

APPLICATION NOTE

Document NO. AN-VHF-051-B

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K.Mori

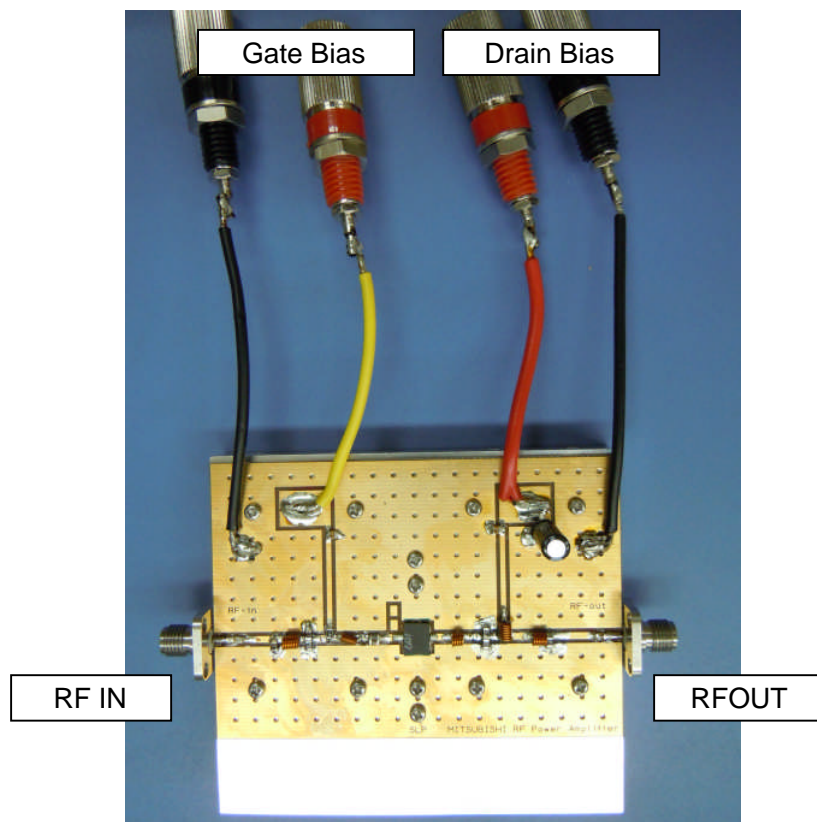
Confirmed : T.Okawa

(Taking charge of Silicon RF by
MIYOSHI Electronics)

SUBJECT: RD04HMS2 single-stage amplifier with $f=135\text{-}175\text{MHz}$ 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

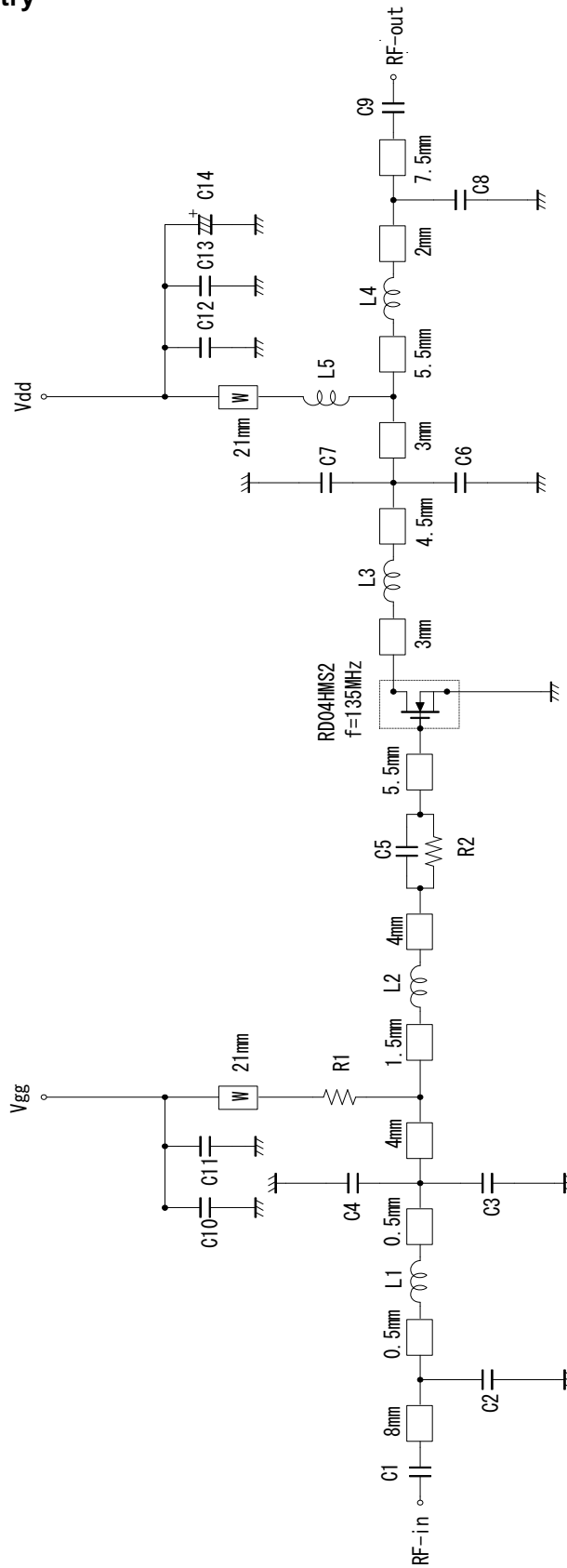


PCB L=80mm W=55mm

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1. Equivalent Circuitry



Note: Board material - Glass-Epoxy Substrate
 Micro strip line width=1.3mm/500HM, er:4.8, t=0.8mm
 W: Line width=1.0mm

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

- AN-VHF-051-B-

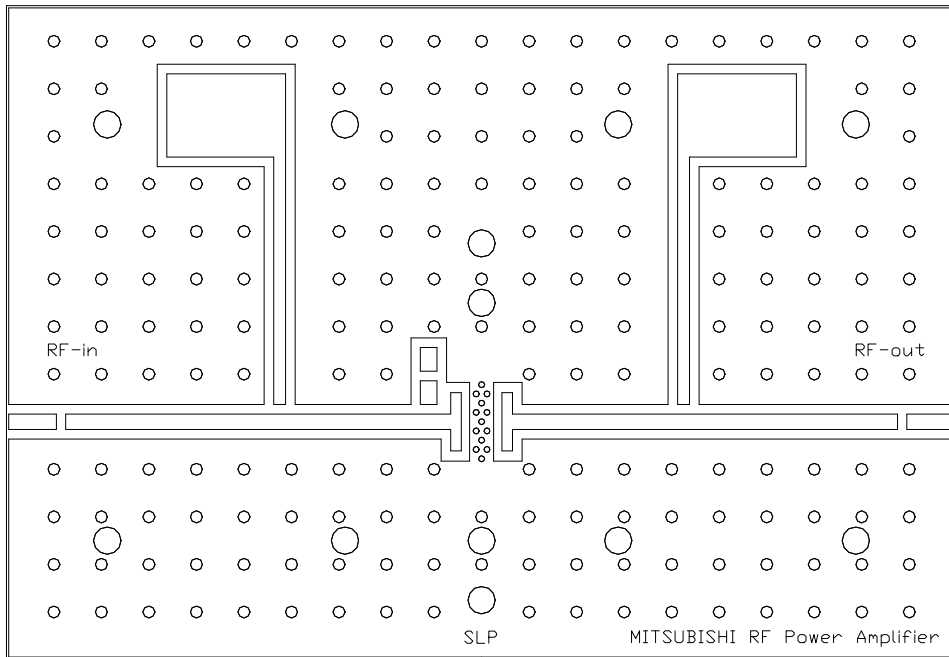
2. PCB Layout

BOARD OUTLINE: 80.0*55.0(mm)

