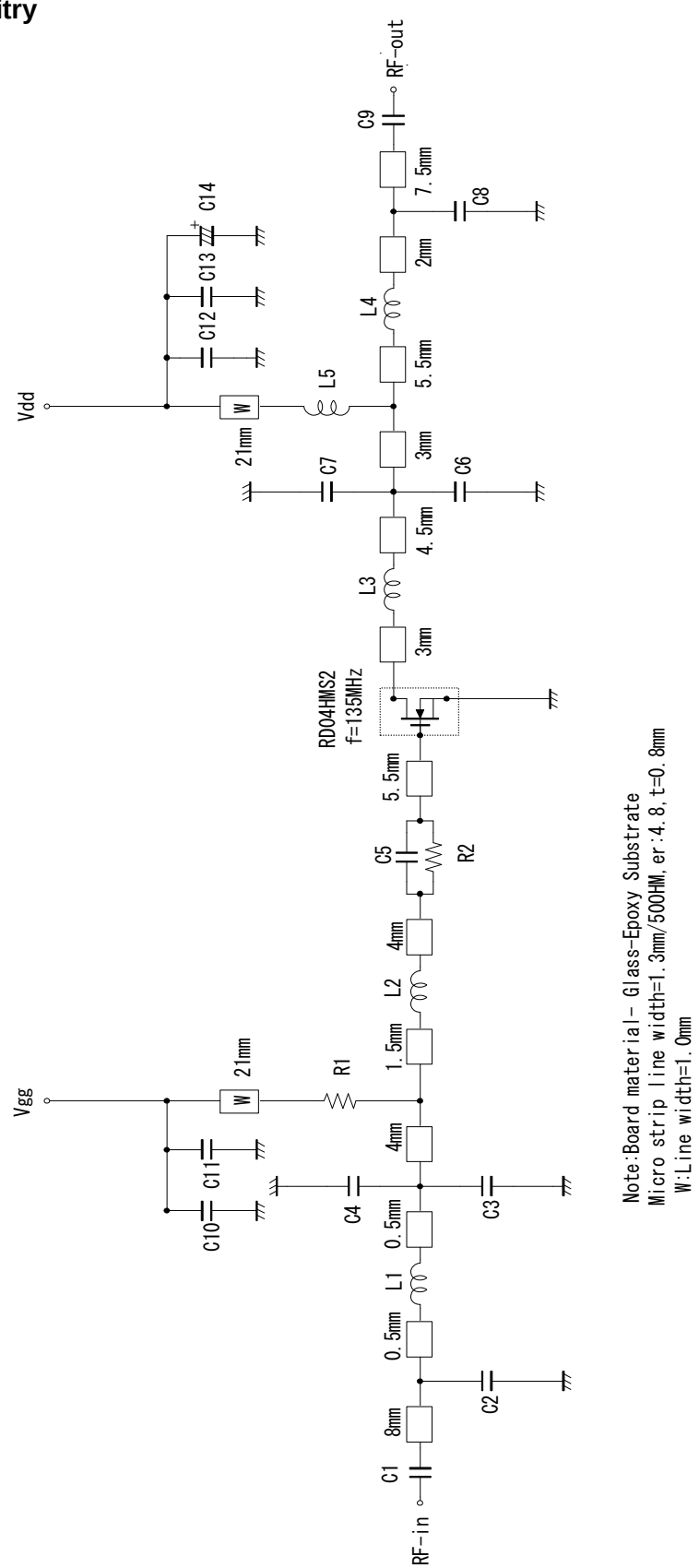
- The evaluation board for RD04HMS2
- Frequency: 135-175MHz
- Typical input power: 0.2W
- Typical output power: 5.5W
- Quiescent Current: 100mA
- Operating Current: 0.65A
- Surface-mounted RF power amplifier structure



PCB L=80mm W=55mm

Contents

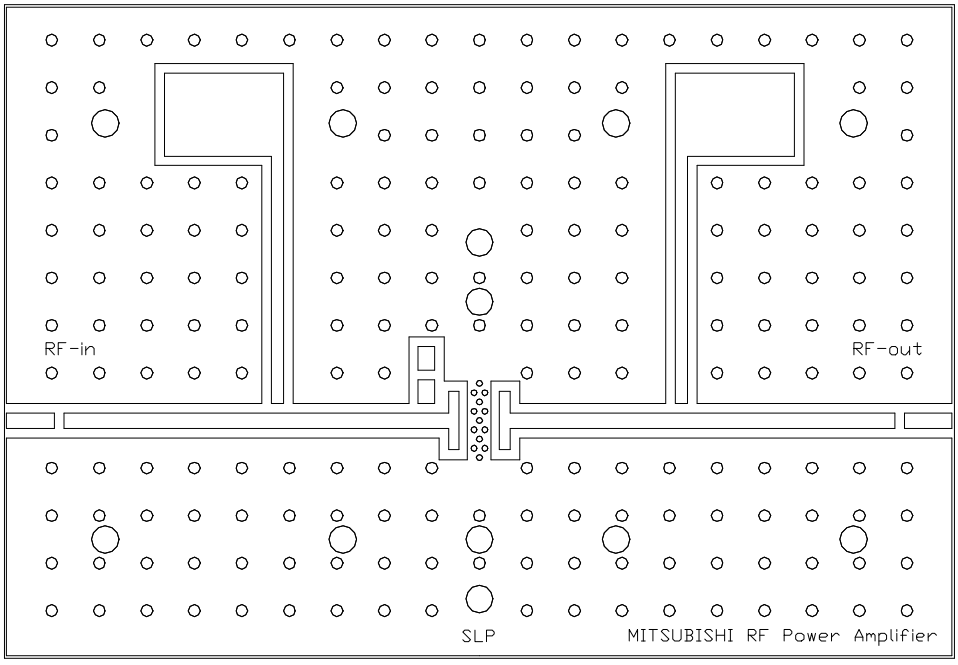
1. Equivalent Circuitry



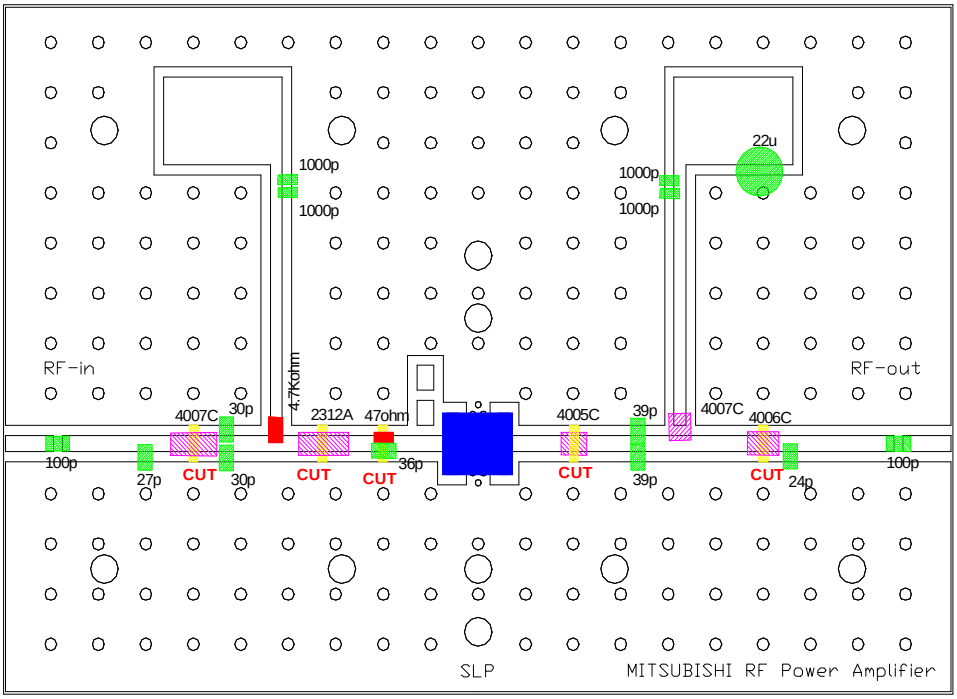
2. PCB Layout

BOARD OUTLINE: 80.0*55.0(mm)
MATERIAL : FR-4<R1705>
THICKNESS : 0.8(mm)

TOP VIEW



TOP VIEW (Parts mounting)



3. Component List and Standard Deliverable

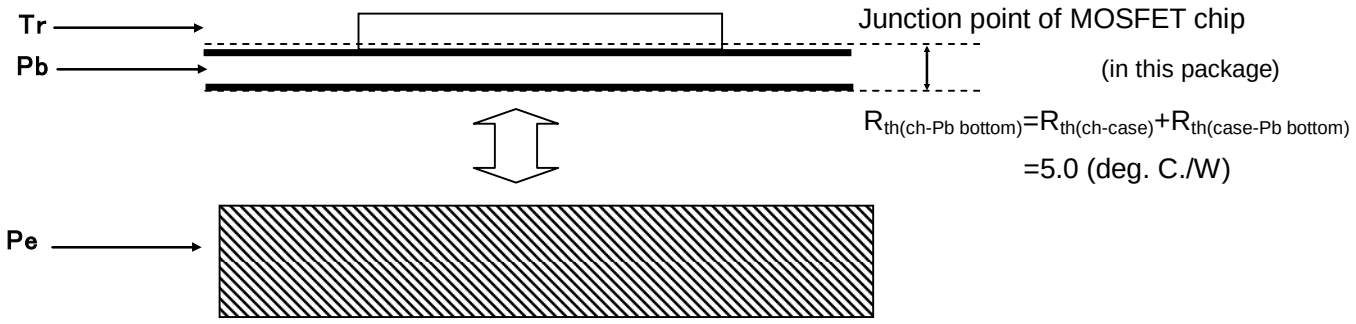
- Component List

No.	Description	P/N	Qty	Manufacturer
Tr	MOSFET	RD04HMS2	1	Mitsubishi Electric Corporation
C 1	100 pF 2012 50V	GRM2162C1H101JA01D	1	MURATA MANUFACTURING CO.
C 2	27 pF 2012 50V	GRM2162C1H270JZ01D	1	MURATA MANUFACTURING CO.
C 3	30 pF 2012 50V	GRM2162C1H300JZ01D	1	MURATA MANUFACTURING CO.
C 4	30 pF 2012 50V	GRM2162C1H300JZ01D	1	MURATA MANUFACTURING CO.
C 5	36 pF 2012 50V	GRM2162C1H360JZ01D	1	MURATA MANUFACTURING CO.
C 6	39 pF 2012 50V	GRM2162C1H390JZ01D	1	MURATA MANUFACTURING CO.
C 7	39 pF 2012 50V	GRM2162C1H390JZ01D	1	MURATA MANUFACTURING CO.
C 8	24 pF 2012 50V	GRM2162C1H240JZ01D	1	MURATA MANUFACTURING CO.
C 9	100 pF 2012 50V	GRM2162C1H101JA01D	1	MURATA MANUFACTURING CO.
C 10	1000 pF 1608 50V	GRM188R11H102KA01E	1	MURATA MANUFACTURING CO.
C 11	1000 pF 1608 50V	GRM188R11H102KA01E	1	MURATA MANUFACTURING CO.
C 12	1000 pF 1608 50V	GRM188R11H102KA01E	1	MURATA MANUFACTURING CO.
C 13	1000 pF 1608 50V	GRM188R11H102KA01E	1	MURATA MANUFACTURING CO.
C 14	22 uF 50V	H1002	1	NICHICON CORPORATION
L 1	57 nH Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=7		1	Homebuilt
L 2	72.7 nH Diameter: Wire=0.23mm Inside=1.1mm T/N of coils=12		1	Homebuilt
L 3	33.2 nH Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=5		1	Homebuilt
L 4	41.9 nH Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=6		1	Homebuilt
L 5	57 nH Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=7		1	Homebuilt
R 1	4.7k ohm 2012	RPC10T472J	1	TAIYOSHA ELECTRIC CO.
R 2	47 ohm 1608	RPC05N470J	1	TAIYOSHA ELECTRIC CO.
Pb	PCB	MS3A0166	1	Homebuilt
Rc	SMA female connector	HRM-300-118S	2	HIROSE ELECTRIC CO.,LTD
Bc 1	Bias connector red color	TM-605R	2	MSK Corporation
Bc 2	Bias connector black color	TM-605B	2	MSK Corporation
Pe	Aluminum pedestal		1	Homebuilt
	Conducting wire		4	Homebuilt
	Screw M2		16	-

- Standard Deliverable

TYPE1	Evaluation Board assembled with all the component
TYPE2	PCB (raw board)

4. Thermal Design of Heat Sink



$Tch_{(delta)}$=(Pout/Efficiency-Pout+Pin) x $R_{th(ch\text{-}Pb\ bottom)}$=(4W/50%-4W+0.2) x 5.0 = 21 (deg. C.)
Also, operating $Tch_{(max)}$=120 (deg. C.), in case of RD series that $Tch_{(max)}$= 150 (deg. C.)
Therefore $T_{Pb\ bottom\text{-}air}$ as delta temperature between Pb bottom and the ambient 60 deg. C.
$T_{Pb\ bottom\text{-}air}=Tch_{(max)} - Tch_{(delta)} - Ta_{(60deg.C.)}$=120-21-60=39 (deg. C.)

