24-23cm RF Power Amplifier Characterization Data

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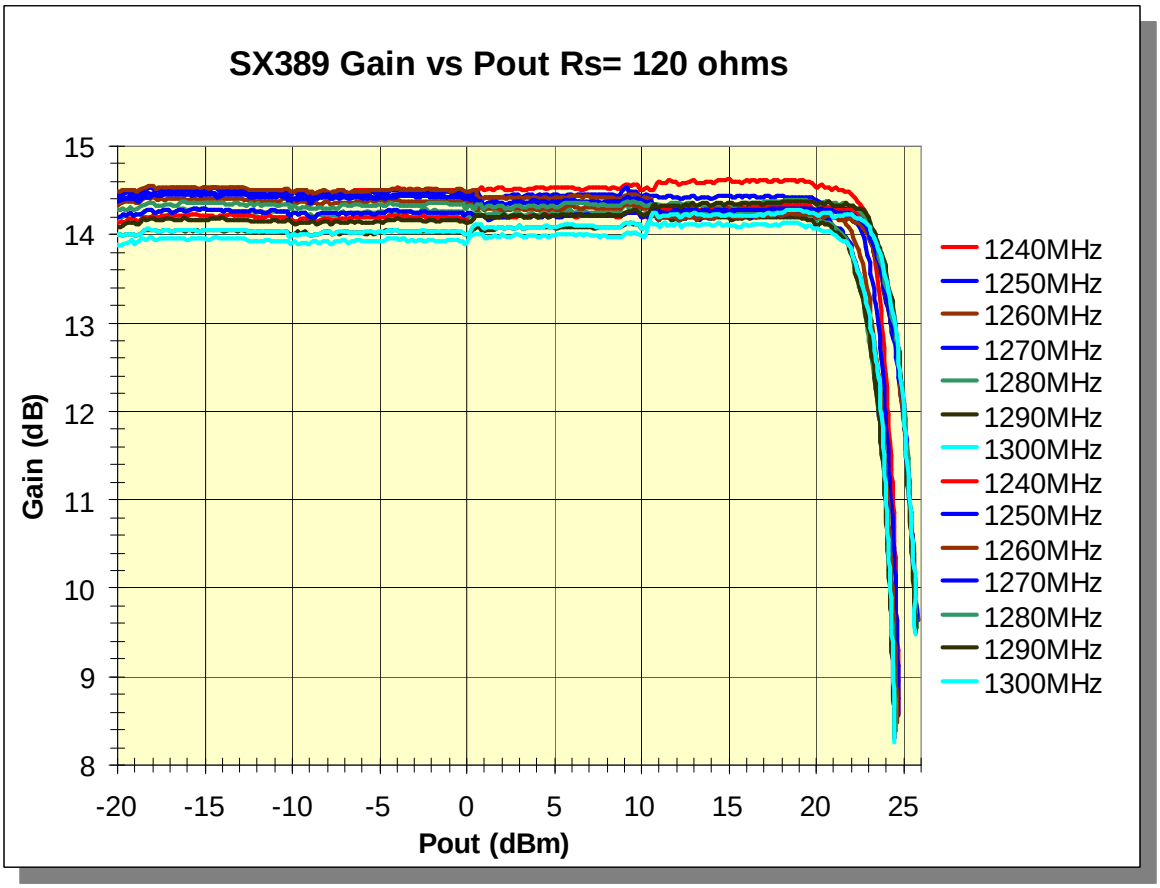
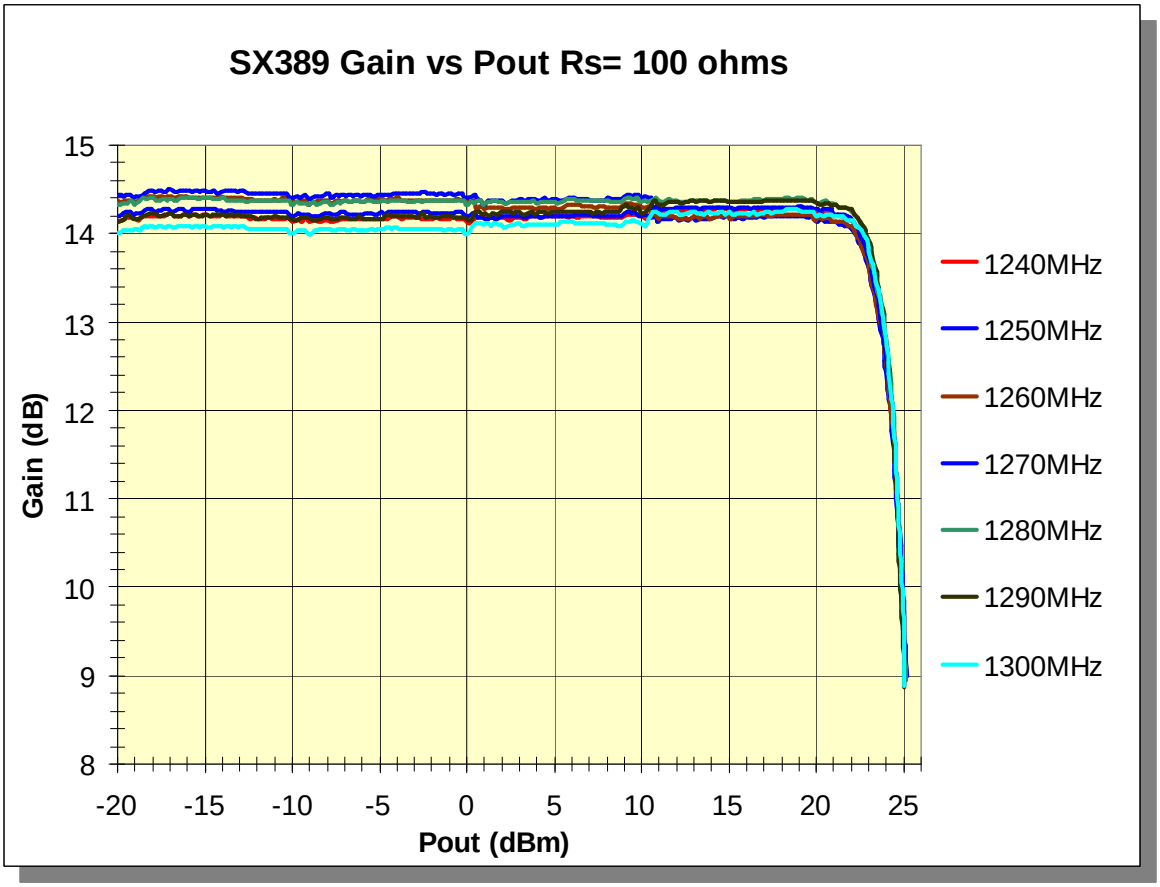
About this Document