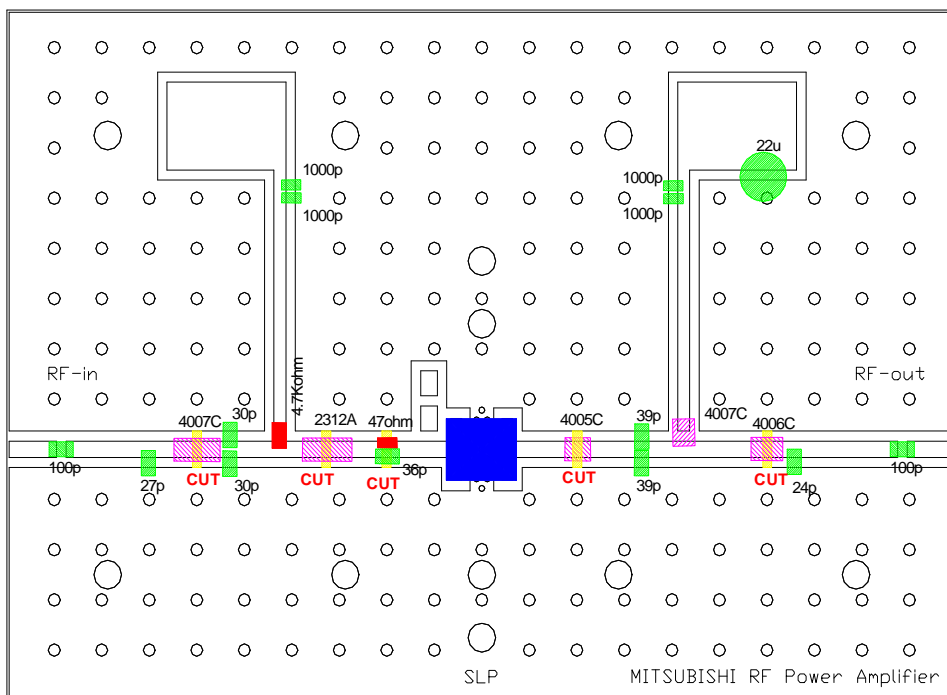
MATERIAL : FR-4<R1705>

THICKNESS : 0.8(mm)

TOP VIEW



TOP VIEW (Parts mounting)



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

- AN-VHF-051-B-

3. Component List and Standard Deliverable

- Component List

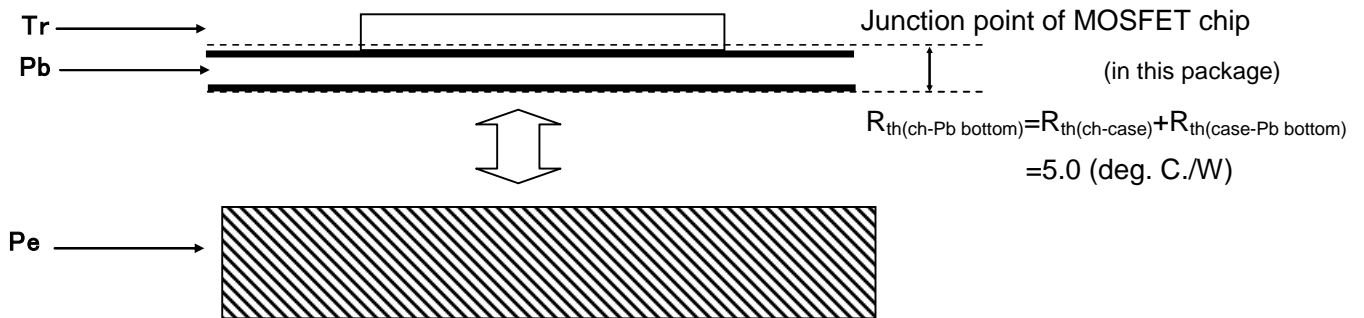
| No. | Description | P/N | Qty | Manufacturer |
|------|--|--------------------|-----|---------------------------------|
| Tr | MOSFET | RD04HMS2 | 1 | Mitsubishi Electric Corporation |
| C 1 | 100 pF 2012 50V | GRM2162C1H101JA01D | 1 | MURATA MANUFACTURING CO. |
| C 2 | 27 pF 2012 50V | GRM2162C1H270JZ01D | 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 | 37 nH * Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=7 | | 1 | YC CORPORATION Co.,Ltd. |
| L 2 | 56 nH * Diameter: Wire=0.23mm Inside=1.1mm T/N of coils=12 | | 1 | YC CORPORATION Co.,Ltd. |
| L 3 | 22 nH * Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=5 | | 1 | YC CORPORATION Co.,Ltd. |
| L 4 | 29 nH * Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=6 | | 1 | YC CORPORATION Co.,Ltd. |
| L 5 | 37 nH * Diameter: Wire=0.4mm Inside=1.6mm T/N of coils=7 | | 1 | YC CORPORATION Co.,Ltd. |
| 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 | - |

* Inductor of Rolling Coil measurement condition : f=100MHz

- Standard Deliverable

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

4. Thermal Design of Heat Sink



$$T_{ch(\Delta)} = (P_{out}/\text{Efficiency} - P_{out} + P_{in}) \times R_{th(ch-Pb\ bottom)} = (4W/50\% - 4W + 0.2) \times 5.0 = 21 \text{ (deg. C.)}$$

Also, operating T_j (" $T_{j(op)}$ ") = 120 (deg. C.), in case of RD series that $T_{ch(max)} = 150$ (deg. C.)

Therefore $T_{Pb\ bottom-air}$ as delta temperature between Pb bottom and the ambient 60 deg. C.

$$T_{Pb\ bottom-air} = "T_{j(op)}" - T_{ch(\Delta)} - T_{a(60\text{deg.C.})} = 120 - 21 - 60 = 39 \text{ (deg. C.)}$$

In terms of long-term reliability, " $T_{j(op)}$ " has to be kept less than 120 deg. C. i.e. $T_{Pb\ bottom-air}$ has to be less than 39 deg. C..

The thermal resistance of the heat sink to border it:

$$R_{th(Pb\ bottom-air)} = T_{Pb\ bottom-air} / (P_{out}/\text{Efficiency} - P_{out} + P_{in}) = 39 / (4W/50\% - 4W + 0.2) = 9.3 \text{ (deg. C./W)}$$