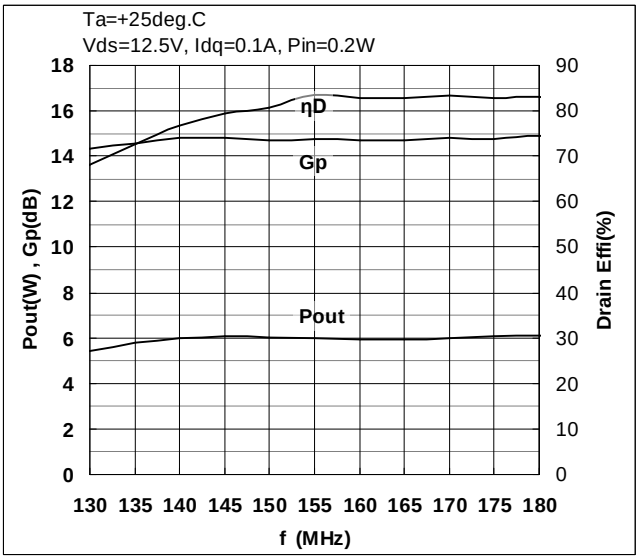
In terms of long-term reliability, operating Tch has to be kept less than 120 deg. C. i.e. $T_{Pb\ bottom\text{-}air}$ has to be less than 39 deg. C..
The thermal resistance of the heat sink to border it:
$Rth_{(Pb\ bottom\text{-}air)}=T_{Pb\ bottom\text{-}air}$/(Pout/Efficiency-Pout+Pin)=39/(4W/50%-4W+0.2)= 9.3 (deg. C./W)
Therefore
it is preferable that the thermal resistance of the heat sink is much smaller than 9.3 deg. C./W.

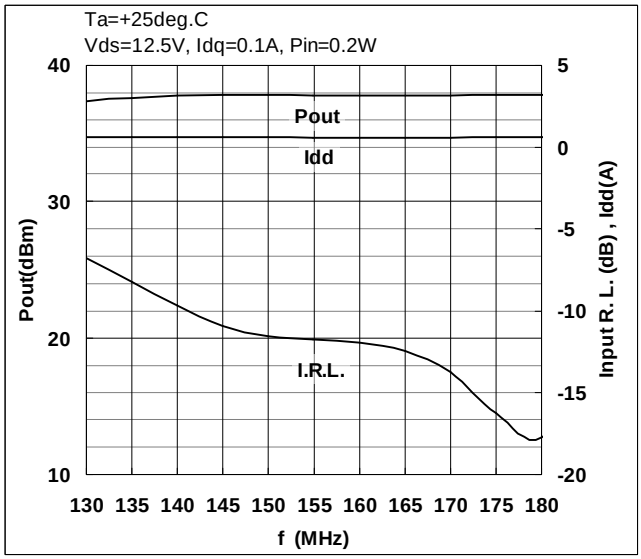
5. Typical Performance

5-1. Frequency vs.

OUTPUT POWER, POWER GAIN, DRAIN EFFICIENCY, DRAIN CURRENT and INPUT RETURN LOSS

(Vds=12.5V)



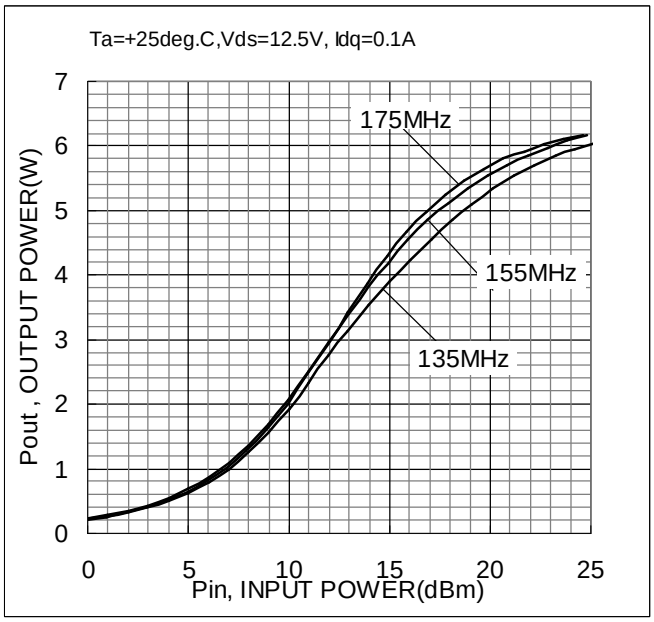


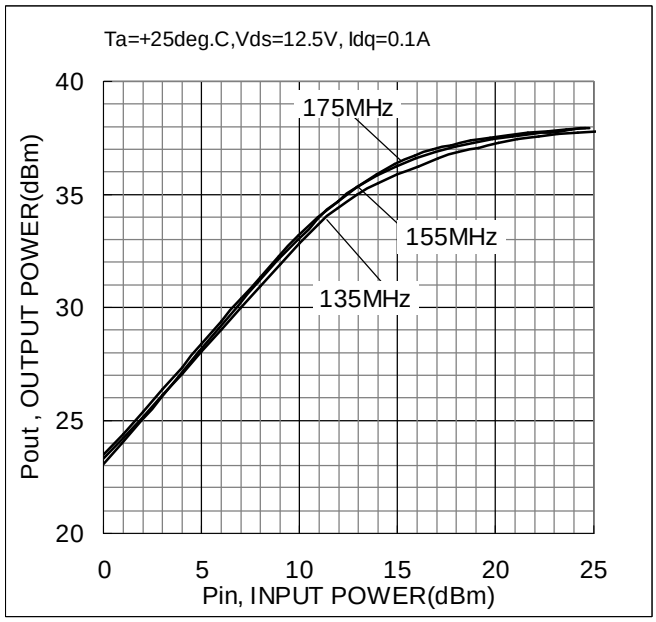
Ta=+25deg. C., Vds=12.5V, Idq=0.1A, Pin=0.2W

Freq.	Vgg	Pin		Pout		Gp	ID(RF)	ηadd	ηD	I.R.L.
(MHz)	(V)	(dBm)	(W)	(dBm)	(W)	(dB)	(A)	(%)	(%)	(dB)
130	2.66	23.0	0.2	37.4	5.4	14.3	0.64	65.6	68.1	-6.8
135	2.66	23.1	0.2	37.6	5.8	14.6	0.64	70.1	72.7	-8.2
140	2.66	23.0	0.2	37.8	6.0	14.8	0.63	74.2	76.8	-9.7
145	2.66	23.0	0.2	37.8	6.1	14.8	0.61	76.7	79.4	-10.9
150	2.66	23.1	0.2	37.8	6.1	14.7	0.60	78.0	80.7	-11.6
155	2.66	23.0	0.2	37.8	6.0	14.7	0.58	80.6	83.4	-11.8
160	2.66	23.0	0.2	37.8	6.0	14.7	0.58	80.1	82.9	-11.9
165	2.66	23.1	0.2	37.8	6.0	14.7	0.58	80.1	82.9	-12.5
170	2.66	23.0	0.2	37.8	6.0	14.8	0.58	80.5	83.3	-13.8
175	2.66	23.1	0.2	37.8	6.1	14.8	0.59	80.0	82.7	-16.3
180	2.66	23.0	0.2	37.9	6.1	14.9	0.59	80.4	83.1	-17.7

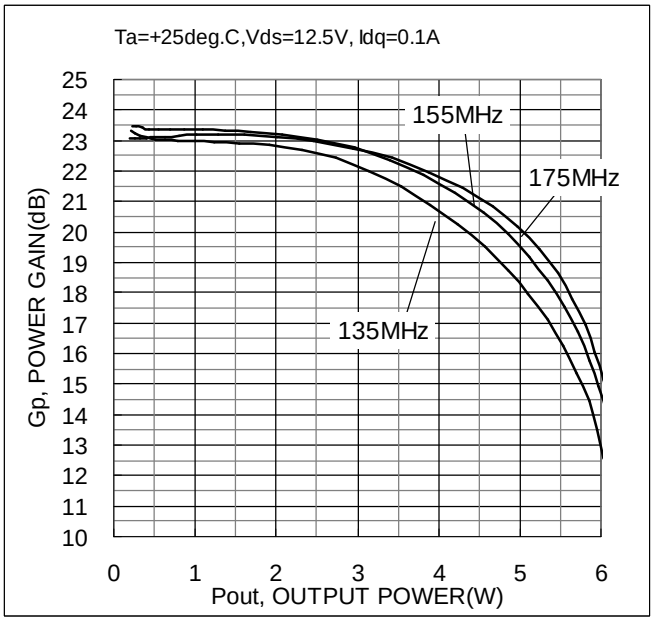
5-2. RF Power vs.

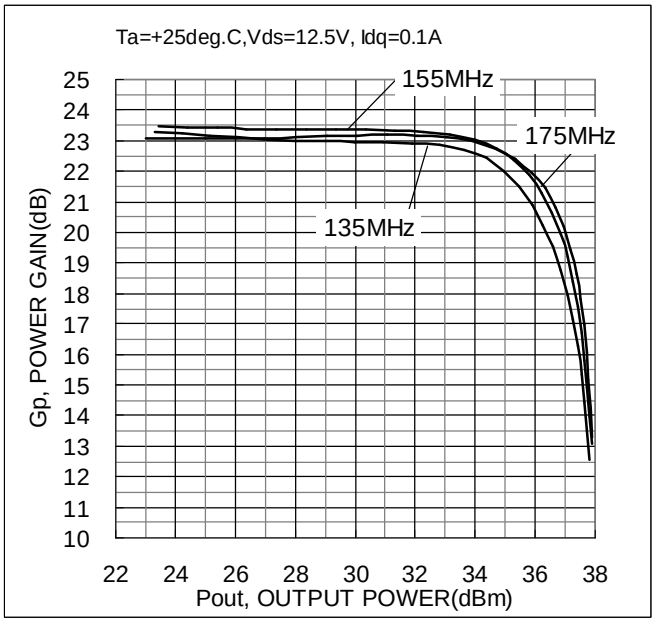
INPUT POWER (Vds=12.5V)