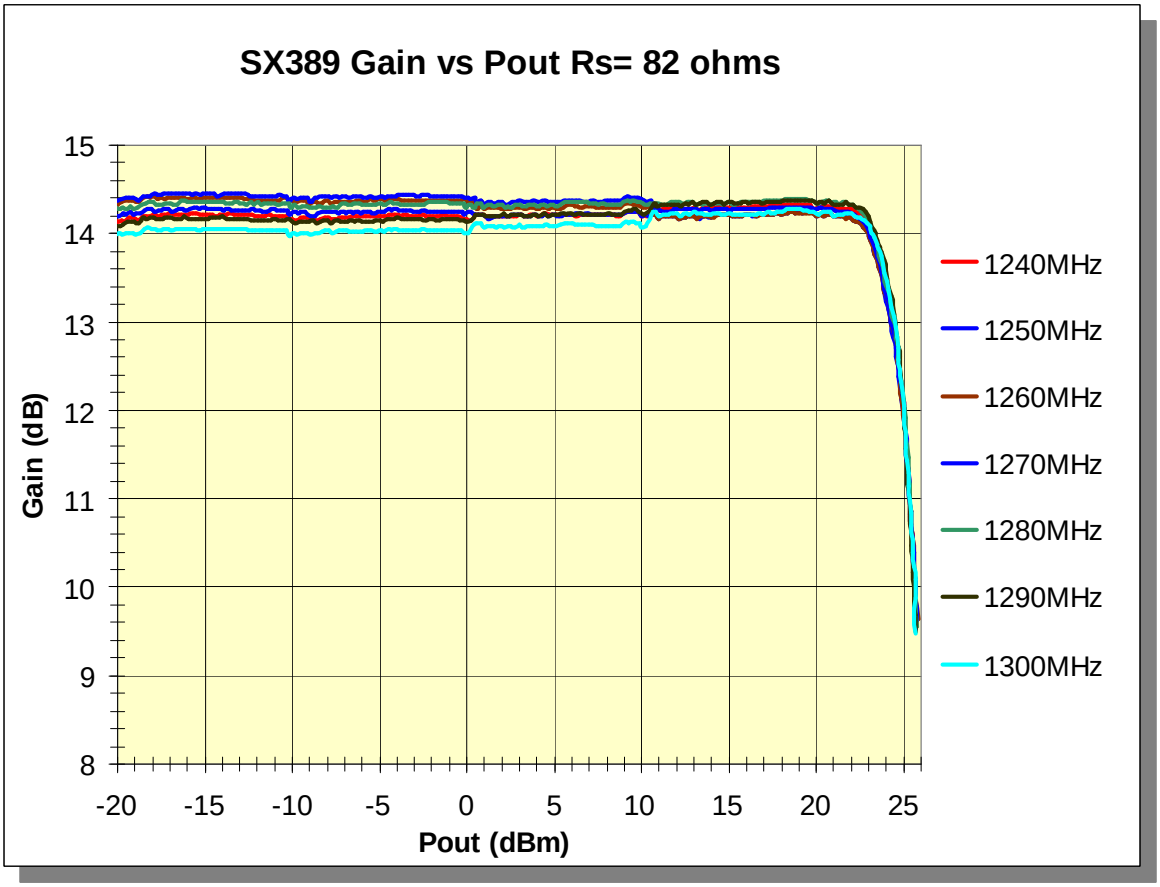
This is a compendium of characterization data taken from the version 0.0h amplifier assembly.

First Stage Amplifier Gain

The first stage amplifier was tested before installing the Mitsubishi RA18H1213G module. The input power was swept from -35 to +17dBm in 0.2dB steps and data was taken from 1270 to 1300MHz in 10MHz steps. Three sweeps were done for collector series resistances of 40 (120/3), 33 (100/3), and 27(82/3) ohms to show the impact of the bias resistors on the 1dB gain compression point.

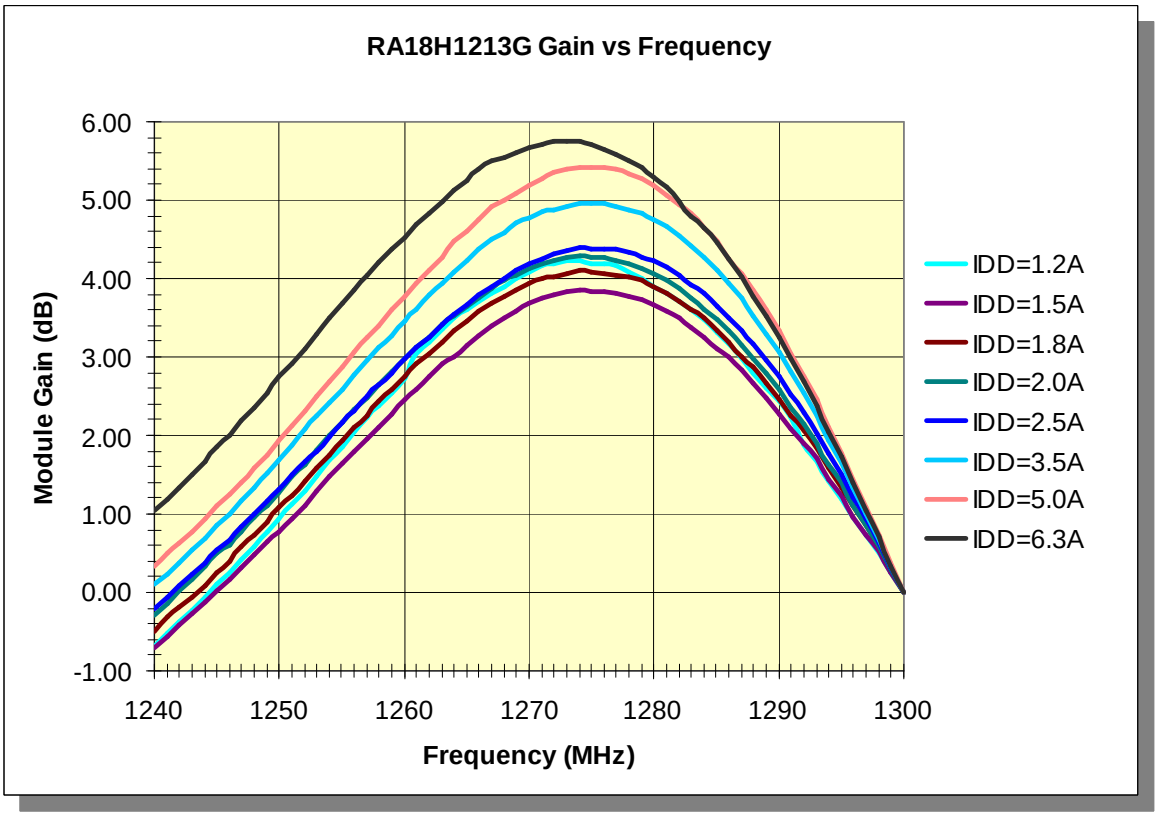



SX389 Gain vs Pout Rs= 100 ohms
Gain (dB)
15
14
13
12
11
10
9
8
-20
-15
-10
-5
0
5
10
15
20
25
Pout (dBm)
1240MHz
1250MHz
1260MHz
1270MHz
1280MHz
1290MHz
1300MHz