Therefore

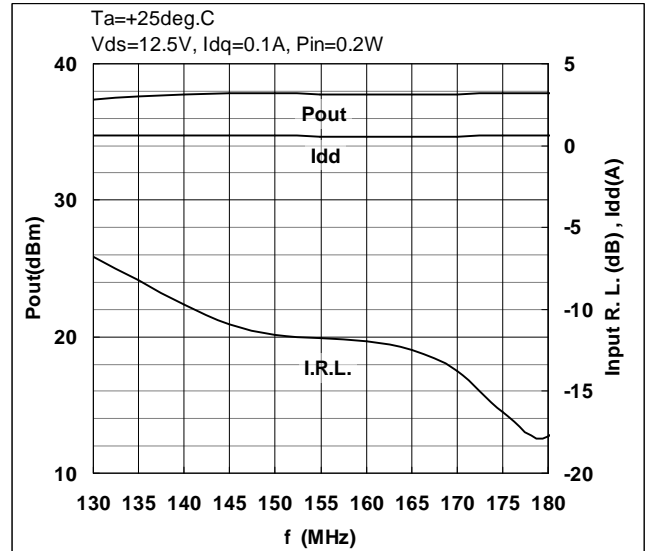
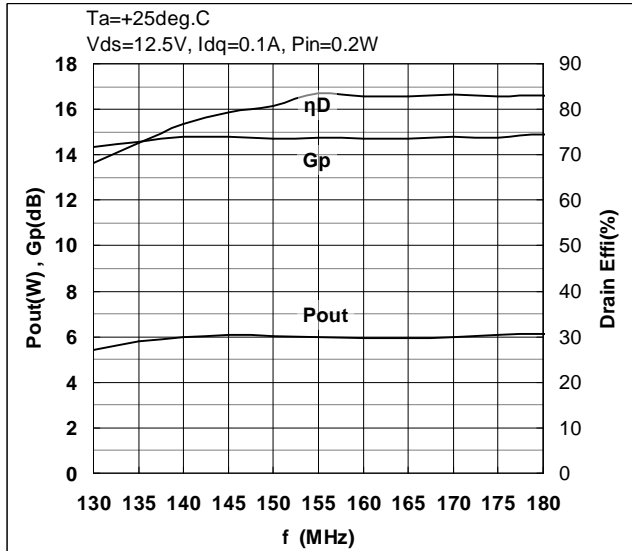
it is preferable that the thermal resistance of the heat sink is much smaller than 9.3 deg. C./W.

5. Typical Performance

5-1. Frequency vs.

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

(Vds=12.5V)

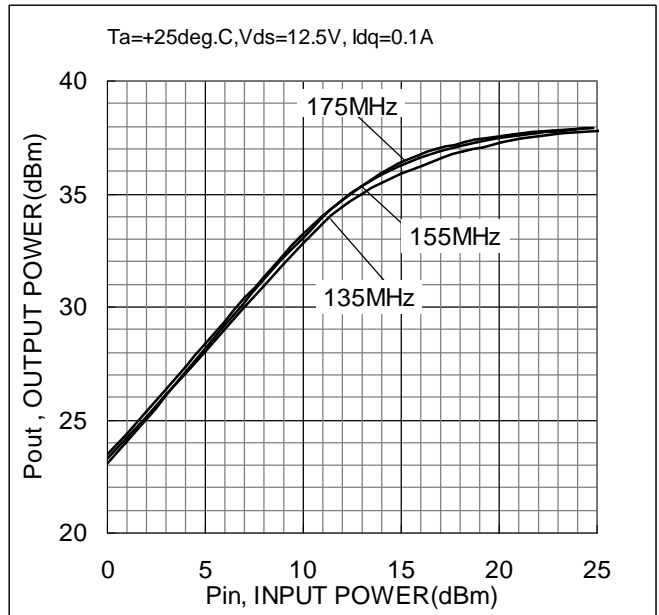
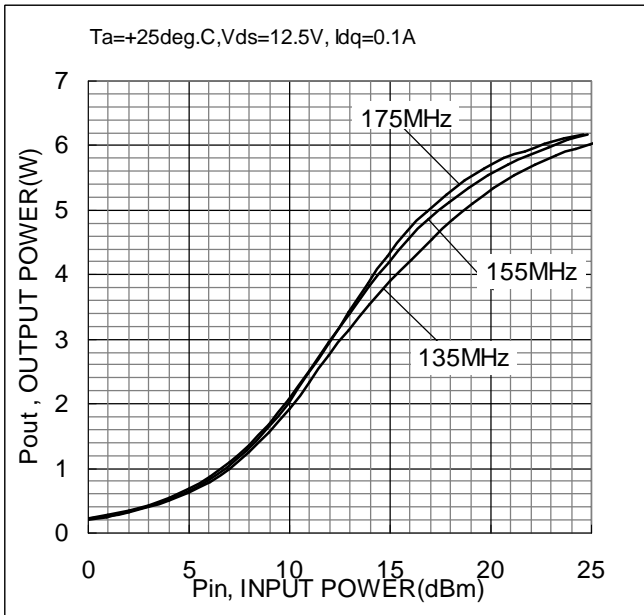


Ta=+25deg. C., Vds=12.5V, Idq=0.1A, Pin=0.2W

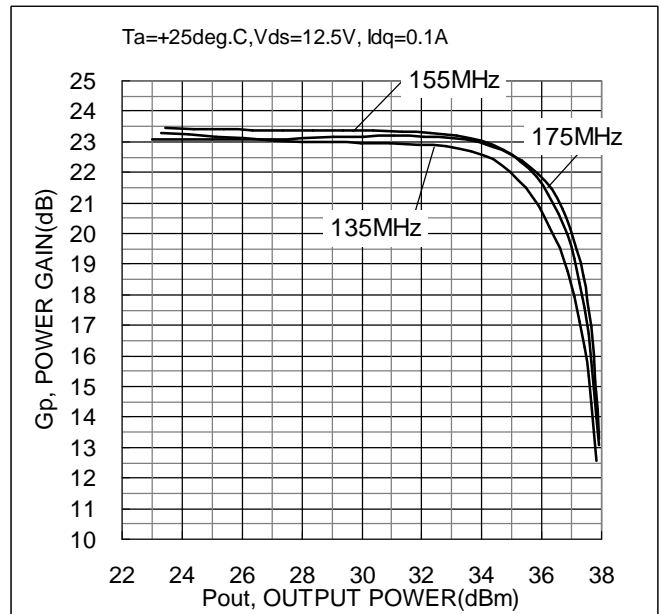
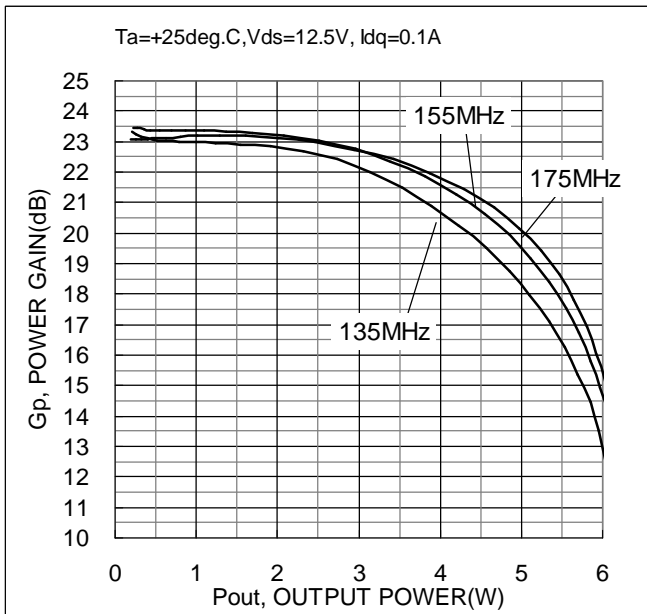
| Freq. (MHz) | Vgg (V) | Pin | | Pout | | Gp (dB) | ID(RF) (A) | ηadd (%) | ηD (%) | I.R.L. (dB) |
|-------------|---------|-------|-----|-------|-----|---------|------------|----------|--------|-------------|
| | | (dBm) | (W) | (dBm) | (W) | | | | | |
| 130 | 2.66 | 23.0 | 0.2 | 37.4 | 5.4 | 14.3 | 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.