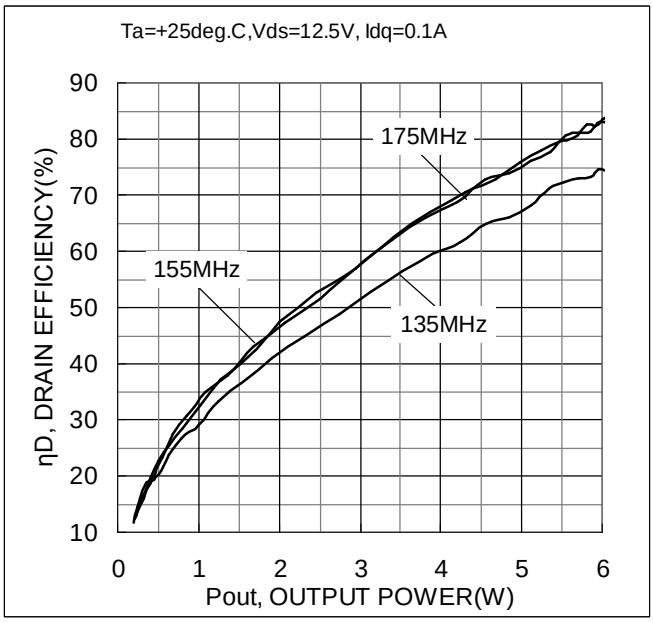


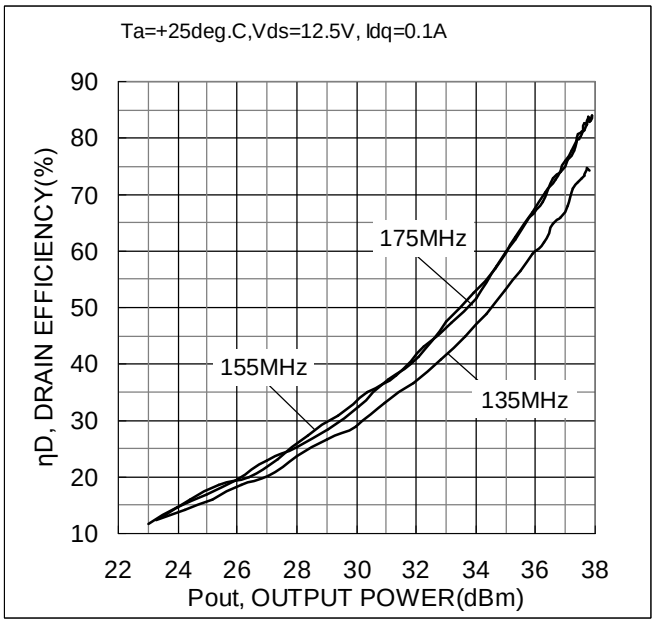
POWER GAIN (Vds=12.5V)



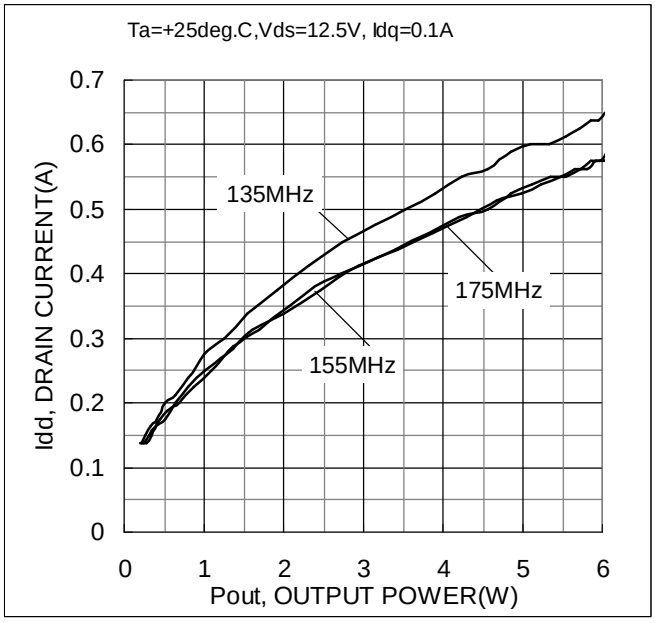


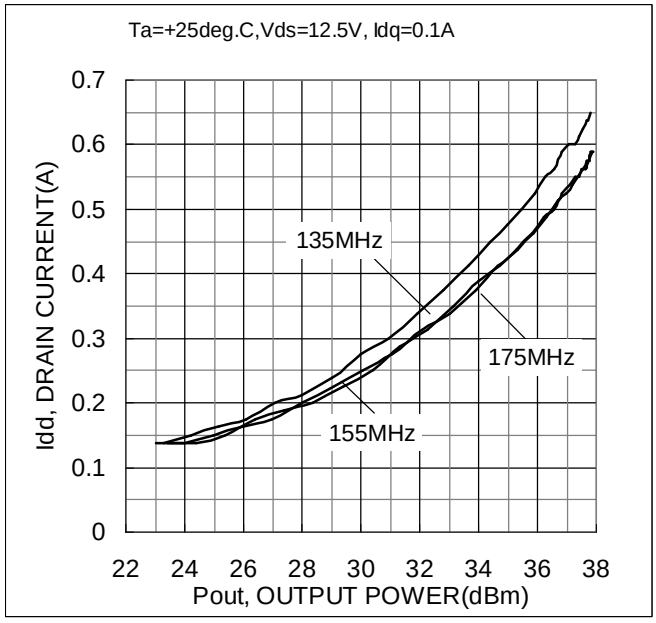
DRAIN EFFICIENCY (Vds=12.5V)



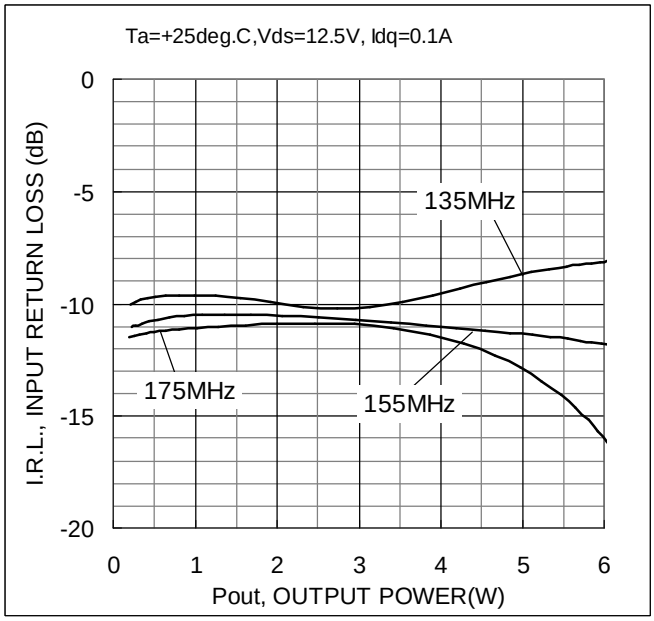


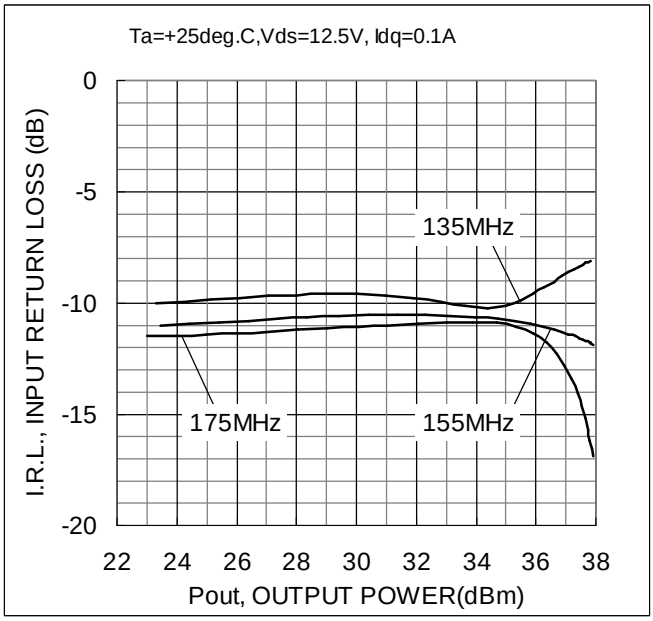
DRAIN CURRENT (Vds=12.5V)





INPUT RETURN LOSS (Vds=12.5V)





Ta=+25deg. C., Vds=12.5V, Idq=0.1A

135MHz	Vgg	Pin		Pout		Gp	ID(RF)	ηadd	ηD	I.R.L.
	(V)	(dBm)	(W)	(dBm)	(W)	(dB)	(A)	(%)	(%)	(dB)
	2.66	0.0	0.00	23.3	0.2	23.3	0.14	12.3	12.4	-10.0
	2.66	1.0	0.00	24.2	0.3	23.2	0.15	14.1	14.1	-9.9
	2.66	2.0	0.00	25.2	0.3	23.2	0.16	16.0	16.1	-9.8
	2.66	3.0	0.00	26.1	0.4	23.1	0.18	18.6	18.7	-9.7
	2.66	4.0	0.00	27.1	0.5	23.0	0.20	20.2	20.3	-9.7
	2.66	5.0	0.00	28.0	0.6	23.0	0.21	23.6	23.8	-9.6
	2.66	6.0	0.00	29.0	0.8	23.0	0.24	26.6	26.8	-9.6
	2.66	7.0	0.01	30.0	1.0	23.0	0.28	28.8	29.0	-9.6
	2.66	8.0	0.01	31.0	1.2	22.9	0.30	33.0	33.2	-9.6
	2.66	9.0	0.01	31.9	1.5	22.9	0.34	36.5	36.7	-9.7
	2.66	10.0	0.01	32.8	1.9	22.8	0.38	40.6	40.8	-9.9
	2.66	11.0	0.01	33.7	2.3	22.7	0.41	44.6	44.9	-10.1
	2.66	11.9	0.02	34.4	2.7	22.4	0.45	48.5	48.7	-10.2
	2.66	12.9	0.02	35.0	3.1	22.0	0.48	52.6	52.9	-10.1
	2.66	14.0	0.03	35.5	3.5	21.5	0.50	56.1	56.5	-9.9
	2.66	15.0	0.03	35.9	3.9	20.9	0.53	58.9	59.4	-9.6
	2.66	16.0	0.04	36.3	4.2	20.2	0.55	61.0	61.6	-9.3
	2.66	17.1	0.05	36.6	4.6	19.5	0.56	64.1	64.8	-9.0
	2.66	18.1	0.06	36.9	4.9	18.8	0.59	65.1	66.0	-8.8
	2.66	19.1	0.08	37.1	5.1	18.0	0.60	67.0	68.1	-8.6
	2.66	20.1	0.10	37.3	5.3	17.1	0.60	69.7	71.1	-8.5
	2.66	21.2	0.13	37.4	5.5	16.3	0.61	70.5	72.2	-8.3
	2.66	22.2	0.17	37.6	5.7	15.3	0.63	70.8	73.0	-8.3
	2.66	23.2	0.21	37.7	5.8	14.4	0.64	70.7	73.3	-8.2
	2.66	24.2	0.26	37.8	6.0	13.5	0.64	71.4	74.7	-8.1
	2.66	25.2	0.33	37.8	6.0	12.6	0.65	70.2	74.3	-8.1

155MHz

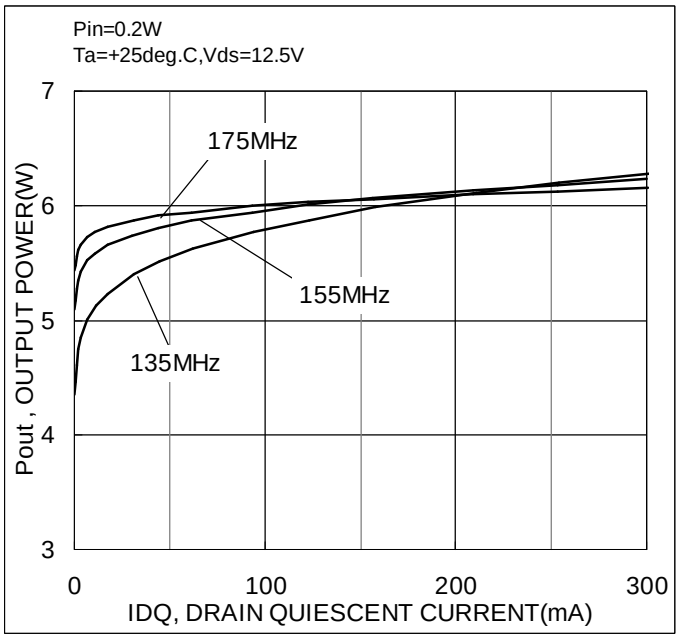
Vgg	Pin		Pout		Gp	ID(RF)	ηadd	ηD	I.R.L.
(V)	(dBm)	(W)	(dBm)	(W)	(dB)	(A)	(%)	(%)	(dB)
2.66	0.0	0.00	23.4	0.2	23.5	0.14	12.7	12.8	-11.0
2.66	1.0	0.00	24.4	0.3	23.4	0.14	15.9	16.0	-11.0
2.66	2.0	0.00	25.4	0.3	23.4	0.15	18.4	18.5	-10.9
2.66	3.0	0.00	26.4	0.4	23.4	0.18	19.8	19.9	-10.8
2.66	4.0	0.00	27.4	0.5	23.4	0.19	23.1	23.2	-10.7
2.66	5.0	0.00	28.4	0.7	23.4	0.20	27.3	27.4	-10.6
2.66	6.0	0.00	29.4	0.9	23.4	0.23	30.6	30.8	-10.6
2.66	7.0	0.01	30.4	1.1	23.4	0.25	34.8	34.9	-10.5
2.66	8.0	0.01	31.4	1.4	23.3	0.29	37.7	37.9	-10.5
2.66	9.0	0.01	32.3	1.7	23.3	0.31	42.9	43.1	-10.5
2.66	10.0	0.01	33.2	2.1	23.2	0.35	47.1	47.3	-10.6
2.66	11.0	0.01	34.0	2.5	23.0	0.39	51.4	51.7	-10.6
2.66	12.0	0.02	34.7	3.0	22.8	0.41	57.0	57.3	-10.7
2.66	13.0	0.02	35.3	3.4	22.4	0.44	61.7	62.0	-10.8
2.66	14.0	0.02	35.8	3.8	21.9	0.46	65.6	66.0	-11.0
2.66	14.9	0.03	36.2	4.2	21.3	0.49	68.3	68.8	-11.1
2.66	15.9	0.04	36.6	4.5	20.6	0.50	72.2	72.8	-11.2
2.66	16.9	0.05	36.9	4.9	19.9	0.53	73.2	73.9	-11.3
2.66	17.9	0.06	37.1	5.1	19.2	0.54	75.2	76.1	-11.4
2.66	18.9	0.08	37.3	5.3	18.4	0.55	76.6	77.8	-11.5
2.66	19.9	0.10	37.4	5.5	17.6	0.55	79.3	80.7	-11.6
2.66	20.9	0.12	37.6	5.7	16.7	0.56	79.5	81.2	-11.6
2.66	21.9	0.15	37.7	5.8	15.8	0.58	79.2	81.4	-11.7
2.66	22.8	0.19	37.8	6.0	14.9	0.58	80.4	83.1	-11.8
2.66	23.8	0.24	37.8	6.1	14.0	0.59	79.4	82.7	-11.8
2.66	24.8	0.30	37.9	6.2	13.1	0.59	79.8	83.9	-11.9