SX389 Gain vs Pout Rs= 82 ohms
Gain (dB)
15
14
13
12
11
10
9
8
-20
-15
-10
-5
0
5
10
15
20
25
Pout (dBm)
1240MHz
1250MHz
1260MHz
1270MHz
1280MHz
1290MHz
1300MHz

Amplifier Gain versus frequency

While the first stage amplifier frequency response is virtually flat across the 1240 to 1300 MHz range the RA18H1213G is fairly peaky with a maximum gain around 1270 MHz that's about 4 to 6 dB above the gain at 1300MHz. The gain close to being the same at 1240 and 1300MHz. The following data sweeps the frequency between 1240 and 1300MHz in 1MHz steps and records the output level referenced to 1300MHz with an RF generator input to the amplifier of +4 dBm. Values are recorded for various values of I_{DD}.

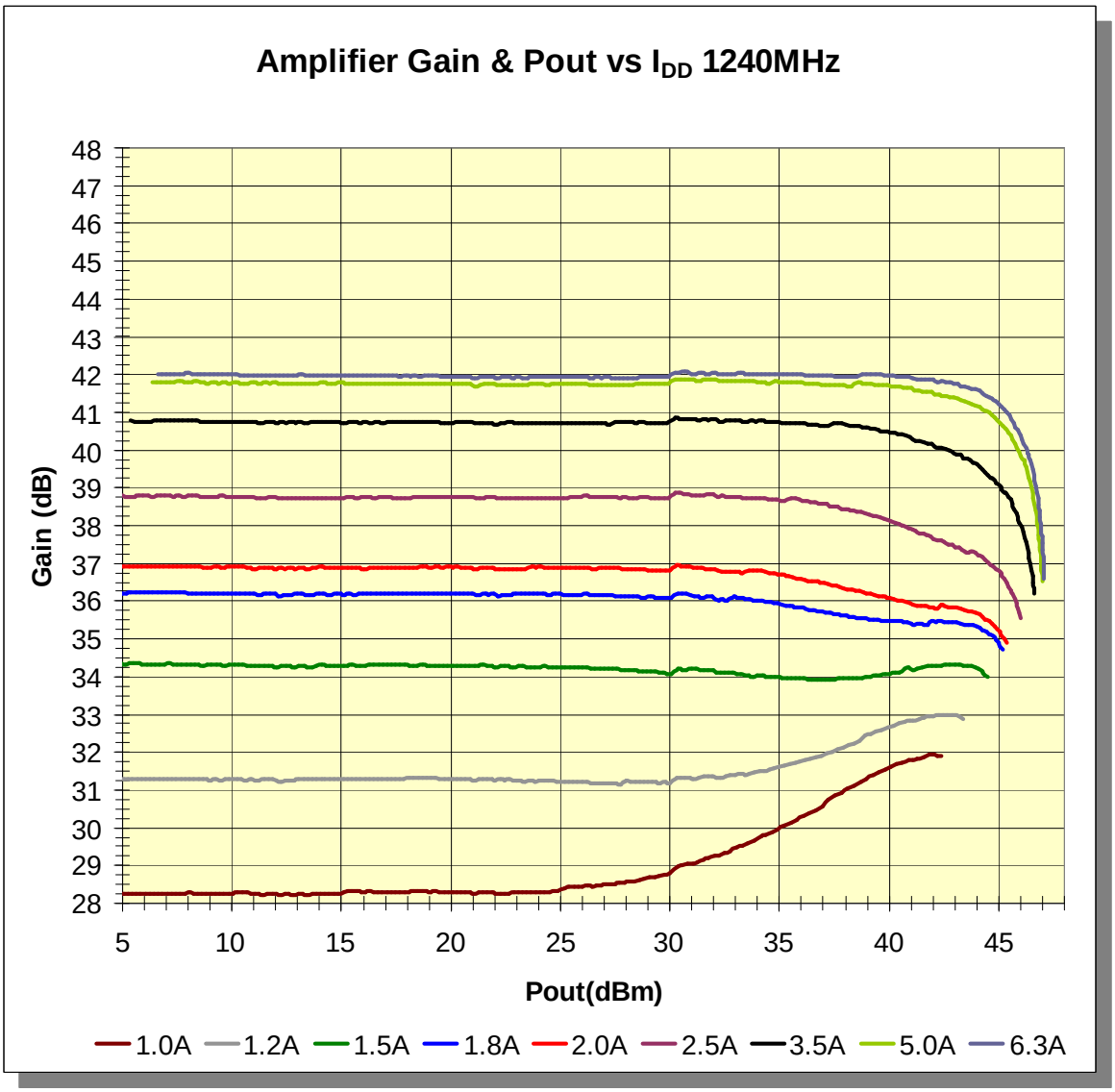


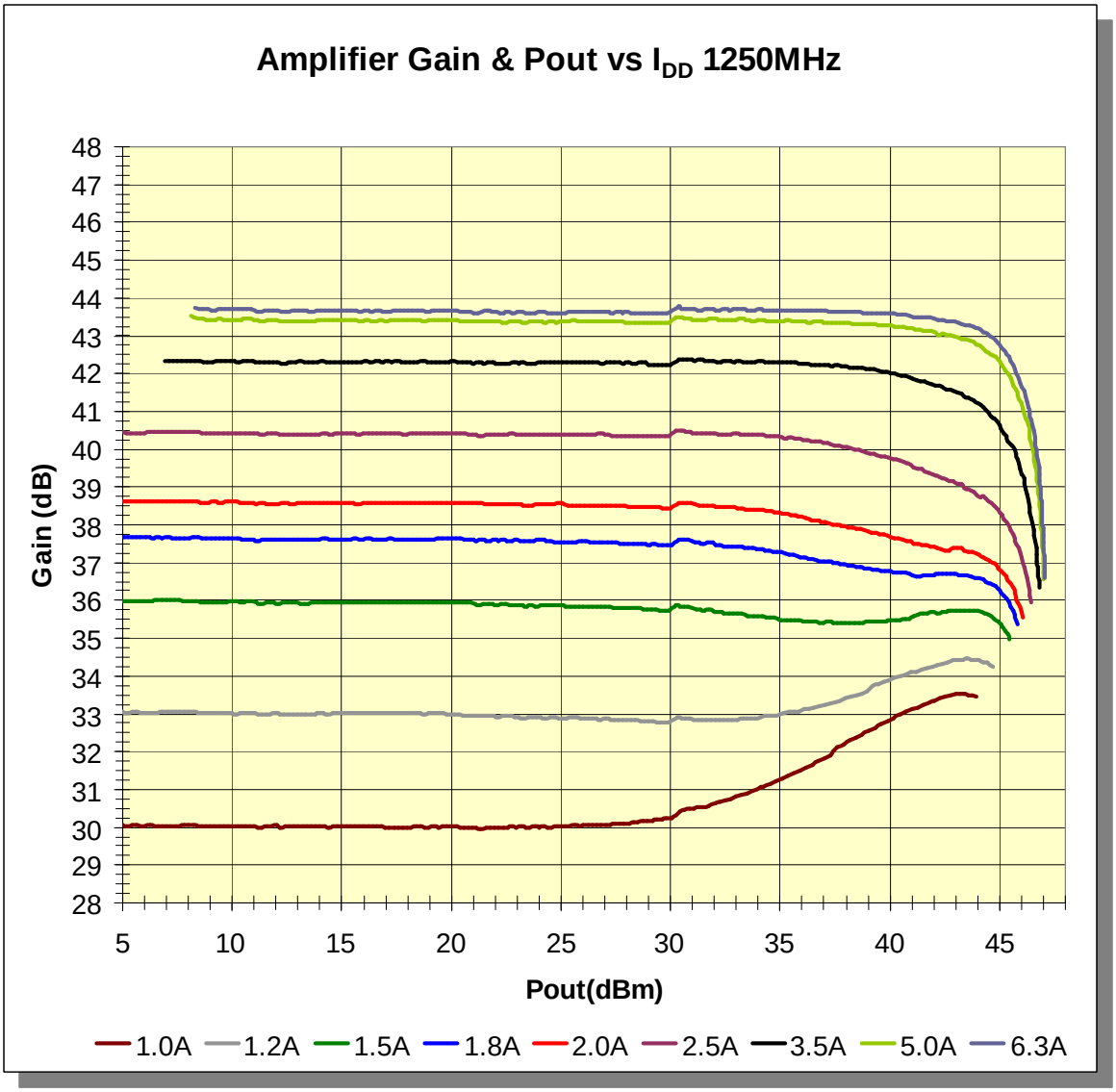
Amplifier Gain and Output power versus I_{DD} bias setting

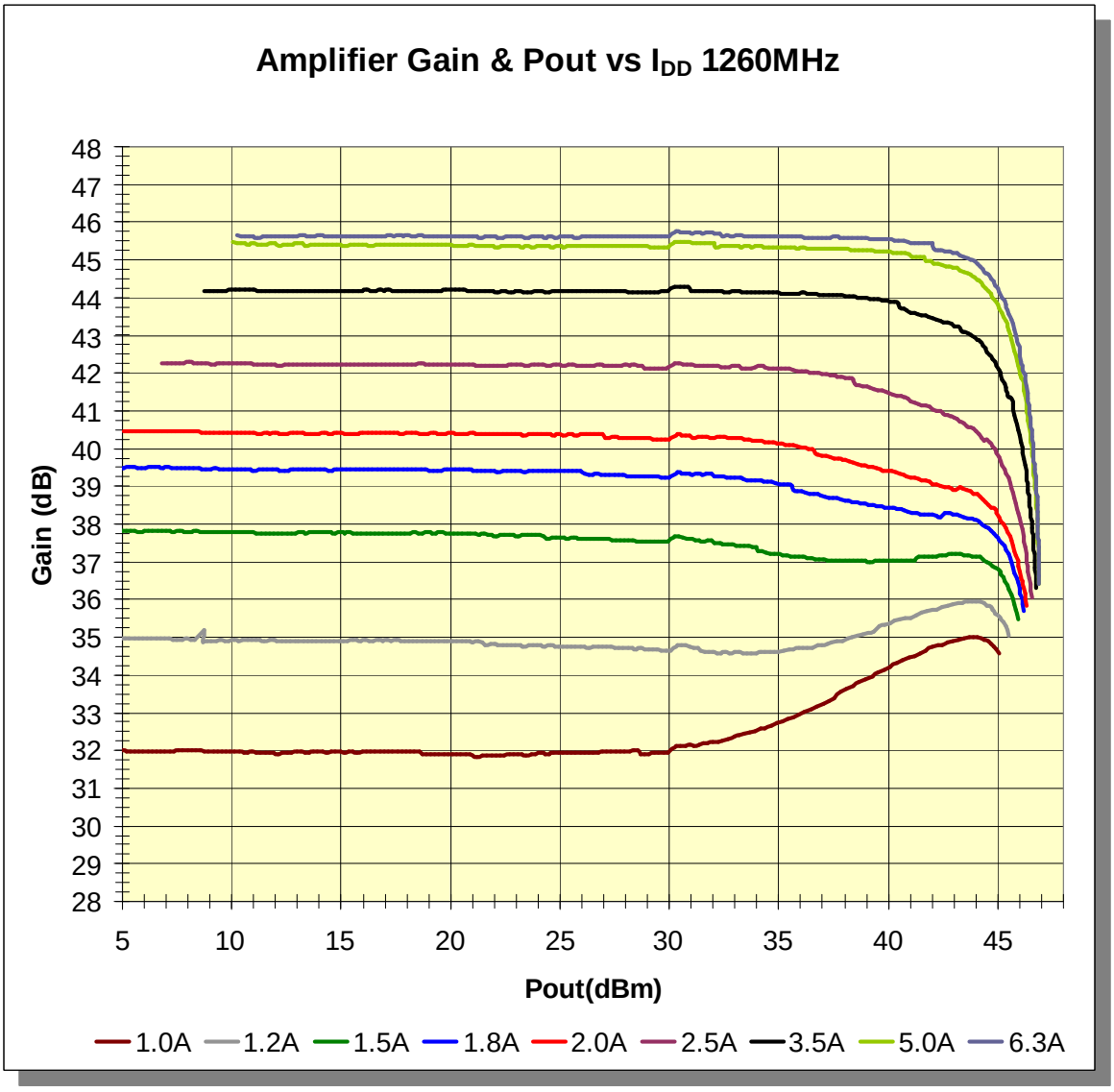
The following graphs show the amplifier's linearity over an RF output power range. The 1dB gain compression points and maximum power the output power can easily be determined. The amplifier output power was plotted against the amplifier gain in 0.2dB steps. This was done for different I_{DD} bias settings. Measurements were take at a 10 MHz frequency interval over the 1240 to 1300 MHz frequency range.