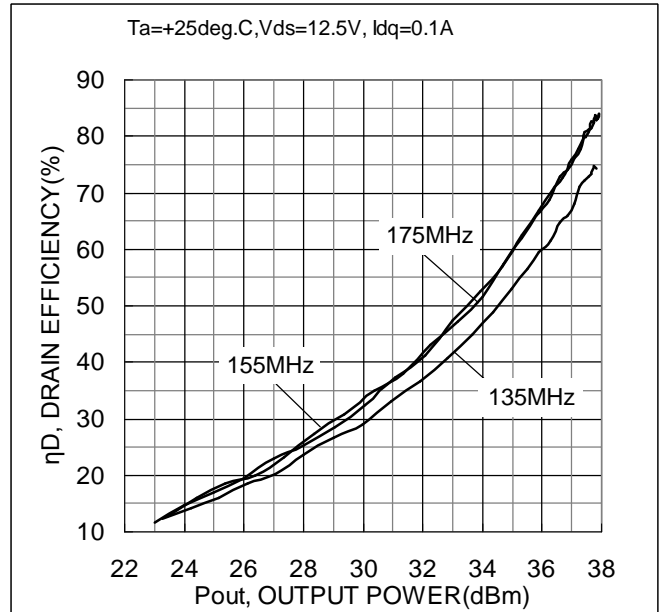
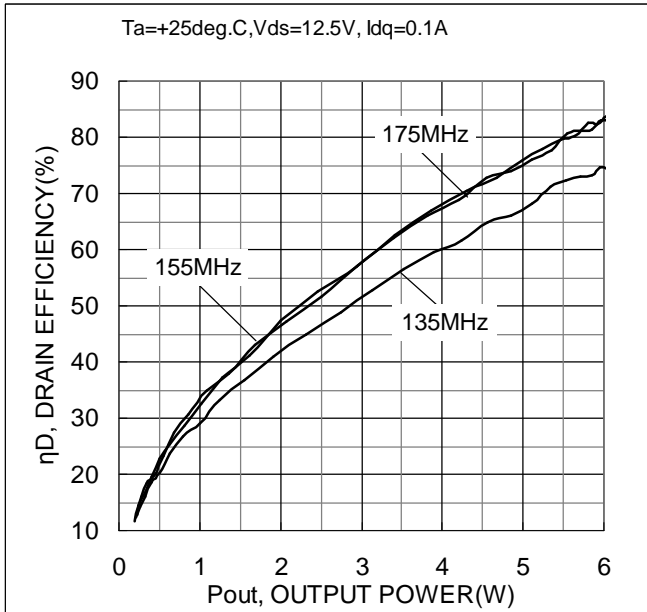
INPUT POWER (Vds=12.5V)



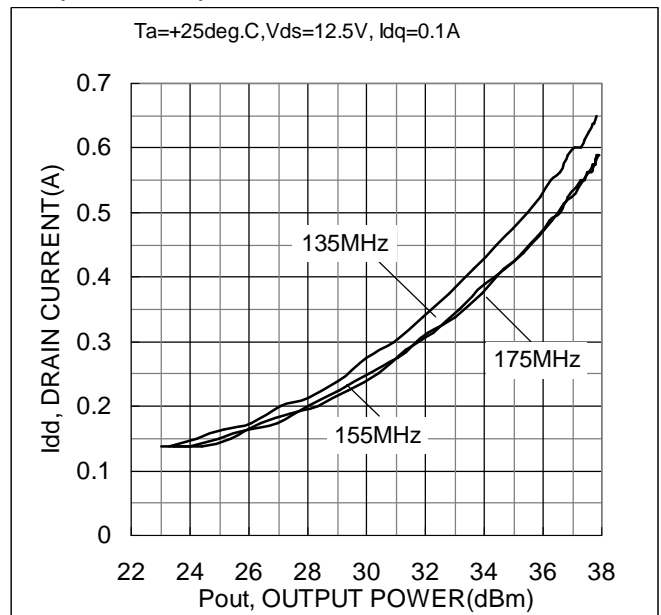
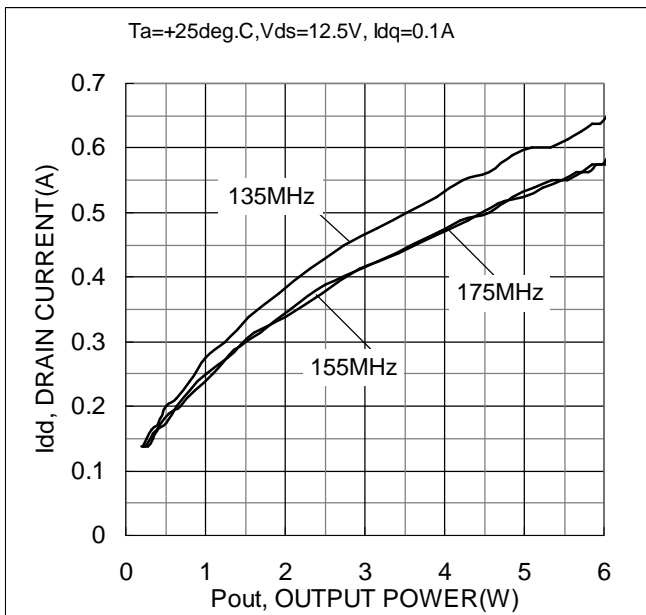
POWER GAIN (Vds=12.5V)



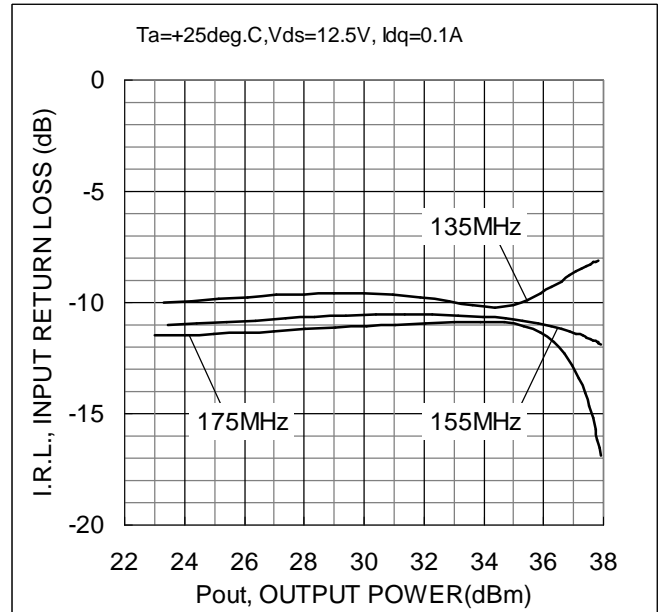
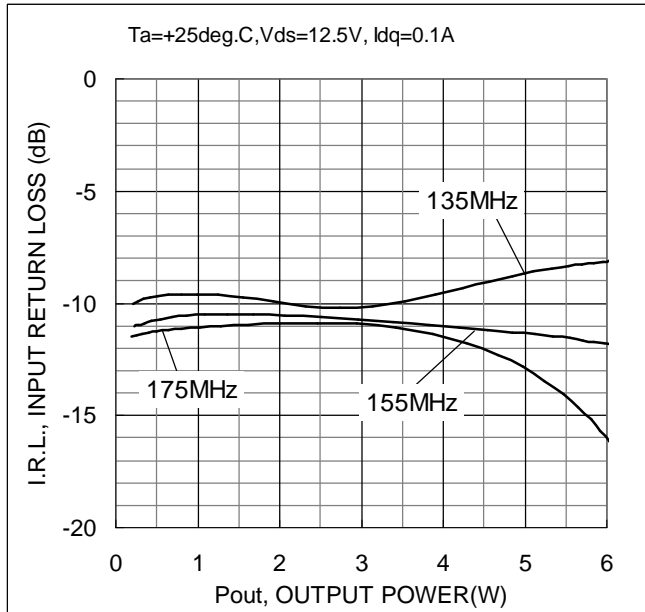
DRAIN EFFICIENCY (Vds=12.5V)