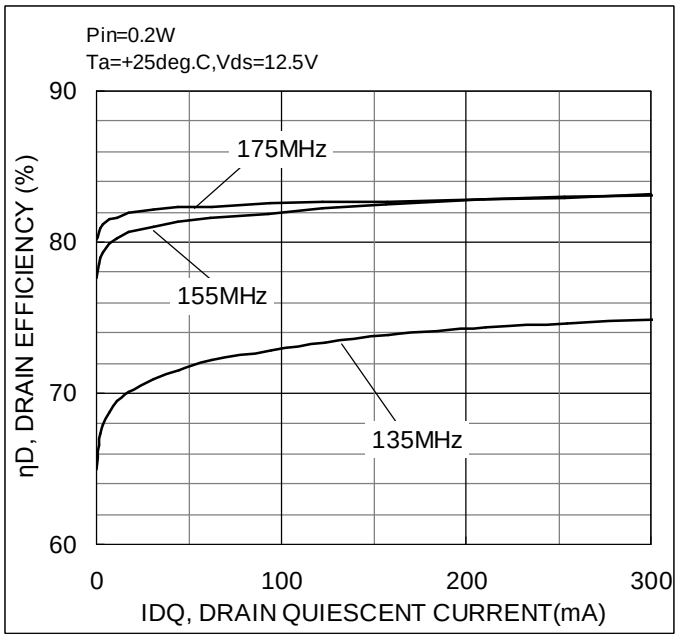
175MHz

Vgg	Pin		Pout		Gp	ID(RF)	ηadd	ηD	I.R.L.
(V)	(dBm)	(W)	(dBm)	(W)	(dB)	(A)	(%)	(%)	(dB)
2.66	-0.1	0.00	23.0	0.2	23.1	0.14	11.5	11.6	-11.5
2.66	0.9	0.00	24.0	0.3	23.1	0.14	14.5	14.5	-11.4
2.66	1.9	0.00	25.0	0.3	23.1	0.15	16.7	16.8	-11.4
2.66	2.9	0.00	26.0	0.4	23.1	0.16	19.4	19.5	-11.3
2.66	3.9	0.00	27.0	0.5	23.1	0.18	22.7	22.9	-11.3
2.66	4.9	0.00	28.0	0.6	23.1	0.20	25.2	25.4	-11.2
2.66	5.9	0.00	29.1	0.8	23.2	0.23	28.4	28.6	-11.1
2.66	6.9	0.00	30.1	1.0	23.2	0.25	32.4	32.5	-11.1
2.66	7.9	0.01	31.1	1.3	23.2	0.28	37.0	37.2	-11.0
2.66	8.9	0.01	32.1	1.6	23.2	0.31	41.0	41.2	-11.0
2.66	9.9	0.01	33.0	2.0	23.1	0.34	47.2	47.4	-10.9
2.66	10.9	0.01	33.9	2.5	23.0	0.38	52.2	52.5	-10.9
2.66	11.9	0.02	34.7	2.9	22.7	0.41	56.6	56.9	-10.9
2.66	12.9	0.02	35.3	3.4	22.4	0.44	62.1	62.5	-11.1
2.66	13.9	0.02	35.9	3.9	22.0	0.46	66.5	66.9	-11.4
2.66	14.9	0.03	36.3	4.3	21.4	0.49	69.9	70.4	-11.8
2.66	15.9	0.04	36.7	4.7	20.8	0.51	72.2	72.8	-12.3
2.66	16.8	0.05	37.0	5.0	20.2	0.53	75.1	75.8	-12.8
2.66	17.8	0.06	37.2	5.2	19.4	0.54	77.0	77.9	-13.4
2.66	18.7	0.07	37.4	5.5	18.6	0.55	78.5	79.6	-14.0
2.66	19.7	0.09	37.5	5.6	17.8	0.56	78.9	80.3	-14.6
2.66	20.7	0.12	37.6	5.8	17.0	0.56	80.9	82.5	-15.2
2.66	21.7	0.15	37.7	5.9	16.1	0.58	80.3	82.3	-15.7
2.66	22.6	0.18	37.8	6.0	15.2	0.58	81.3	83.8	-16.2
2.66	23.6	0.23	37.9	6.1	14.2	0.59	80.0	83.1	-16.5
2.66	24.6	0.29	37.9	6.2	13.3	0.59	80.0	83.9	-16.9

5-3. Drain Quiescent Current vs.

OUTPUT POWER and DRAIN EFFICIENCY (Vds=12.5V)





Ta=+25deg. C., Vds=12.5V, Pin=0.2W

135MHz	Vgg	Idq	Pin		Pout		Idd	ηD	ηadd	Gain	I.R.L.
	(V)	(mA)	(dBm)	(W)	(dBm)	(W)	(A)	(%)	(%)	(dB)	(dB)
	2.10	0.3	23.0	0.2	36.4	4.4	0.54	65.0	62.0	13.4	-8.8
	2.15	0.5	23.0	0.2	36.5	4.5	0.54	65.7	62.8	13.5	-8.8
	2.21	1.3	23.0	0.2	36.6	4.6	0.55	66.6	63.7	13.7	-8.8
	2.25	2.2	23.0	0.2	36.8	4.7	0.56	67.4	64.5	13.7	-8.9
	2.30	3.7	23.0	0.2	36.9	4.9	0.57	68.0	65.2	13.8	-8.9
	2.36	6.9	23.0	0.2	37.0	5.0	0.58	68.8	66.0	14.0	-8.9
	2.40	11.3	23.0	0.2	37.1	5.1	0.59	69.5	66.8	14.1	-8.9
	2.45	17.8	23.0	0.2	37.2	5.2	0.60	70.1	67.4	14.2	-8.9
	2.51	31.1	23.0	0.2	37.3	5.4	0.61	71.0	68.3	14.3	-9.0
	2.55	44.7	23.0	0.2	37.4	5.5	0.62	71.6	69.0	14.4	-9.0
	2.60	62.4	23.0	0.2	37.5	5.6	0.62	72.2	69.6	14.5	-9.0
	2.66	94.1	23.0	0.2	37.6	5.8	0.63	72.9	70.3	14.6	-9.0
	2.70	123.5	23.0	0.2	37.7	5.9	0.64	73.3	70.8	14.7	-9.0
	2.75	158.0	23.0	0.2	37.8	6.0	0.65	73.9	71.4	14.8	-9.1
	2.81	210.4	23.0	0.2	37.9	6.1	0.66	74.3	71.9	14.9	-9.1
	2.85	254.3	23.0	0.2	37.9	6.2	0.66	74.6	72.2	14.9	-9.1
	2.90	301.3	23.0	0.2	38.0	6.3	0.67	74.9	72.5	15.0	-9.1

155MHz

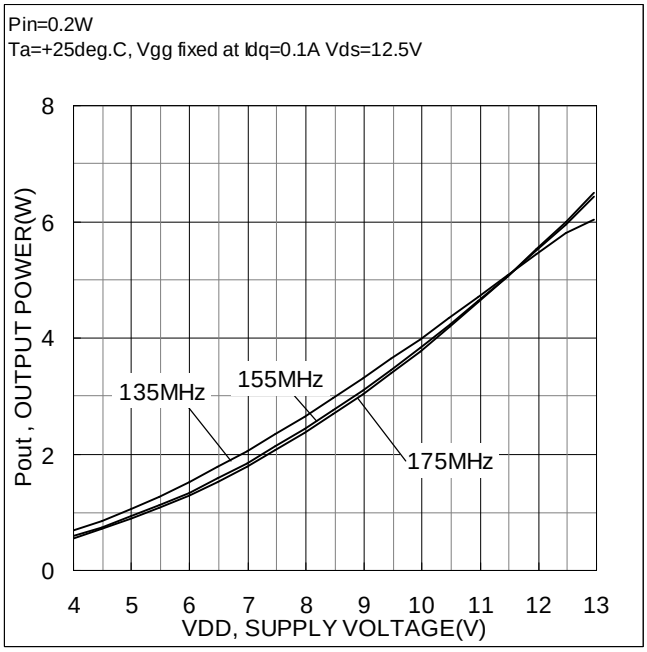
Vgg (V)	Idq (mA)	Pin (dBm)	Pin (W)	Pout (dBm)	Pout (W)	Idd (A)	ηD (%)	ηadd (%)	Gain (dB)	I.R.L. (dB)
2.10	0.2	23.0	0.2	37.1	5.1	0.52	77.6	74.6	14.1	-10.2
2.15	0.5	23.0	0.2	37.1	5.2	0.53	78.1	75.1	14.1	-10.2
2.21	1.3	23.0	0.2	37.2	5.3	0.54	78.6	75.6	14.2	-10.2
2.25	2.2	23.0	0.2	37.3	5.3	0.54	78.9	76.0	14.3	-10.2
2.30	3.6	23.0	0.2	37.3	5.4	0.55	79.3	76.4	14.3	-10.2
2.36	6.8	23.0	0.2	37.4	5.5	0.55	79.9	77.0	14.4	-10.2
2.40	11.1	23.0	0.2	37.5	5.6	0.56	80.2	77.4	14.5	-10.2
2.45	17.6	23.0	0.2	37.5	5.7	0.56	80.7	77.8	14.5	-10.2
2.51	30.8	23.0	0.2	37.6	5.7	0.57	81.0	78.2	14.6	-10.2
2.55	44.1	23.0	0.2	37.6	5.8	0.57	81.3	78.6	14.7	-10.2
2.60	61.7	23.0	0.2	37.7	5.9	0.58	81.6	78.8	14.7	-10.2
2.66	93.2	23.0	0.2	37.7	5.9	0.58	81.9	79.1	14.7	-10.3
2.70	122.4	23.0	0.2	37.8	6.0	0.58	82.3	79.5	14.8	-10.3
2.75	156.7	23.0	0.2	37.8	6.1	0.59	82.5	79.8	14.8	-10.3
2.81	209.3	23.0	0.2	37.9	6.1	0.59	82.8	80.1	14.9	-10.3
2.85	252.9	23.0	0.2	37.9	6.2	0.60	82.9	80.2	14.9	-10.3
2.90	300.0	23.0	0.2	38.0	6.2	0.60	83.2	80.5	14.9	-10.3