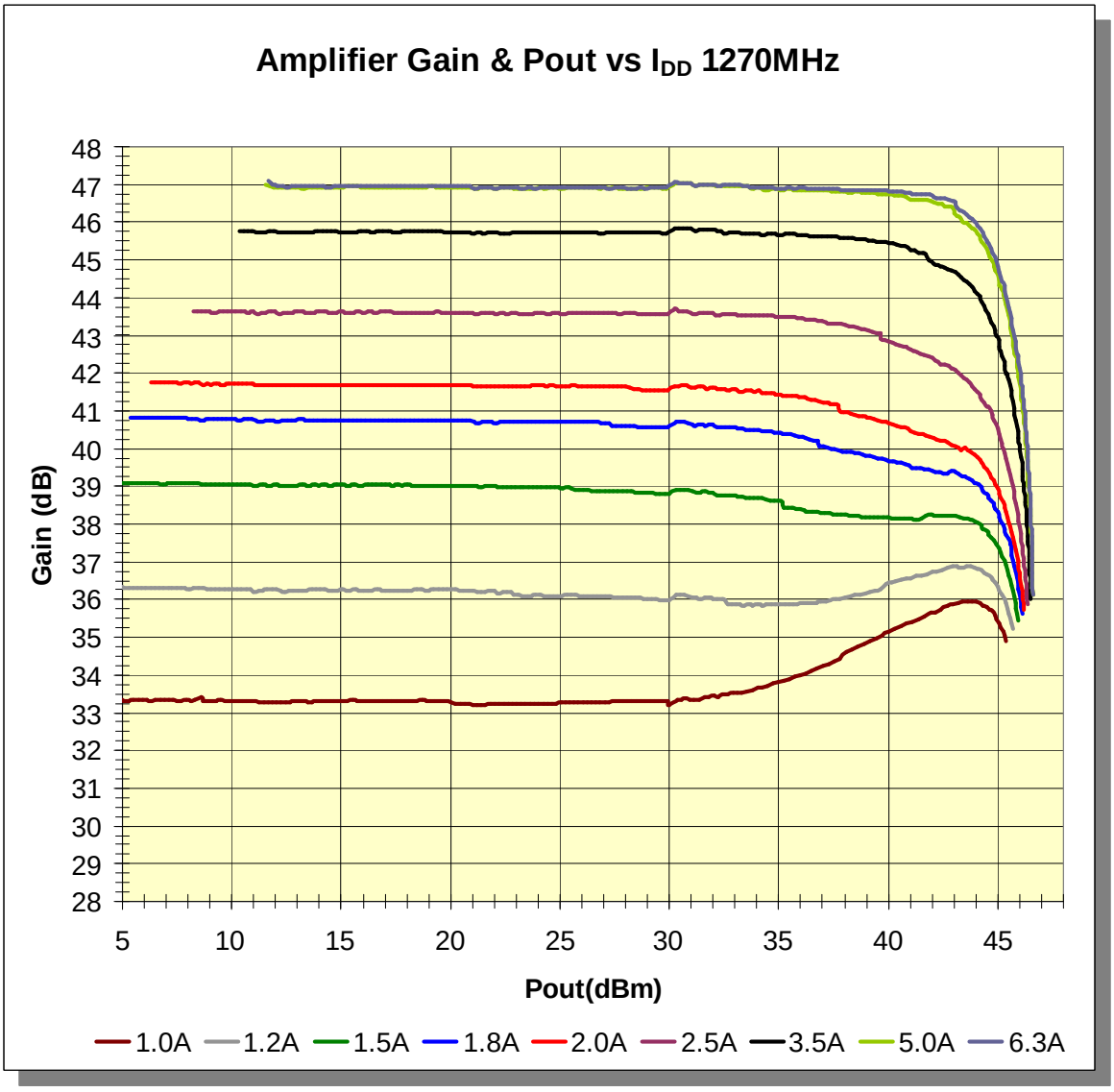
Note that at some lower bias currents there isn't enough gain in the module to reach the 1dB compression point before the maximum module RF input power is reached. Also if you draw a line through the 1dB compression points for various bias currents you'll find the points very close over a wide range of biases.

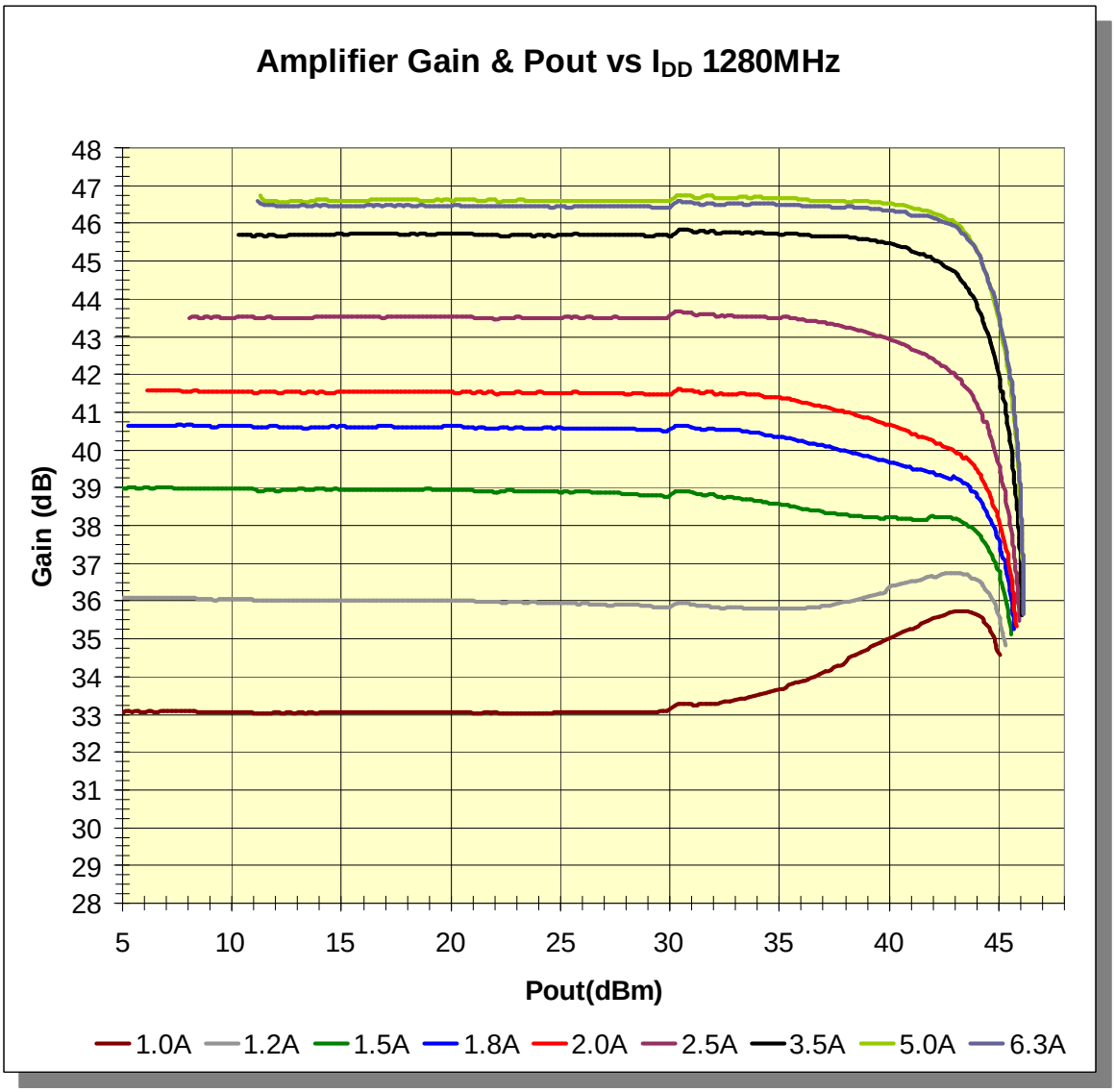
TheI RA18H1213G module gain by itself has also been plotted but that data isn't included in the compendium as it's typically just lower by 14.2 dB, the average value of the first stage gain. So to estimate the gain of the module alone, simply subtract 14.2 dB from the gain in the graphs shown below. Note also that at lower bias currents the gain actually increases with input power. A bit more will be shown about this in the next section.