DRAIN CURRENT (Vds=12.5V)



INPUT RETURN LOSS (Vds=12.5V)



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

| 135MHz | Vgg (V) | Pin (dBm) | Pin (W) | Pout (dBm) | Pout (W) | Gp (dB) | ID(RF) (A) | η_{add} (%) | η_D (%) | I.R.L. (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 |

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

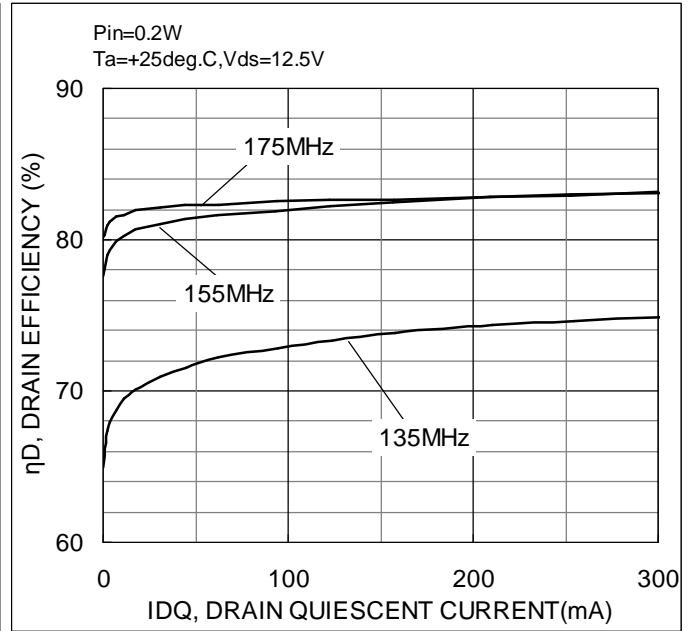
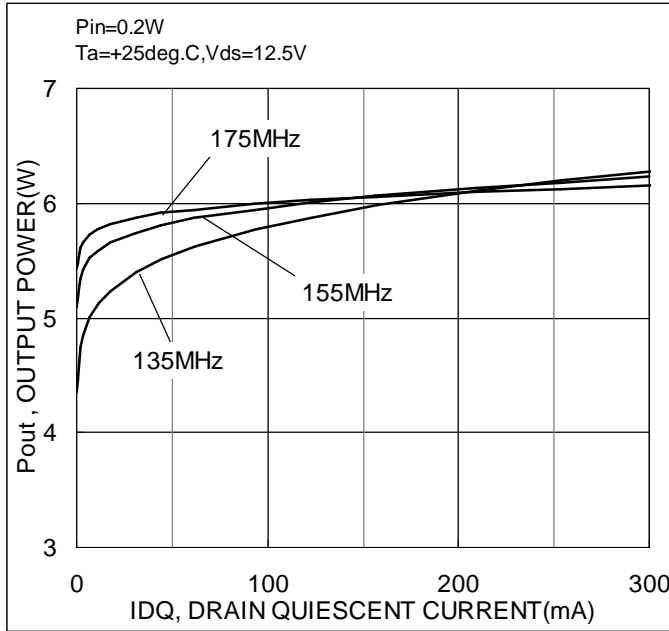
- AN-VHF-051-B-

| 155MHz | V _{gg} | Pin | | Pout | | G _p | ID(RF) | η _{add} | η _D | 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 | V _{gg} | Pin | | Pout | | G _p | ID(RF) | η _{add} | η _D | 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 (V) | Idq (mA) | Pin (dBm) | Pin (W) | Pout (dBm) | Pout (W) | Idd (A) | ηD (%) | ηadd (%) | Gain (dB) | I.R.L. (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 |

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

- AN-VHF-051-B-

155MHz

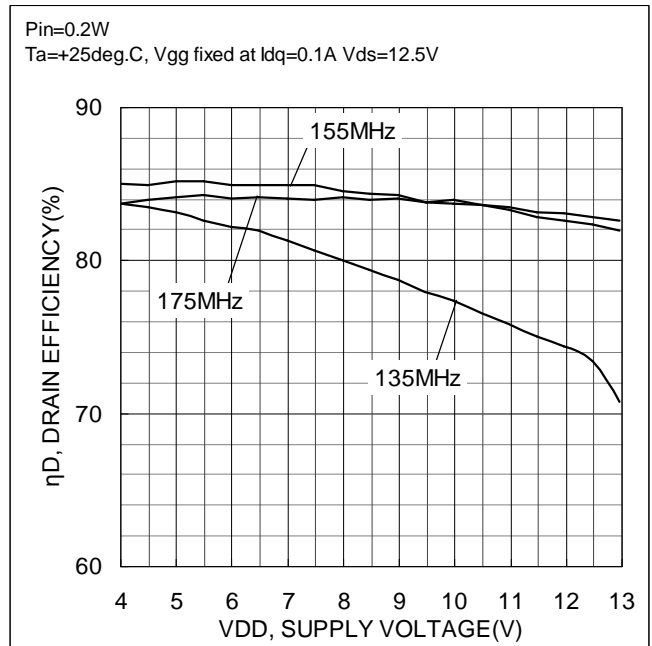
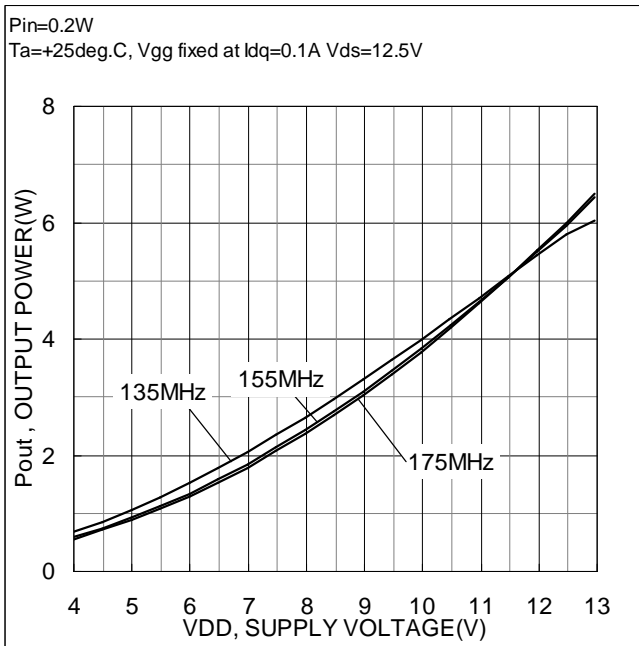
| V _{gg} (V) | I _{dq} (mA) | Pin (dBm) (W) | | Pout (dBm) (W) | | I _{dd} (A) | η _D (%) | η _{add} (%) | Gain (dB) | I.R.L. (dB) |
|------------------------|-------------------------|------------------|-----|-------------------|-----|------------------------|-----------------------|-------------------------|--------------|----------------|
| 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