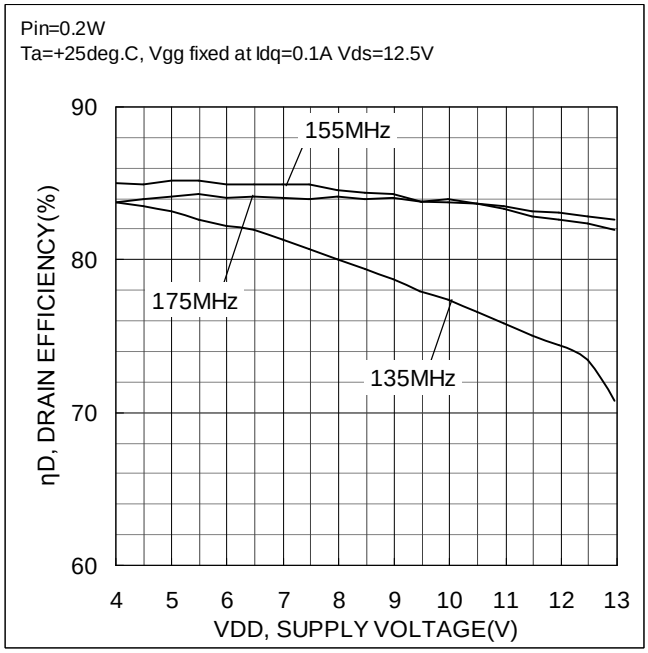
175MHz

Vgg (V)	Idq (mA)	Pin (dBm)	Pin (W)	Pout (dBm)	Pout (W)	Idd (A)	ηD (%)	ηadd (%)	Gain (dB)	I.R.L. (dB)
2.10	0.2	23.0	0.2	37.4	5.4	0.54	80.2	77.2	14.3	-9.7
2.15	0.4	23.0	0.2	37.4	5.5	0.55	80.4	77.5	14.4	-9.8
2.21	1.1	23.0	0.2	37.5	5.6	0.55	80.7	77.8	14.4	-9.8
2.25	2.1	23.0	0.2	37.5	5.6	0.55	81.0	78.1	14.5	-9.8
2.30	3.5	23.0	0.2	37.5	5.7	0.56	81.2	78.4	14.5	-9.8
2.36	6.9	23.0	0.2	37.6	5.7	0.56	81.5	78.7	14.6	-9.8
2.40	11.1	23.0	0.2	37.6	5.8	0.56	81.6	78.8	14.6	-9.8
2.45	17.6	23.0	0.2	37.7	5.8	0.57	81.9	79.1	14.6	-9.8
2.51	30.8	23.0	0.2	37.7	5.9	0.57	82.1	79.3	14.7	-9.8
2.55	44.1	23.0	0.2	37.7	5.9	0.57	82.3	79.5	14.7	-9.9
2.60	61.9	23.0	0.2	37.7	5.9	0.58	82.3	79.5	14.7	-9.9
2.66	93.6	23.0	0.2	37.8	6.0	0.58	82.6	79.8	14.8	-9.9
2.70	122.7	23.0	0.2	37.8	6.0	0.58	82.6	79.9	14.8	-9.9
2.75	157.1	23.0	0.2	37.8	6.1	0.59	82.7	79.9	14.8	-9.9
2.81	209.5	23.0	0.2	37.9	6.1	0.59	82.9	80.1	14.8	-9.9
2.85	253.3	23.0	0.2	37.9	6.1	0.59	83.0	80.2	14.8	-10.0
2.90	300.5	23.0	0.2	37.9	6.2	0.59	83.1	80.4	14.9	-10.0

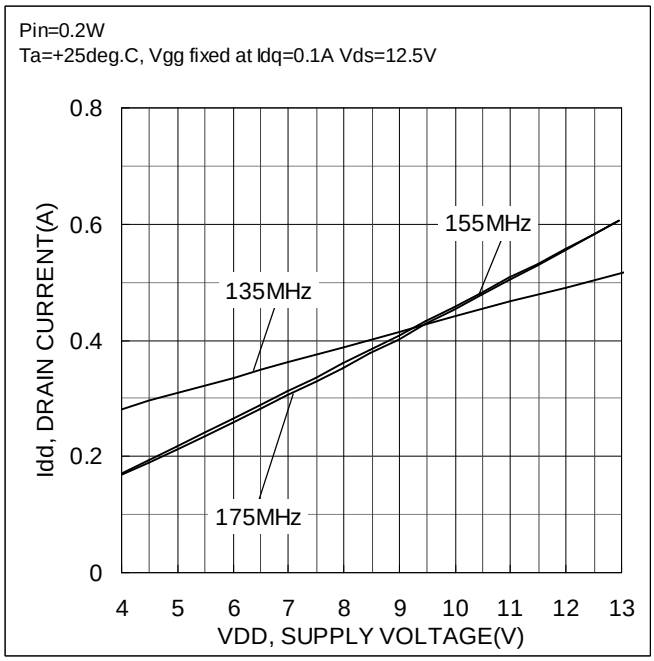
5-4. DC Power Supply vs.

OUTPUT POWER and DRAIN EFFICIENCY (Idq=0.1A)





DRAIN CURRENT (Idq=0.1A)



Ta=+25deg. C., Idq=0.1A

135MHz

Vgg (V)	Vdd (V)	Idq (mA)	Pin (dBm)	Pin (W)	Pout (dBm)	Pout (W)	Idd (A)	ηD (%)	ηadd (%)	Gain (dB)	I.R.L. (dB)
2.67	4.0	0.08	23.0	0.2	28.3	0.7	0.20	83.7	59.1	5.3	-8.8
2.67	4.5	0.08	23.0	0.2	29.3	0.9	0.23	83.5	64.0	6.3	-8.8
2.67	5.0	0.08	23.0	0.2	30.3	1.1	0.26	83.2	67.6	7.3	-8.8
2.67	5.5	0.08	23.0	0.2	31.1	1.3	0.28	82.6	69.7	8.1	-8.8
2.67	6.0	0.08	23.0	0.2	31.8	1.5	0.31	82.2	71.5	8.8	-8.9
2.67	6.5	0.08	23.0	0.2	32.5	1.8	0.34	81.9	72.8	9.5	-8.9
2.67	7.0	0.08	23.0	0.2	33.1	2.1	0.36	81.3	73.4	10.1	-8.9
2.67	7.5	0.09	23.0	0.2	33.7	2.3	0.39	80.6	73.8	10.7	-8.9
2.67	8.0	0.09	23.0	0.2	34.2	2.6	0.41	80.0	74.0	11.2	-8.9
2.67	8.5	0.09	23.0	0.2	34.7	3.0	0.44	79.4	74.0	11.7	-8.9
2.67	9.0	0.09	23.0	0.2	35.2	3.3	0.47	78.7	74.0	12.2	-9.0
2.67	9.5	0.09	23.0	0.2	35.6	3.6	0.49	78.0	73.6	12.6	-9.0
2.67	10.0	0.09	23.0	0.2	36.0	4.0	0.52	77.4	73.5	13.0	-9.0
2.67	10.5	0.10	23.0	0.2	36.4	4.3	0.54	76.5	73.0	13.4	-9.0
2.67	11.0	0.10	23.0	0.2	36.7	4.7	0.56	75.9	72.6	13.7	-9.0
2.67	11.5	0.10	23.0	0.2	37.1	5.1	0.59	75.1	72.1	14.1	-9.0
2.67	12.0	0.10	23.0	0.2	37.4	5.4	0.61	74.4	71.7	14.4	-9.0
2.67	12.5	0.10	23.0	0.2	37.6	5.8	0.63	73.5	70.9	14.6	-9.0
2.67	13.0	0.11	23.0	0.2	37.8	6.0	0.66	70.8	68.4	14.8	-9.0

155MHz

Vgg (V)	Vdd (V)	Idq (mA)	Pin (dBm)	Pin (W)	Pout (dBm)	Pout (W)	Idd (A)	ηD (%)	ηadd (%)	Gain (dB)	I.R.L. (dB)
2.67	4.0	0.08	23.0	0.2	27.7	0.6	0.17	85.0	55.8	4.6	-11.2
2.67	4.5	0.08	23.0	0.2	28.7	0.7	0.19	84.9	62.0	5.7	-11.1
2.67	5.0	0.08	23.0	0.2	29.7	0.9	0.22	85.1	66.6	6.6	-11.1
2.67	5.5	0.08	23.0	0.2	30.5	1.1	0.24	85.2	69.9	7.5	-11.1
2.67	6.0	0.08	23.0	0.2	31.3	1.3	0.26	84.9	72.2	8.3	-11.0
2.67	6.5	0.08	23.0	0.2	32.0	1.6	0.29	84.9	74.1	9.0	-11.0
2.67	7.0	0.08	23.0	0.2	32.7	1.8	0.31	84.9	75.7	9.7	-10.9
2.67	7.5	0.09	23.0	0.2	33.3	2.1	0.34	84.9	76.9	10.2	-10.9
2.67	8.0	0.09	23.0	0.2	33.9	2.4	0.36	84.6	77.6	10.8	-10.9
2.67	8.5	0.09	23.0	0.2	34.4	2.7	0.38	84.4	78.2	11.4	-10.8
2.67	9.0	0.09	23.0	0.2	34.9	3.1	0.41	84.3	78.9	11.9	-10.8
2.67	9.5	0.09	23.0	0.2	35.4	3.4	0.43	83.8	79.0	12.4	-10.7
2.67	10.0	0.09	23.0	0.2	35.8	3.8	0.46	84.0	79.6	12.9	-10.7
2.67	10.5	0.10	23.0	0.2	36.3	4.2	0.48	83.6	79.7	13.3	-10.6
2.67	11.0	0.10	23.0	0.2	36.7	4.6	0.51	83.4	79.8	13.7	-10.6
2.67	11.5	0.10	23.0	0.2	37.0	5.1	0.53	82.9	79.6	14.0	-10.5
2.67	12.0	0.10	23.0	0.2	37.4	5.5	0.56	82.6	79.6	14.4	-10.4
2.67	12.5	0.10	23.0	0.2	37.8	6.0	0.58	82.3	79.6	14.7	-10.4
2.67	13.0	0.11	23.0	0.2	38.1	6.4	0.60	82.0	79.4	15.1	-10.4