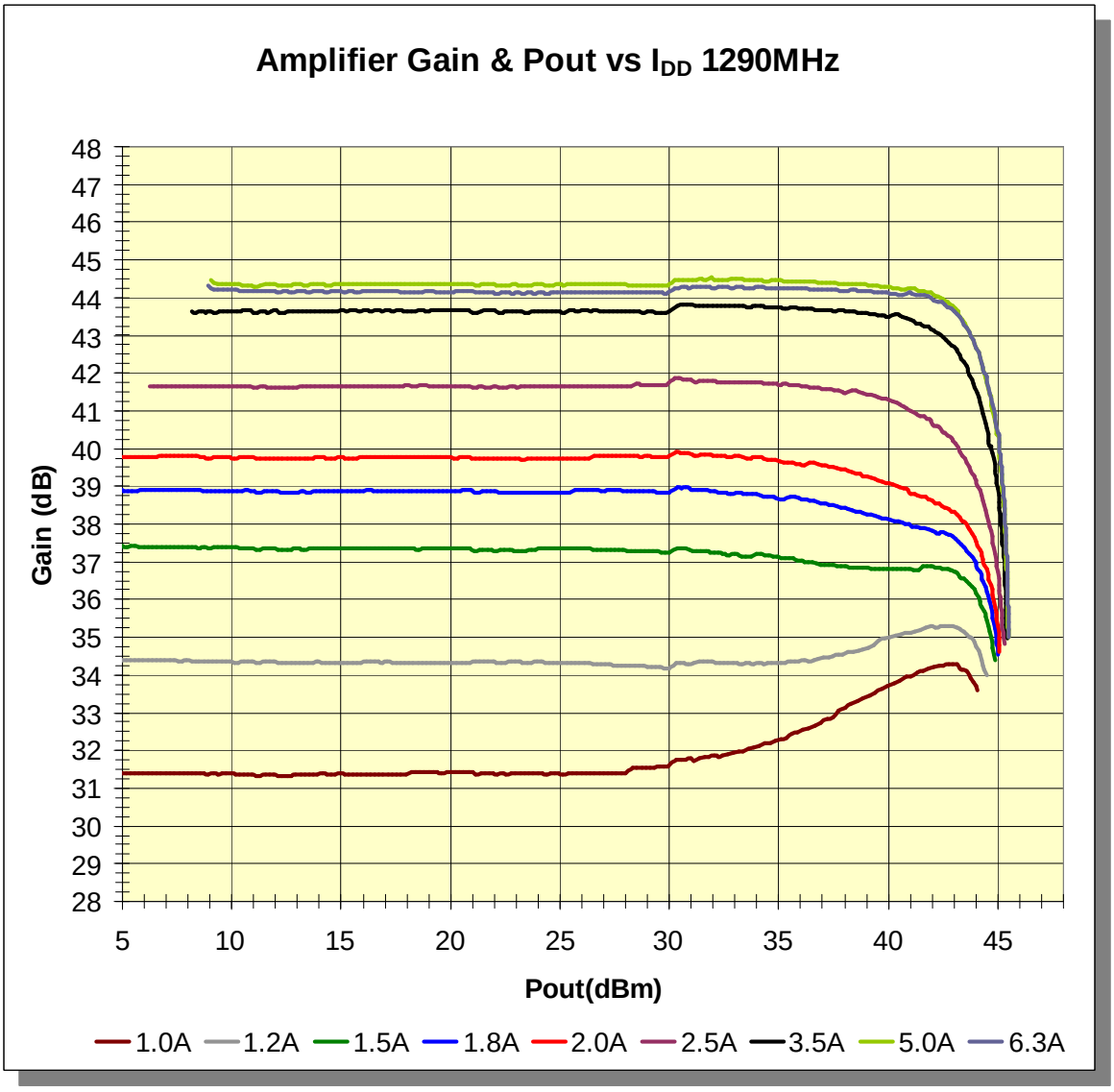

Amplifier Gain & Pout vs I_{DD} 1240MHz
Gain (dB)
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
5
10
15
20
25
30
35
40
45
Pout(dBm)
1.0A
1.2A
1.5A
1.8A
2.0A
2.5A
3.5A
5.0A
6.3A