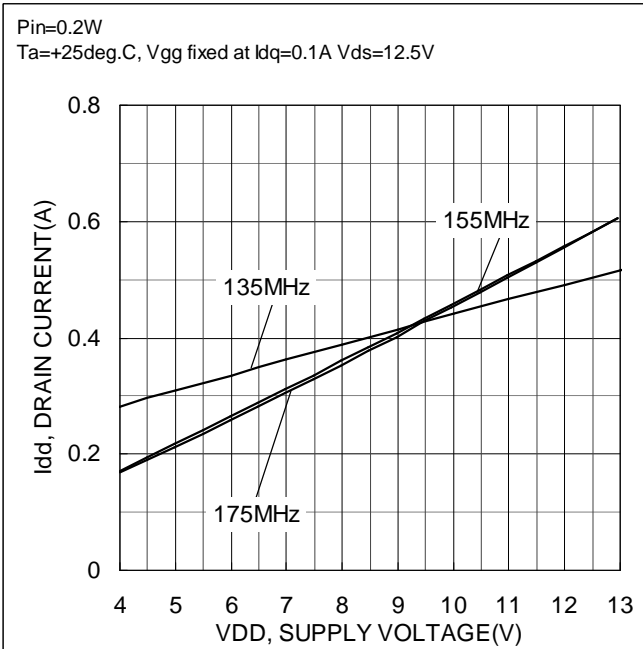
| V _{gg} (V) | I _{dq} (mA) | Pin (dBm) (W) | | Pout (dBm) (W) | | I _{dd} (A) | η _D (%) | η _{add} (%) | Gain (dB) | I.R.L. (dB) |
|------------------------|-------------------------|------------------|-----|-------------------|-----|------------------------|-----------------------|-------------------------|--------------|----------------|
| 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 ($I_{dq}=0.1A$)



DRAIN CURRENT ($I_{dq}=0.1A$)



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

- AN-VHF-051-B-

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

| 135MHz | Vgg (V) | Vdd (V) | Idq (mA) | Pin (dBm) | Pin (W) | Pout (dBm) | Pout (W) | Idd (A) | η_D (%) | η_{add} (%) | 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) | η_D (%) | η_{add} (%) | 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 |

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

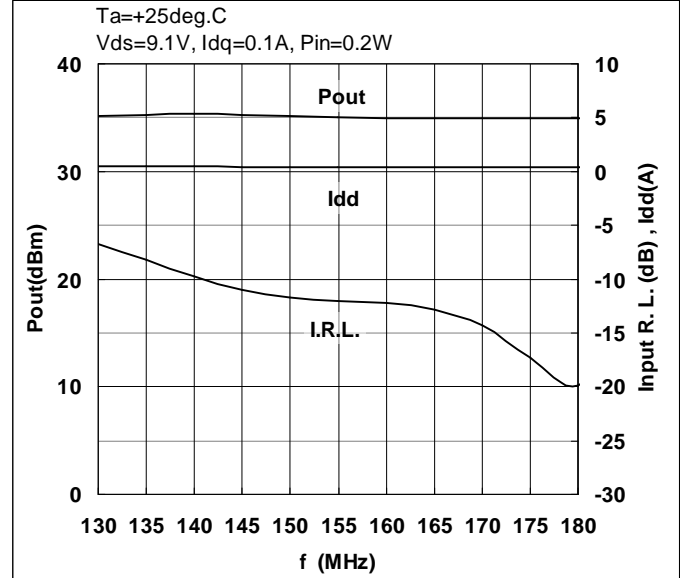
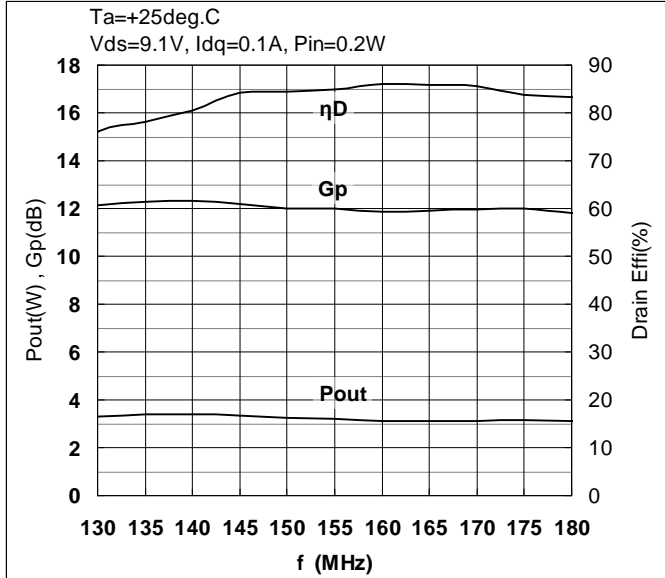
- AN-VHF-051-B-

| 175MHz | V _{gg} (V) | V _{dd} (V) | I _{dq} (mA) | Pin (dBm) (W) | | Pout (dBm) (W) | | I _{dd} (A) | η _D (%) | η _{add} (%) | 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)

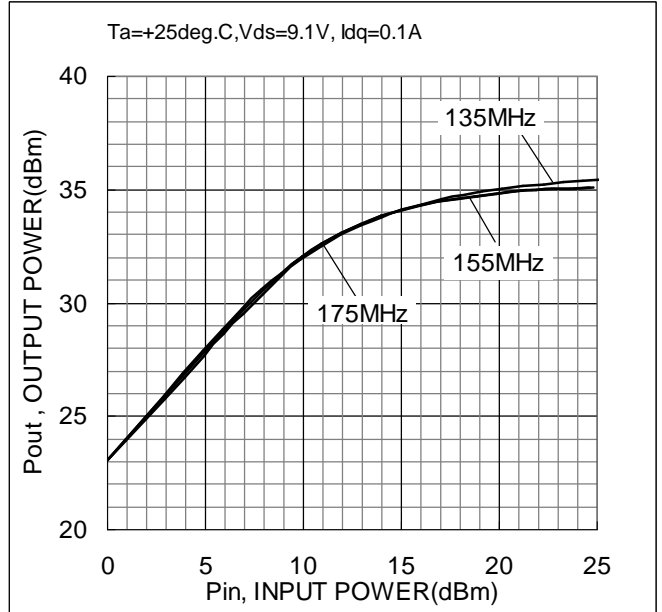
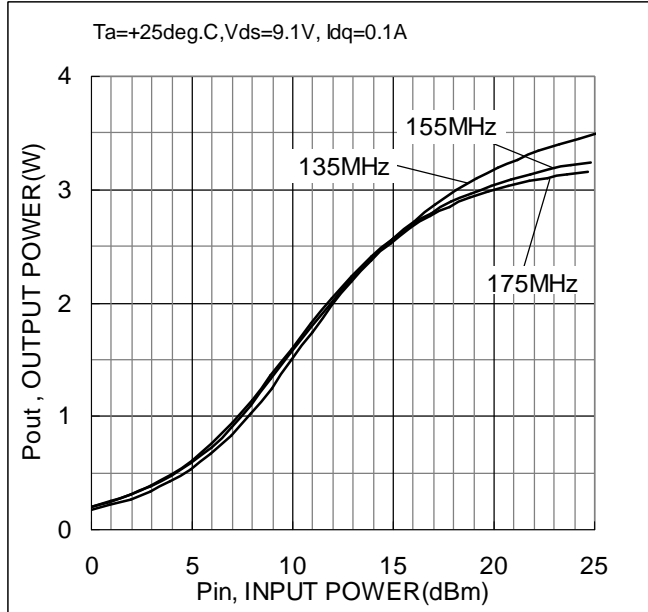