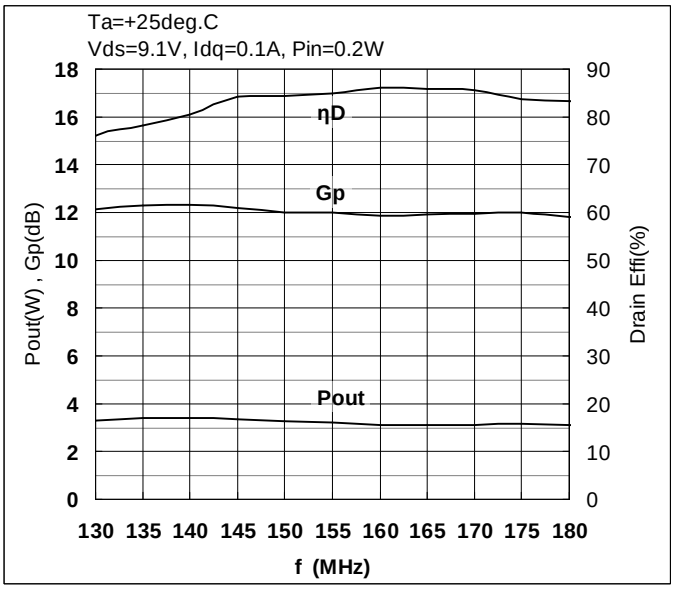
175MHz

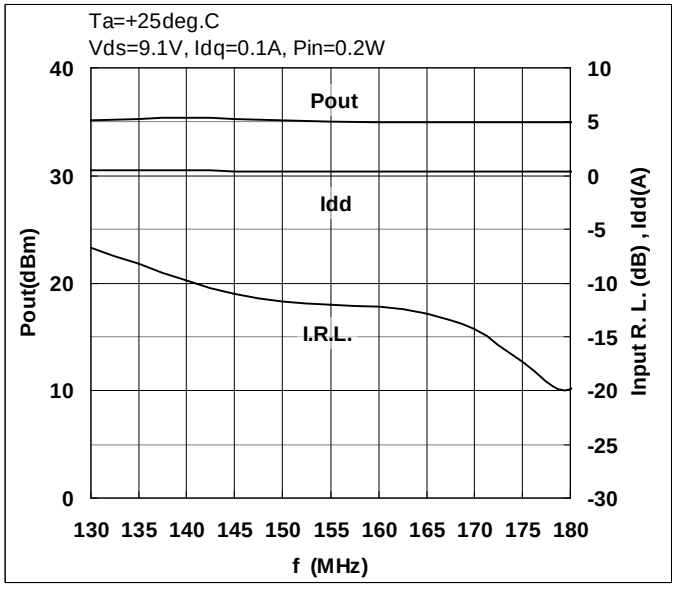
Vgg (V)	Vdd (V)	Idq (mA)	Pin (dBm)	Pin (W)	Pout (dBm)	Pout (W)	Idd (A)	ηD (%)	ηadd (%)	Gain (dB)	I.R.L. (dB)
2.67	4.0	0.08	23.0	0.2	27.5	0.6	0.17	83.7	53.7	4.4	-11.2
2.67	4.5	0.08	23.0	0.2	28.5	0.7	0.19	84.0	60.3	5.5	-11.1
2.67	5.0	0.08	23.0	0.2	29.5	0.9	0.21	84.1	65.2	6.5	-11.1
2.67	5.5	0.08	23.0	0.2	30.4	1.1	0.23	84.3	68.7	7.3	-11.1
2.67	6.0	0.08	23.0	0.2	31.1	1.3	0.26	84.0	71.0	8.1	-11.0
2.67	6.5	0.08	23.0	0.2	31.9	1.5	0.28	84.2	73.1	8.8	-11.0
2.67	7.0	0.08	23.0	0.2	32.5	1.8	0.30	84.1	74.7	9.5	-10.9
2.67	7.5	0.09	23.0	0.2	33.2	2.1	0.33	84.0	75.8	10.1	-10.9
2.67	8.0	0.09	23.0	0.2	33.7	2.4	0.35	84.1	77.0	10.7	-10.9
2.67	8.5	0.09	23.0	0.2	34.3	2.7	0.38	84.0	77.7	11.3	-10.8
2.67	9.0	0.09	23.0	0.2	34.8	3.0	0.40	84.1	78.5	11.8	-10.8
2.67	9.5	0.09	23.0	0.2	35.3	3.4	0.43	83.8	78.8	12.3	-10.7
2.67	10.0	0.09	23.0	0.2	35.8	3.8	0.45	83.7	79.3	12.7	-10.7
2.67	10.5	0.10	23.0	0.2	36.2	4.2	0.48	83.6	79.6	13.2	-10.6
2.67	11.0	0.10	23.0	0.2	36.6	4.6	0.50	83.5	79.9	13.6	-10.6
2.67	11.5	0.10	23.0	0.2	37.0	5.1	0.53	83.2	79.9	14.0	-10.5
2.67	12.0	0.10	23.0	0.2	37.4	5.5	0.56	83.1	80.1	14.4	-10.4
2.67	12.5	0.10	23.0	0.2	37.8	6.0	0.58	82.8	80.1	14.8	-10.4
2.67	13.0	0.11	23.0	0.2	38.1	6.5	0.61	82.6	80.1	15.1	-10.4

5-5. Frequency vs.

OUTPUT POWER, POWER GAIN, DRAIN EFFICIENCY, DRAIN CURRENT and INPUT RETURN LOSS

(Vds=9.1V)



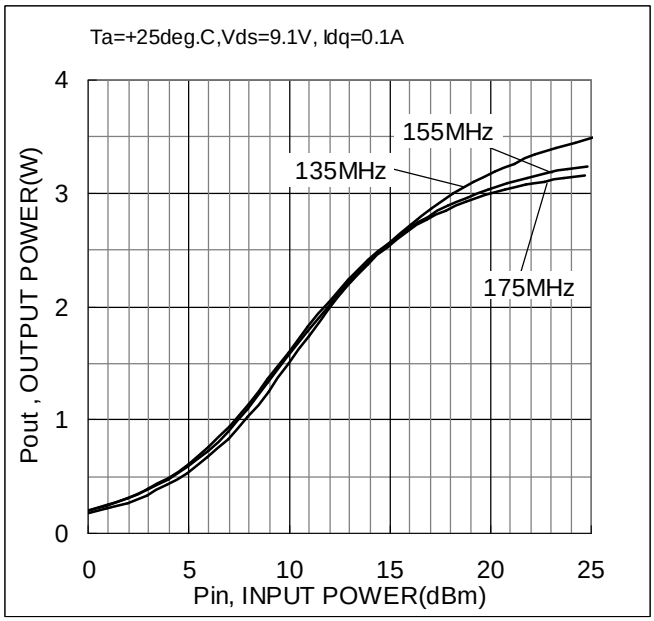


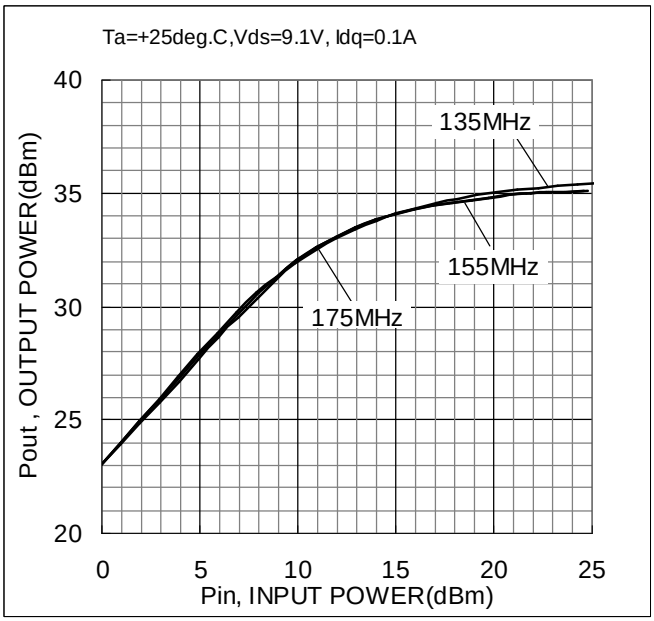
Ta=+25deg. C., Vds=9.1V, Idq=0.1A, Pin=0.2W

Freq. (MHz)	Vgg (V)	Pin (dBm)	Pin (W)	Pout (dBm)	Pout (W)	Gp (dB)	ID(RF) (A)	ηadd (%)	ηD (%)	I.R.L. (dB)
130	2.68	23.0	0.2	35.2	3.3	12.1	0.48	71.3	76.0	-6.7
135	2.68	23.0	0.2	35.3	3.4	12.3	0.48	73.5	78.1	-8.2
140	2.68	23.0	0.2	35.3	3.4	12.3	0.46	75.8	80.5	-9.7
145	2.68	23.1	0.2	35.3	3.3	12.2	0.44	79.0	84.1	-10.9
150	2.68	23.1	0.2	35.1	3.3	12.0	0.43	79.2	84.5	-11.7
155	2.68	23.1	0.2	35.0	3.2	12.0	0.41	79.6	85.0	-12.0
160	2.68	23.1	0.2	35.0	3.1	11.9	0.40	80.5	86.1	-12.3
165	2.68	23.0	0.2	34.9	3.1	11.9	0.40	80.2	85.7	-12.9
170	2.68	23.0	0.2	34.9	3.1	11.9	0.40	80.1	85.5	-14.3
175	2.68	23.0	0.2	35.0	3.1	12.0	0.41	78.3	83.6	-17.3
180	2.68	23.1	0.2	35.0	3.1	11.8	0.41	77.8	83.2	-19.9

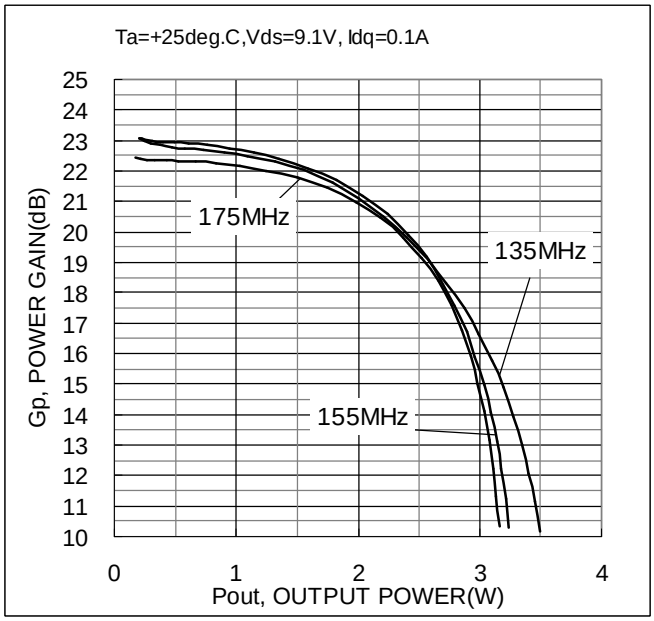
5-6. RF Power vs.

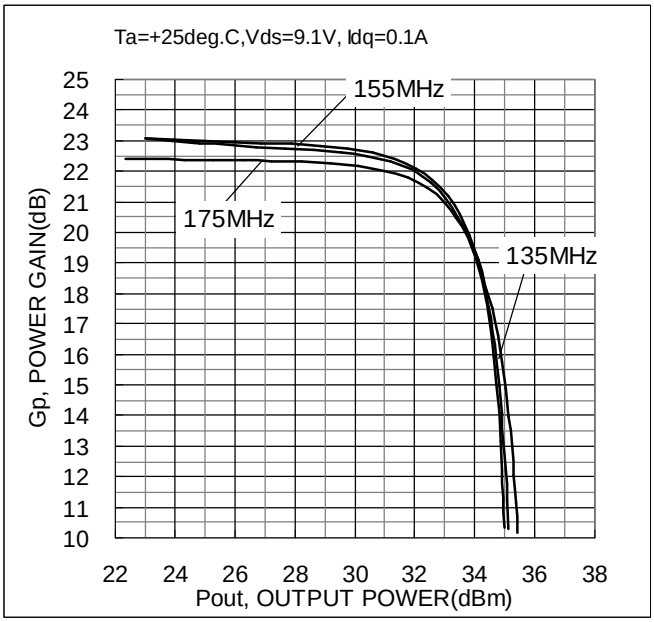
INPUT POWER (Vds=9.1V)



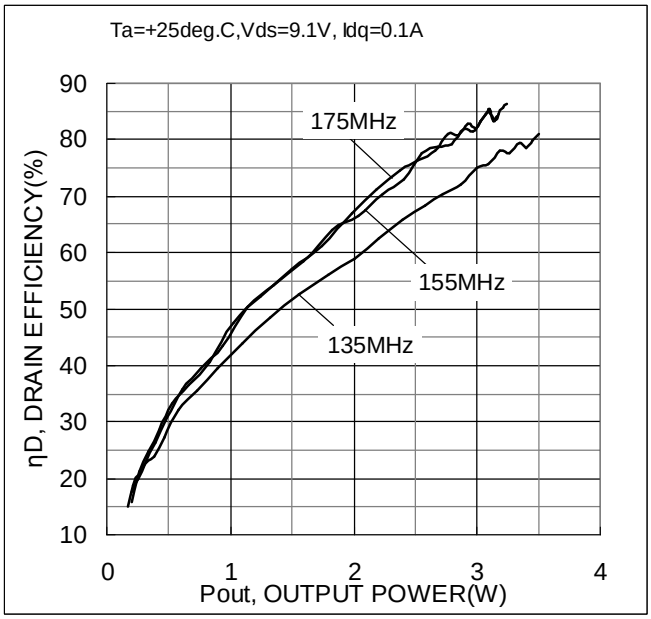


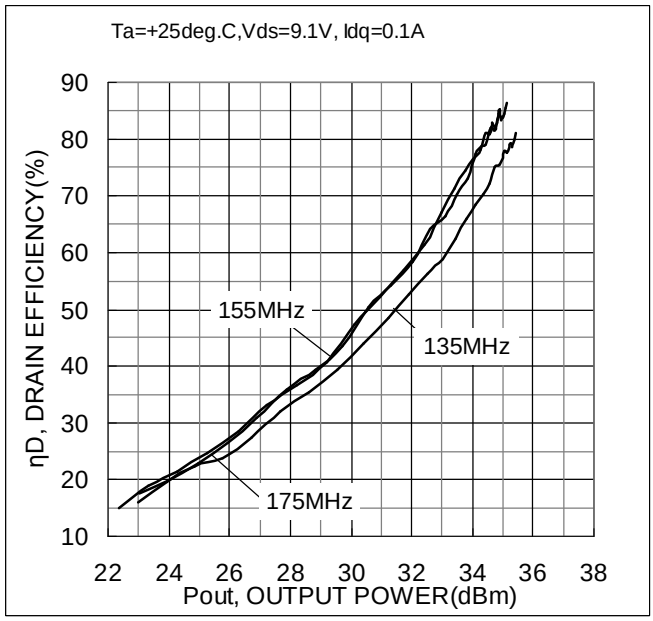
POWER GAIN (Vds=9.1V)