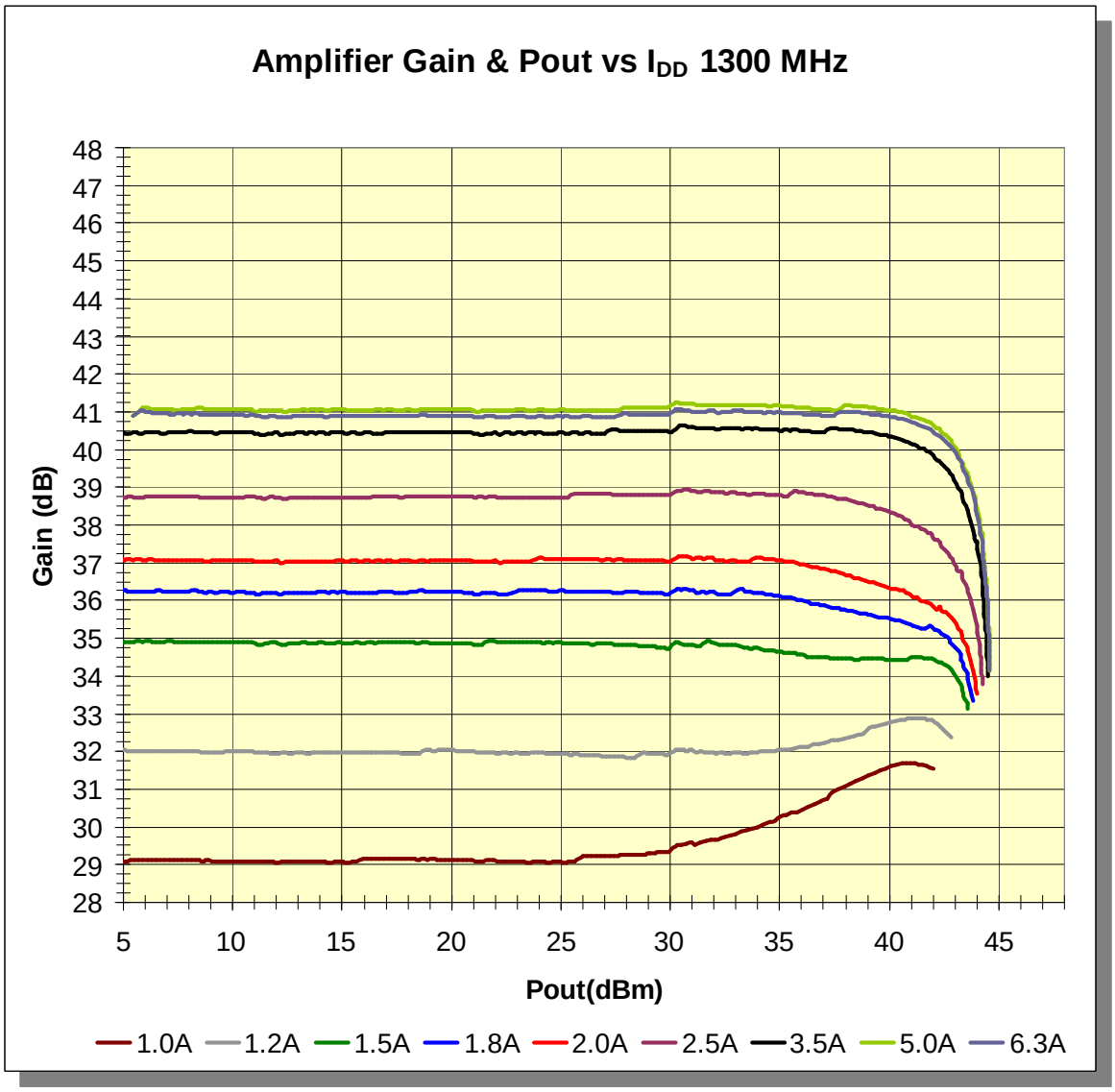

Amplifier Gain & Pout vs I_{DD} 1250MHz
Gain (dB)
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
5
10
15
20
25
30
35
40
45
Pout(dBm)
1.0A
1.2A
1.5A
1.8A
2.0A
2.5A
3.5A
5.0A
6.3A


Amplifier Gain & Pout vs I_{DD} 1260MHz
Gain (dB)
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
5
10
15
20
25
30
35
40
45
Pout(dBm)
1.0A
1.2A
1.5A
1.8A
2.0A
2.5A
3.5A
5.0A
6.3A


Amplifier Gain & Pout vs I_{DD} 1270MHz
Gain (dB)
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
5
10
15
20
25
30
35
40
45
Pout(dBm)
1.0A
1.2A
1.5A
1.8A
2.0A
2.5A
3.5A
5.0A
6.3A

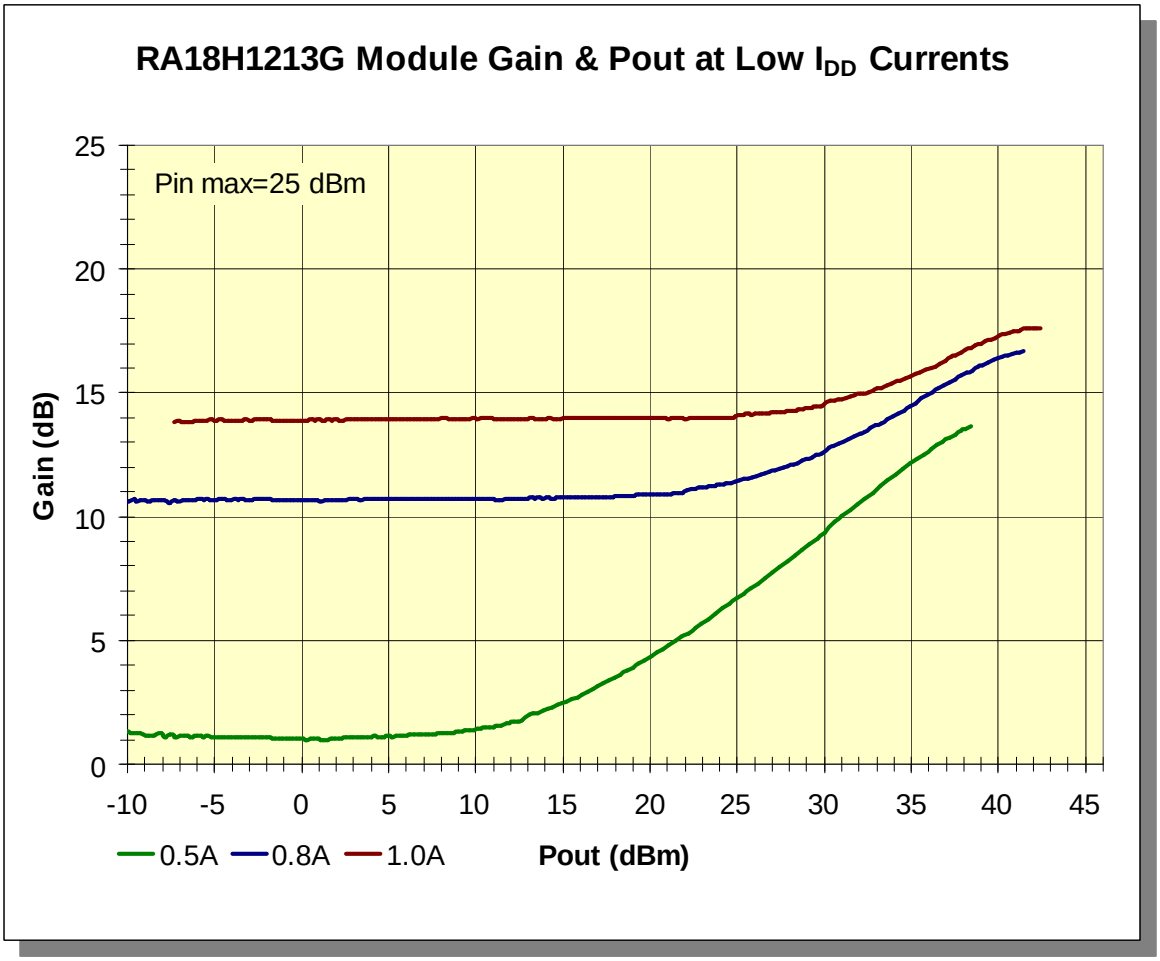

Amplifier Gain & Pout vs I_{DD} 1280MHz
Gain (dB)
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
5
10
15
20
25
30
35
40
45
Pout(dBm)
1.0A
1.2A
1.5A
1.8A
2.0A
2.5A
3.5A
5.0A
6.3A