Ta=+25deg. C., Vds=9.1V, Idq=0.1A, Pin=0.2W

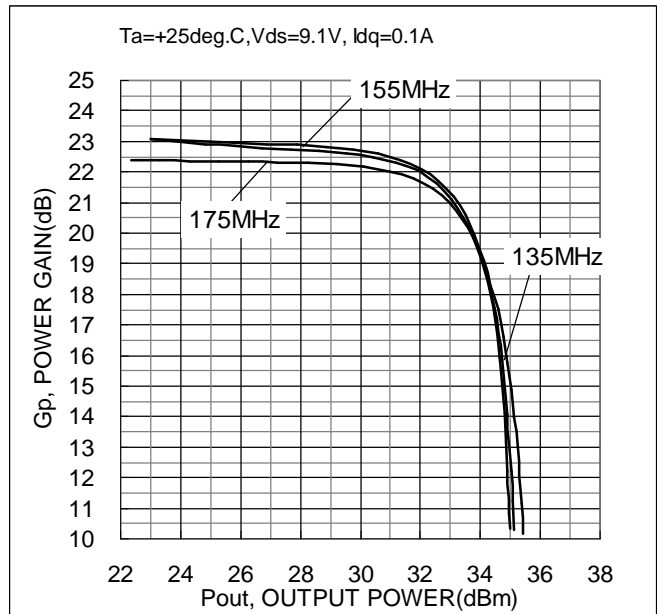
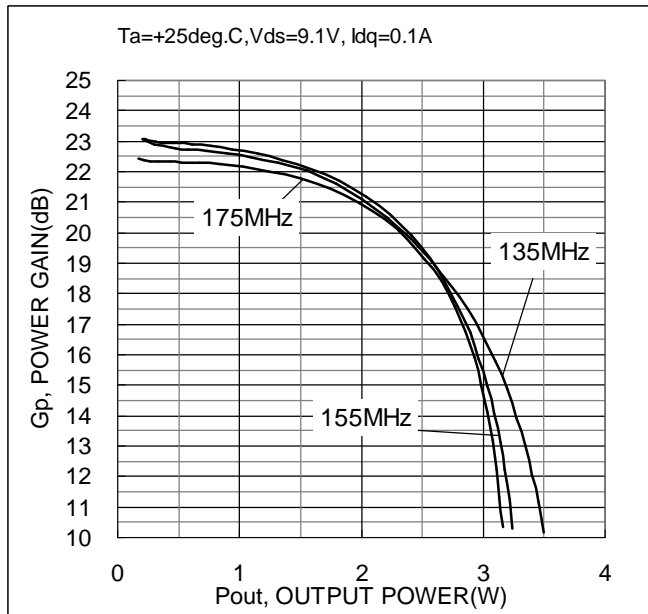
| Freq. (MHz) | Vgg (V) | Pin (dBm) | Pin (W) | Pout (dBm) | Pout (W) | Gp (dB) | ID(RF) (A) | ηadd (%) | ηD (%) | I.R.L. (dB) |
|-------------|---------|-----------|---------|------------|----------|---------|------------|----------|--------|-------------|
| 130 | 2.68 | 23.0 | 0.2 | 35.2 | 3.3 | 12.1 | 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.

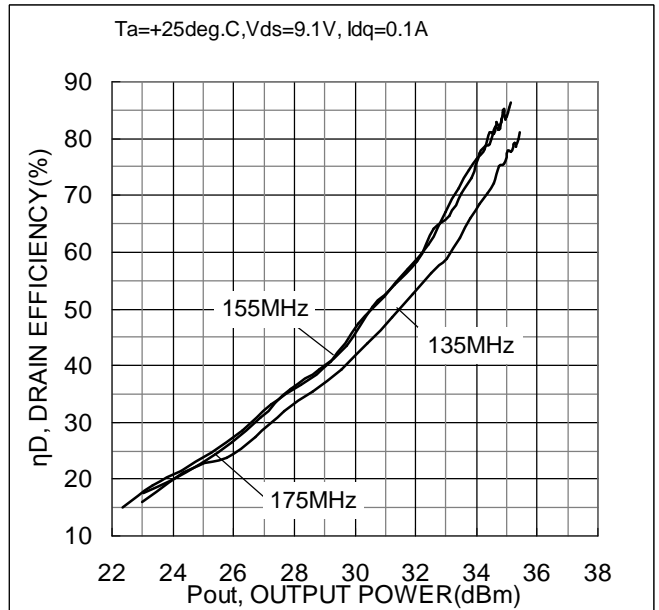
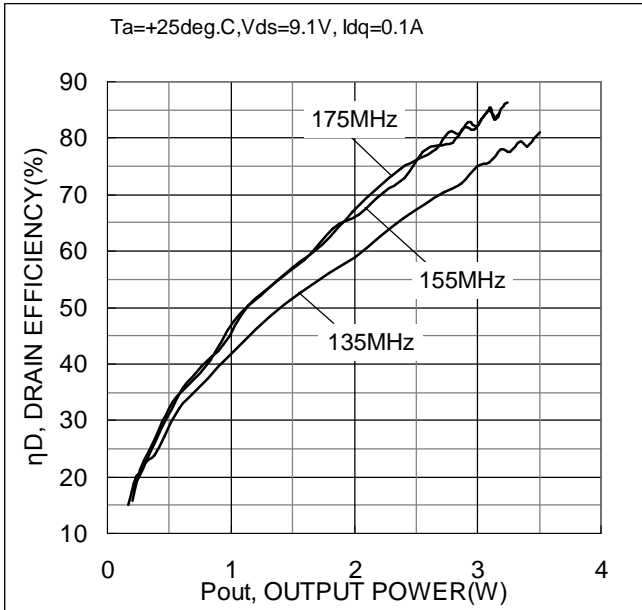
INPUT POWER (Vds=9.1V)



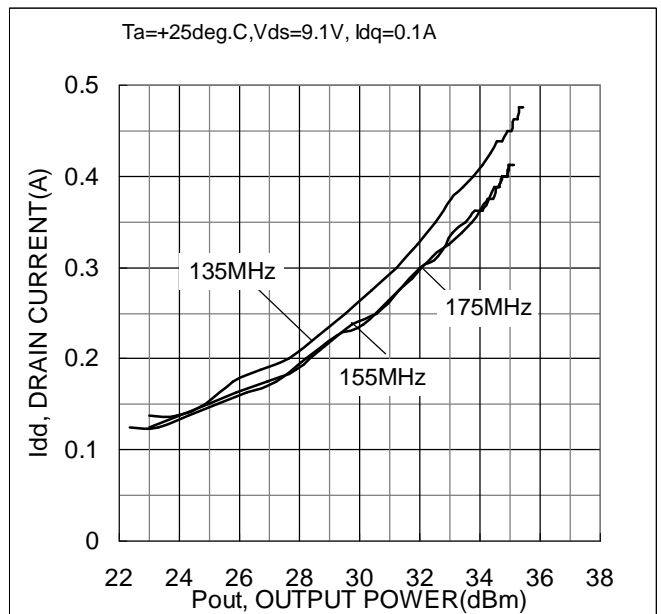
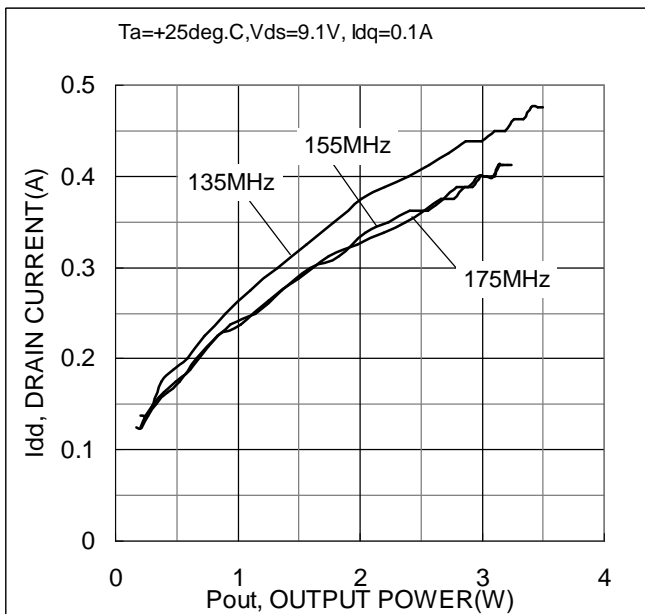
POWER GAIN (Vds=9.1V)