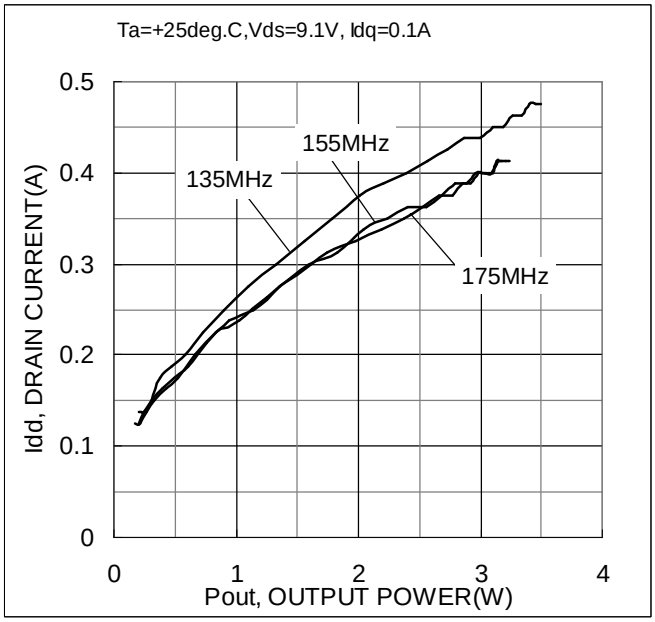


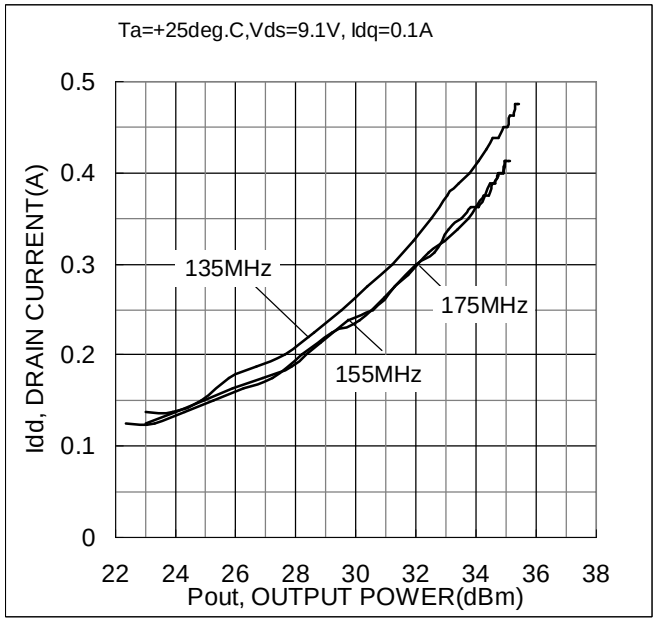
DRAIN EFFICIENCY (Vds=9.1V)



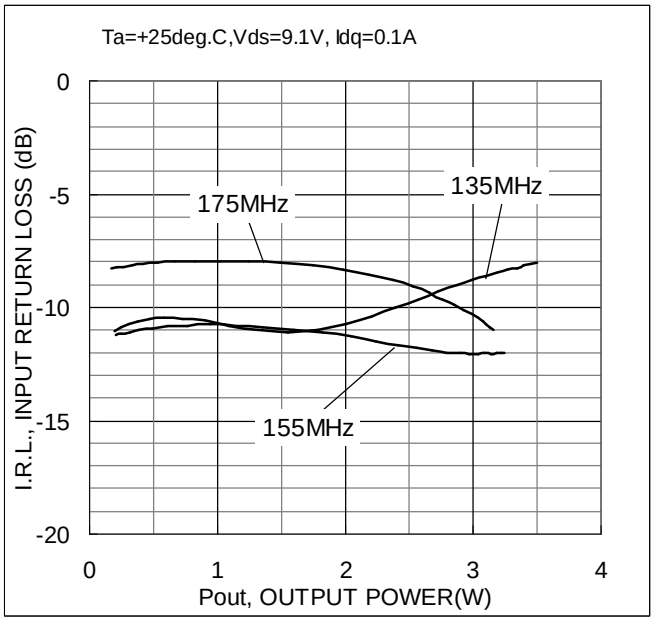


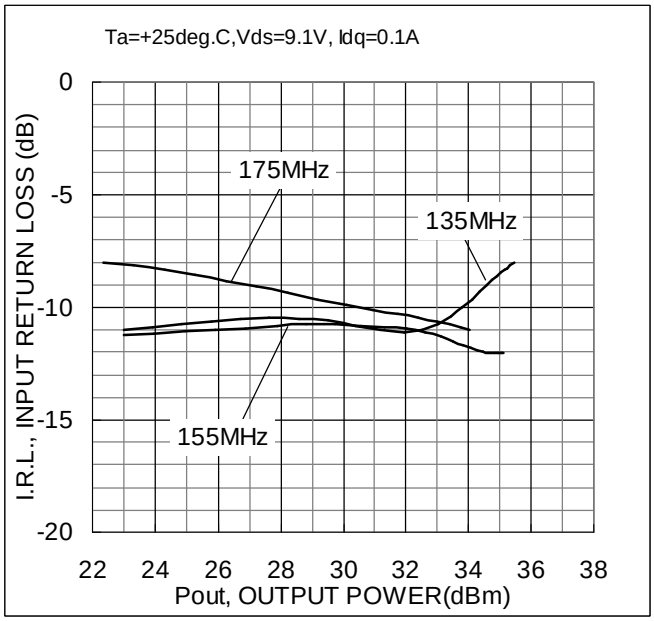
DRAIN CURRENT (Vds=9.1V)





INPUT RETURN LOSS (Vds=9.1V)





Ta=+25deg. C., Vds=9.1V, Idq=0.1A

135MHz	Vgg	Pin		Pout		Gp	ID(RF)	ηadd	ηD	I.R.L.
	(V)	(dBm)	(W)	(dBm)	(W)	(dB)	(A)	(%)	(%)	(dB)
	2.68	-0.1	0.00	23.0	0.2	23.1	0.14	11.5	11.5	-11.0
	2.68	0.9	0.00	23.9	0.2	23.0	0.14	14.3	14.3	-10.9
	2.68	1.9	0.00	24.9	0.3	22.9	0.15	16.2	16.3	-10.7
	2.68	2.9	0.00	25.8	0.4	22.8	0.18	17.3	17.3	-10.6
	2.68	3.9	0.00	26.7	0.5	22.8	0.19	19.8	19.9	-10.5
	2.68	4.9	0.00	27.7	0.6	22.7	0.20	23.2	23.3	-10.5
	2.68	5.9	0.00	28.6	0.7	22.7	0.23	25.7	25.9	-10.5
	2.68	6.9	0.00	29.5	0.9	22.6	0.25	28.6	28.7	-10.6
	2.68	7.9	0.01	30.4	1.1	22.5	0.28	31.7	31.9	-10.8
	2.68	8.9	0.01	31.2	1.3	22.3	0.30	35.0	35.2	-11.0
	2.68	9.9	0.01	31.9	1.6	22.0	0.33	38.1	38.4	-11.1
	2.68	10.9	0.01	32.5	1.8	21.6	0.35	40.6	40.9	-11.0
	2.68	11.9	0.02	33.0	2.0	21.1	0.38	42.5	42.9	-10.7
	2.68	12.9	0.02	33.4	2.2	20.5	0.39	45.1	45.5	-10.4
	2.68	14.0	0.03	33.8	2.4	19.8	0.40	47.5	48.0	-10.0
	2.68	15.0	0.03	34.1	2.6	19.1	0.41	49.2	49.8	-9.6
	2.68	16.0	0.04	34.4	2.7	18.3	0.43	50.5	51.3	-9.3
	2.68	17.1	0.05	34.6	2.9	17.5	0.44	51.5	52.4	-9.0
	2.68	18.1	0.06	34.8	3.0	16.6	0.44	53.5	54.7	-8.8
	2.68	19.1	0.08	34.9	3.1	15.8	0.45	53.6	55.1	-8.6
	2.68	20.2	0.10	35.0	3.2	14.9	0.45	54.9	56.7	-8.4
	2.68	21.2	0.13	35.1	3.3	14.0	0.46	54.2	56.4	-8.3
	2.68	22.2	0.17	35.2	3.3	13.0	0.46	54.9	57.7	-8.3
	2.68	23.2	0.21	35.3	3.4	12.1	0.48	53.6	57.2	-8.2
	2.68	24.2	0.27	35.4	3.5	11.1	0.48	53.7	58.1	-8.1
	2.68	25.3	0.34	35.4	3.5	10.2	0.48	53.3	58.9	-8.1

155MHz

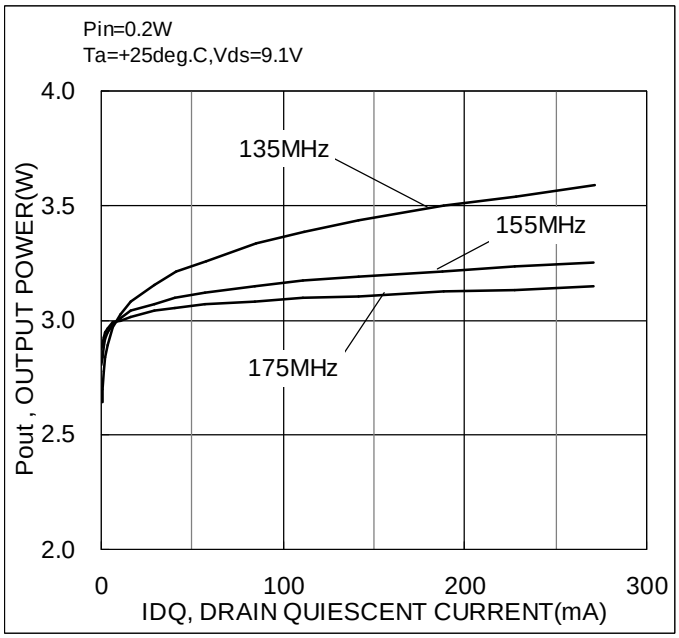
Vgg	Pin		Pout		Gp	ID(RF)	ηadd	ηD	I.R.L.
(V)	(dBm)	(W)	(dBm)	(W)	(dB)	(A)	(%)	(%)	(dB)
2.68	-0.1	0.00	23.0	0.2	23.1	0.13	12.8	12.8	-11.2
2.68	0.9	0.00	24.0	0.3	23.0	0.14	14.4	14.5	-11.1
2.68	2.0	0.00	25.0	0.3	23.0	0.15	16.6	16.7	-11.1
2.68	3.0	0.00	25.9	0.4	23.0	0.16	19.1	19.2	-11.0
2.68	4.0	0.00	26.9	0.5	22.9	0.18	22.3	22.4	-10.9
2.68	5.0	0.00	27.9	0.6	22.9	0.19	25.9	26.1	-10.8
2.68	6.0	0.00	28.8	0.8	22.8	0.21	28.5	28.7	-10.8
2.68	7.0	0.01	29.7	0.9	22.7	0.24	31.5	31.7	-10.8
2.68	8.0	0.01	30.6	1.1	22.6	0.25	36.4	36.6	-10.8
2.68	8.9	0.01	31.3	1.4	22.4	0.28	39.2	39.4	-10.9
2.68	9.9	0.01	32.0	1.6	22.1	0.30	42.2	42.5	-11.0
2.68	10.9	0.01	32.6	1.8	21.7	0.31	46.3	46.6	-11.1
2.68	11.9	0.02	33.1	2.0	21.2	0.34	48.0	48.3	-11.3
2.68	12.9	0.02	33.5	2.2	20.6	0.35	50.7	51.2	-11.5
2.68	13.9	0.02	33.8	2.4	19.9	0.36	52.6	53.1	-11.7
2.68	14.9	0.03	34.1	2.6	19.2	0.36	55.7	56.4	-11.8
2.68	15.9	0.04	34.3	2.7	18.4	0.38	56.5	57.3	-11.9
2.68	16.9	0.05	34.5	2.8	17.6	0.39	56.6	57.6	-12.0
2.68	17.9	0.06	34.6	2.9	16.7	0.39	58.3	59.6	-12.0
2.68	18.9	0.08	34.7	3.0	15.9	0.40	57.8	59.3	-12.1
2.68	19.8	0.10	34.8	3.0	15.0	0.40	58.7	60.7	-12.1
2.68	20.8	0.12	34.9	3.1	14.1	0.40	59.4	61.8	-12.0
2.68	21.8	0.15	35.0	3.1	13.1	0.41	57.9	60.8	-12.1
2.68	22.8	0.19	35.0	3.2	12.2	0.41	57.8	61.5	-12.0
2.68	23.8	0.24	35.1	3.2	11.3	0.41	57.6	62.3	-12.0
2.68	24.8	0.30	35.1	3.2	10.3	0.41	57.0	62.8	-12.0