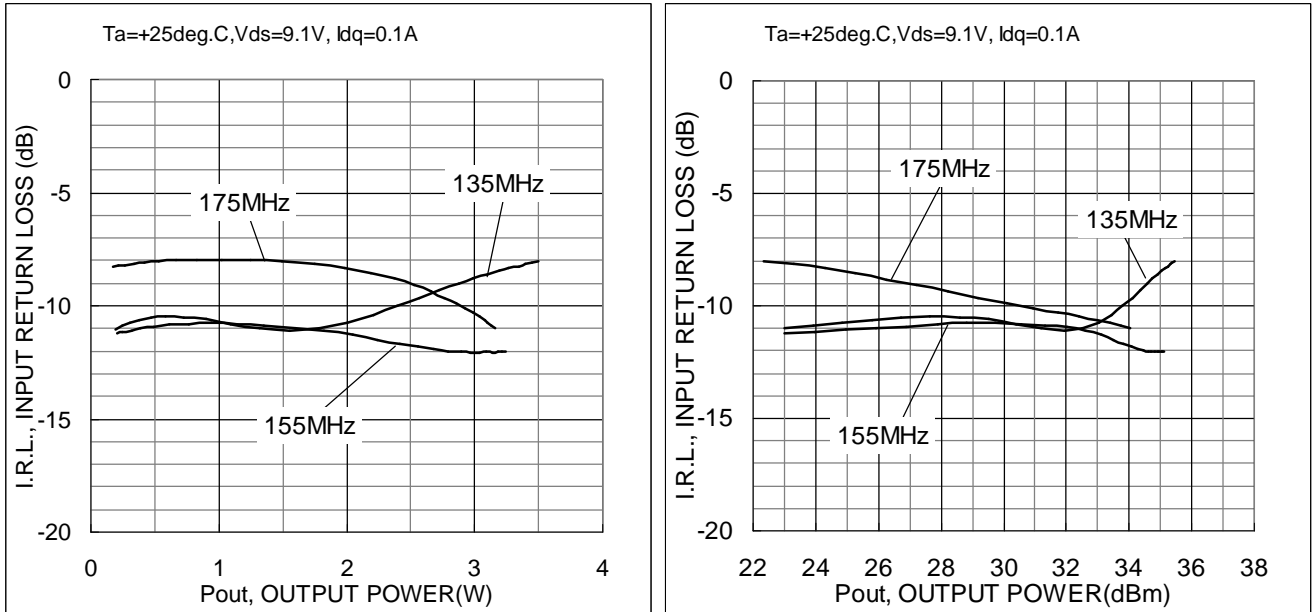
DRAIN EFFICIENCY (Vds=9.1V)



DRAIN CURRENT (Vds=9.1V)



INPUT RETURN LOSS (Vds=9.1V)



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

| 135MHz | Vgg (V) | Pin (dBm) | Pin (W) | Pout (dBm) | Pout (W) | Gp (dB) | ID(RF) (A) | η_{add} (%) | η_D (%) | I.R.L. (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 |

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

- AN-VHF-051-B-

155MHz

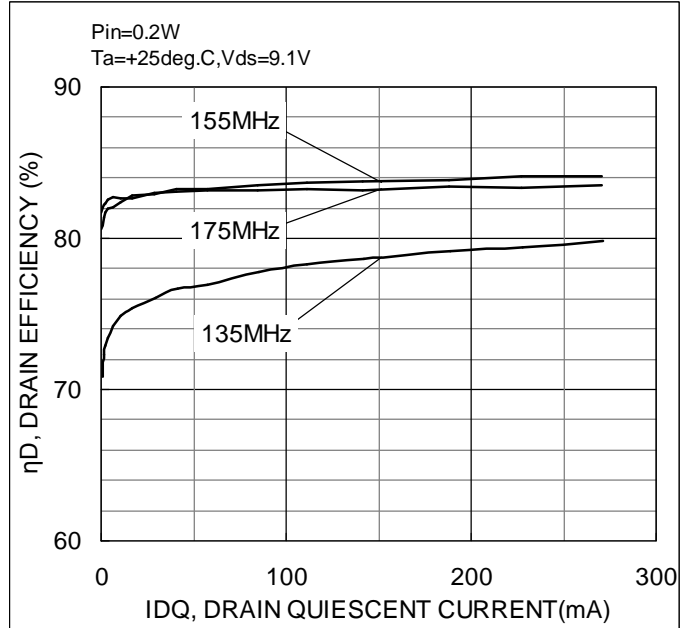
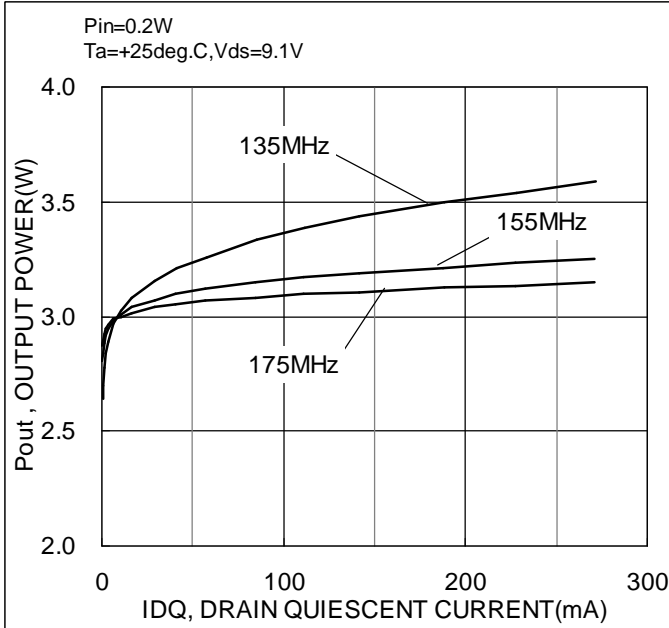
| V _{gg} (V) | P _{in} (dBm) (W) | | P _{out} (dBm) (W) | | G _p (dB) | ID(RF) (A) | η _{add} (%) | η _D (%) | I.R.L. (dB) |
|------------------------|------------------------------|------|-------------------------------|-----|------------------------|---------------|-------------------------|-----------------------|----------------|
| 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

| V _{gg} (V) | P _{in} (dBm) (W) | | P _{out} (dBm) (W) | | G _p (dB) | ID(RF) (A) | η _{add} (%) | η _D (%) | I.R.L. (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 (V) | Idq (mA) | Pin (dBm) | Pin (W) | Pout (dBm) | Pout (W) | Idd (A) | ηD (%) | ηadd (%) | Gain (dB) | I.R.L. (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 |

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

- AN-VHF-051-B-

155MHz

| V _{gg} (V) | I _{dq} (mA) | Pin (dBm) (W) | | Pout (dBm) (W) | | I _{dd} (A) | η _D (%) | η _{add} (%) | Gain (dB) | I.R.L. (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

| V _{gg} (V) | I _{dq} (mA) | Pin (dBm) (W) | | Pout (dBm) (W) | | I _{dd} (A) | η _D (%) | η _{add} (%) | Gain (dB) | I.R.L. (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 |