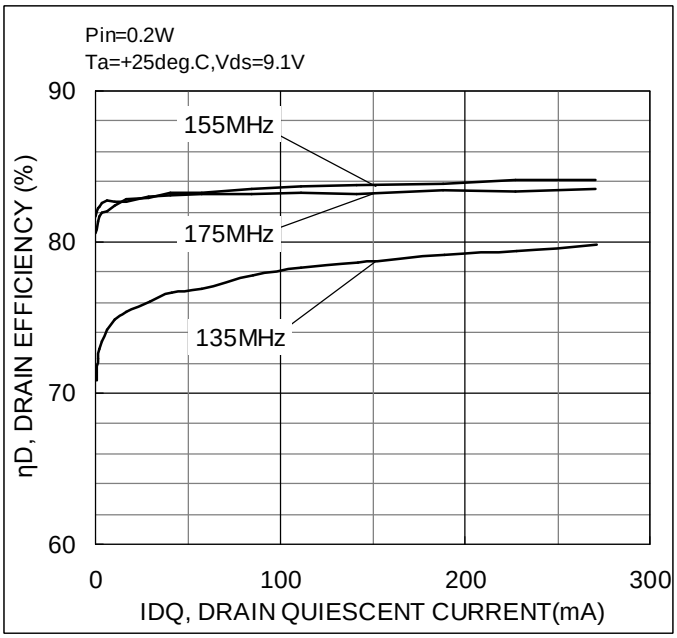
175MHz

Vgg	Pin		Pout		Gp	ID(RF)	ηadd	ηD	I.R.L.
(V)	(dBm)	(W)	(dBm)	(W)	(dB)	(A)	(%)	(%)	(dB)
2.68	-0.1	0.00	22.4	0.2	22.4	0.13	10.9	11.0	-8.3
2.68	0.9	0.00	23.3	0.2	22.4	0.13	13.6	13.7	-8.2
2.68	1.9	0.00	24.3	0.3	22.4	0.14	15.5	15.6	-8.2
2.68	2.9	0.00	25.3	0.3	22.3	0.15	17.8	17.9	-8.1
2.68	3.9	0.00	26.3	0.4	22.3	0.16	20.7	20.8	-8.1
2.68	4.9	0.00	27.2	0.5	22.3	0.18	24.0	24.2	-8.0
2.68	5.9	0.00	28.2	0.7	22.3	0.20	26.5	26.6	-8.0
2.68	6.9	0.00	29.2	0.8	22.3	0.23	29.4	29.6	-8.0
2.68	7.9	0.01	30.1	1.0	22.2	0.24	34.3	34.6	-8.0
2.68	8.9	0.01	31.0	1.2	22.0	0.26	37.7	37.9	-8.0
2.68	10.0	0.01	31.8	1.5	21.8	0.29	41.3	41.6	-8.0
2.68	11.0	0.01	32.4	1.7	21.4	0.31	44.3	44.6	-8.1
2.68	12.0	0.02	33.0	2.0	21.0	0.33	48.4	48.8	-8.3
2.68	12.9	0.02	33.4	2.2	20.5	0.34	51.3	51.8	-8.6
2.68	13.9	0.02	33.8	2.4	19.8	0.35	53.6	54.2	-8.8
2.68	14.9	0.03	34.0	2.5	19.1	0.36	54.9	55.6	-9.1
2.68	15.8	0.04	34.3	2.7	18.4	0.38	55.9	56.8	-9.4
2.68	16.8	0.05	34.4	2.8	17.6	0.38	58.0	59.0	-9.6
2.68	17.8	0.06	34.6	2.9	16.8	0.39	57.5	58.8	-9.9
2.68	18.7	0.07	34.7	2.9	15.9	0.39	58.7	60.3	-10.1
2.68	19.7	0.09	34.8	3.0	15.0	0.40	57.8	59.7	-10.3
2.68	20.7	0.12	34.8	3.0	14.1	0.40	58.3	60.7	-10.5
2.68	21.7	0.15	34.9	3.1	13.2	0.40	58.5	61.5	-10.7
2.68	22.7	0.19	34.9	3.1	12.2	0.40	58.4	62.1	-10.8
2.68	23.7	0.23	35.0	3.1	11.3	0.41	56.2	60.7	-10.9
2.68	24.6	0.29	35.0	3.2	10.4	0.41	55.6	61.3	-11.0

5-7. Drain Quiescent Current vs.

OUTPUT POWER and DRAIN EFFICIENCY (Vds=9.1V)





Ta=+25deg. C., Vds=9.1V, Pin=0.2W

135MHz	Vgg	Idq	Pin		Pout		Idd	ηD	ηadd	Gain	I.R.L.
	(V)	(mA)	(dBm)	(W)	(dBm)	(W)	(A)	(%)	(%)	(dB)	(dB)
	2.10	0.4	23.0	0.2	34.2	2.6	0.41	70.9	65.5	11.2	-8.7
	2.15	0.7	23.0	0.2	34.3	2.7	0.42	71.4	66.1	11.3	-8.8
	2.21	1.3	23.0	0.2	34.4	2.8	0.42	72.3	67.2	11.5	-8.8
	2.25	2.2	23.0	0.2	34.5	2.8	0.43	72.9	67.8	11.6	-8.8
	2.30	3.4	23.0	0.2	34.6	2.9	0.43	73.4	68.4	11.6	-8.8
	2.36	6.6	23.0	0.2	34.7	3.0	0.44	74.2	69.2	11.7	-8.8
	2.40	10.6	23.0	0.2	34.8	3.0	0.44	74.9	70.0	11.8	-8.9
	2.45	16.7	23.0	0.2	34.9	3.1	0.45	75.4	70.5	11.9	-8.9
	2.51	29.0	23.0	0.2	35.0	3.2	0.46	76.1	71.3	12.0	-8.9
	2.55	41.2	23.0	0.2	35.1	3.2	0.46	76.6	71.9	12.1	-8.9
	2.60	57.5	23.0	0.2	35.1	3.3	0.47	76.9	72.2	12.1	-8.9
	2.66	85.1	23.0	0.2	35.2	3.3	0.47	77.8	73.1	12.2	-9.0
	2.70	111.4	23.0	0.2	35.3	3.4	0.48	78.3	73.6	12.3	-9.0
	2.75	141.7	23.0	0.2	35.4	3.4	0.48	78.6	74.1	12.4	-9.0
	2.81	188.6	23.0	0.2	35.4	3.5	0.49	79.2	74.6	12.4	-9.0
	2.85	228.0	23.0	0.2	35.5	3.5	0.49	79.4	75.0	12.5	-9.0
	2.90	271.5	23.0	0.2	35.6	3.6	0.49	79.8	75.4	12.6	-9.1

155MHz

Vgg	Idq	Pin		Pout		Idd	ηD	ηadd	Gain	I.R.L.
(V)	(mA)	(dBm)	(W)	(dBm)	(W)	(A)	(%)	(%)	(dB)	(dB)
2.10	0.3	23.0	0.2	34.5	2.8	0.38	80.6	74.8	11.5	-10.4
2.15	0.6	23.0	0.2	34.5	2.8	0.39	80.8	75.1	11.5	-10.4
2.21	1.2	23.0	0.2	34.6	2.9	0.39	81.4	75.8	11.6	-10.4
2.25	2.1	23.0	0.2	34.7	2.9	0.39	81.7	76.1	11.6	-10.5
2.30	3.5	23.0	0.2	34.7	2.9	0.39	81.9	76.3	11.7	-10.5
2.36	6.6	23.0	0.2	34.7	3.0	0.40	82.1	76.6	11.7	-10.5
2.40	10.5	23.0	0.2	34.8	3.0	0.40	82.4	76.9	11.7	-10.5
2.45	16.6	23.0	0.2	34.8	3.0	0.40	82.8	77.4	11.8	-10.5
2.51	28.9	23.0	0.2	34.9	3.1	0.41	82.9	77.5	11.8	-10.5
2.55	40.8	23.0	0.2	34.9	3.1	0.41	83.2	77.8	11.9	-10.5
2.60	57.2	23.0	0.2	34.9	3.1	0.41	83.3	77.9	11.9	-10.5
2.66	84.7	23.0	0.2	35.0	3.1	0.41	83.5	78.2	12.0	-10.6
2.70	111.0	23.0	0.2	35.0	3.2	0.42	83.6	78.4	12.0	-10.6
2.75	141.2	23.0	0.2	35.0	3.2	0.42	83.8	78.5	12.0	-10.6
2.81	187.9	23.0	0.2	35.1	3.2	0.42	83.8	78.6	12.0	-10.6
2.85	227.6	23.0	0.2	35.1	3.2	0.42	84.1	78.9	12.1	-10.6
2.90	270.8	23.0	0.2	35.1	3.3	0.42	84.1	78.9	12.1	-10.6

175MHz

Vgg	Idq	Pin		Pout		Idd	ηD	ηadd	Gain	I.R.L.
(V)	(mA)	(dBm)	(W)	(dBm)	(W)	(A)	(%)	(%)	(dB)	(dB)
2.10	0.3	23.0	0.2	34.6	2.9	0.39	81.7	76.0	11.6	-10.1
2.15	0.5	23.0	0.2	34.6	2.9	0.39	82.0	76.4	11.6	-10.1
2.21	1.3	23.0	0.2	34.7	2.9	0.39	82.2	76.6	11.6	-10.2
2.25	2.2	23.0	0.2	34.7	2.9	0.39	82.3	76.7	11.7	-10.2
2.30	3.4	23.0	0.2	34.7	3.0	0.39	82.5	76.9	11.7	-10.2
2.36	6.5	23.0	0.2	34.8	3.0	0.40	82.8	77.2	11.7	-10.2
2.40	10.6	23.0	0.2	34.8	3.0	0.40	82.6	77.2	11.8	-10.2
2.45	16.6	23.0	0.2	34.8	3.0	0.40	82.7	77.2	11.8	-10.2
2.51	28.9	23.0	0.2	34.8	3.0	0.40	83.0	77.6	11.8	-10.3
2.55	40.7	23.0	0.2	34.9	3.1	0.40	83.1	77.7	11.9	-10.3
2.60	57.2	23.0	0.2	34.9	3.1	0.41	83.1	77.7	11.9	-10.3
2.66	84.5	23.0	0.2	34.9	3.1	0.41	83.2	77.8	11.9	-10.3
2.70	110.9	23.0	0.2	34.9	3.1	0.41	83.3	77.9	11.9	-10.3
2.75	141.1	23.0	0.2	34.9	3.1	0.41	83.2	77.8	11.9	-10.4
2.81	188.2	23.0	0.2	35.0	3.1	0.41	83.4	78.1	11.9	-10.4
2.85	227.4	23.0	0.2	35.0	3.1	0.41	83.3	78.0	11.9	-10.4
2.90	270.9	23.0	0.2	35.0	3.1	0.41	83.5	78.2	12.0	-10.4

6. Revision history

Revision	Change	Date
-	Initial release	30-SEP.-2010
A	P.19 DRAIN EFFICIENCY (Vds=9.1V) The writing error of prevision graph was corrected.	17-DEC.-2010