Amplifier Gain & Pout vs I_{DD} 1290MHz
Gain (dB)
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
5
10
15
20
25
30
35
40
45
Pout(dBm)
1.0A
1.2A
1.5A
1.8A
2.0A
2.5A
3.5A
5.0A
6.3A


Amplifier Gain & Pout vs I_{DD} 1300 MHz
Gain (dB)
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
5
10
15
20
25
30
35
40
45
Pout(dBm)
1.0A
1.2A
1.5A
1.8A
2.0A
2.5A
3.5A
5.0A
6.3A

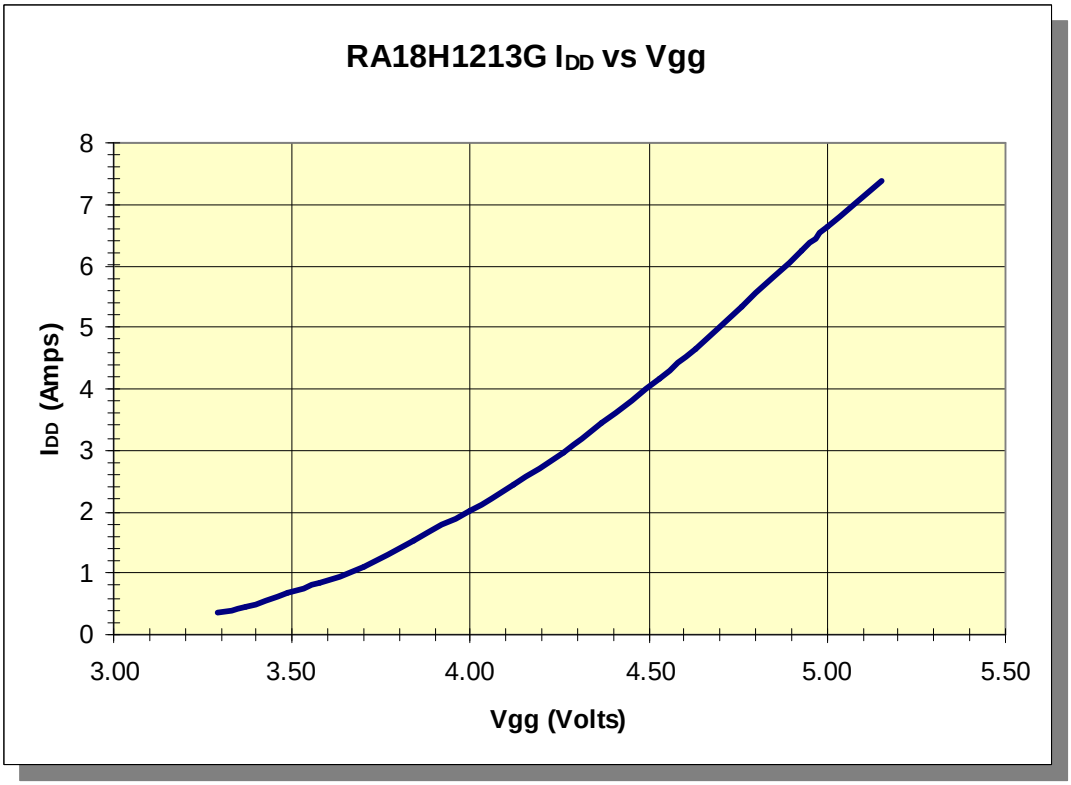
Amplifier Gain and Output power versus I_{DD} at low bias settings

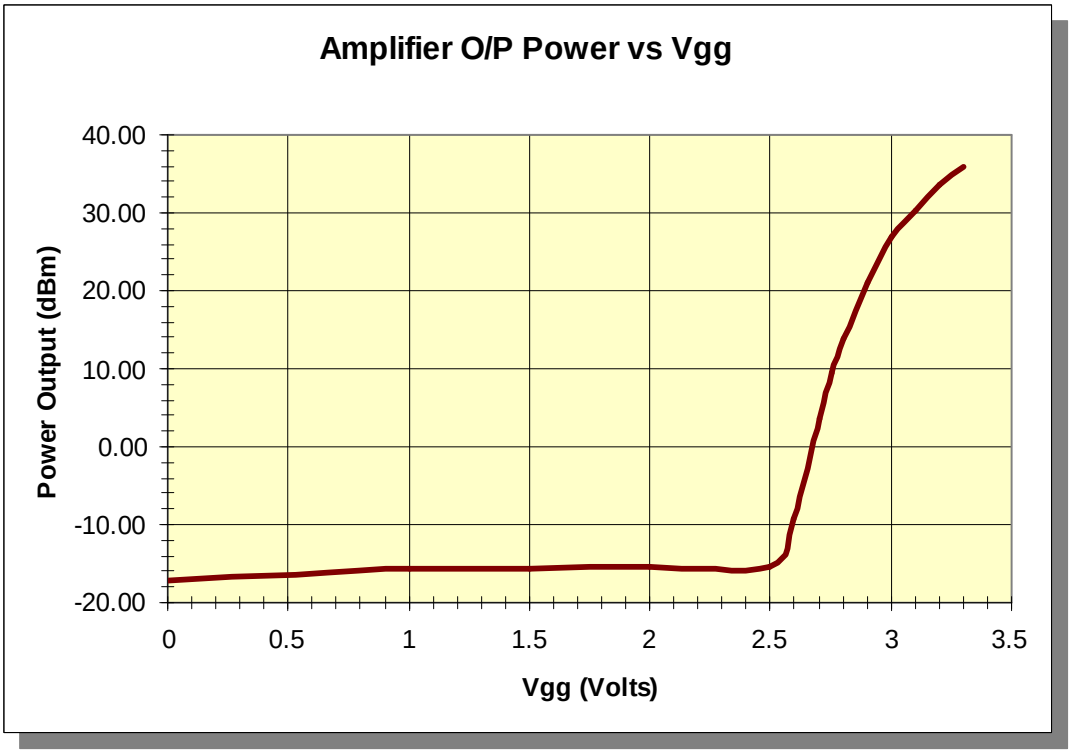
This one caught me off guard a bit as I initially began the characterization with low bias currents and monitored these phenomena thinking that the amplifier stability must be in question. It's not. I believe the amplifier self biases with RF input at VBIAS voltages near threshold. So as the RF input power increases so does the gain and this becomes more pronounced at low bias currents but disappears when bias currents are increased. The following graph shows this for 1240MHz. The gain change versus RF input power is the pretty much the same across the frequency band. The graph shows the gain of the module with the first stage gain removed.
This phenomenon becomes a bit of a concern when designing a circuit to prevent an associated T / R relay from hot switching. It means that VBIAS must be held low or there may be significant RF output.



Amplifier I_{DD} and Output Power versus VBIAS (Vgg)

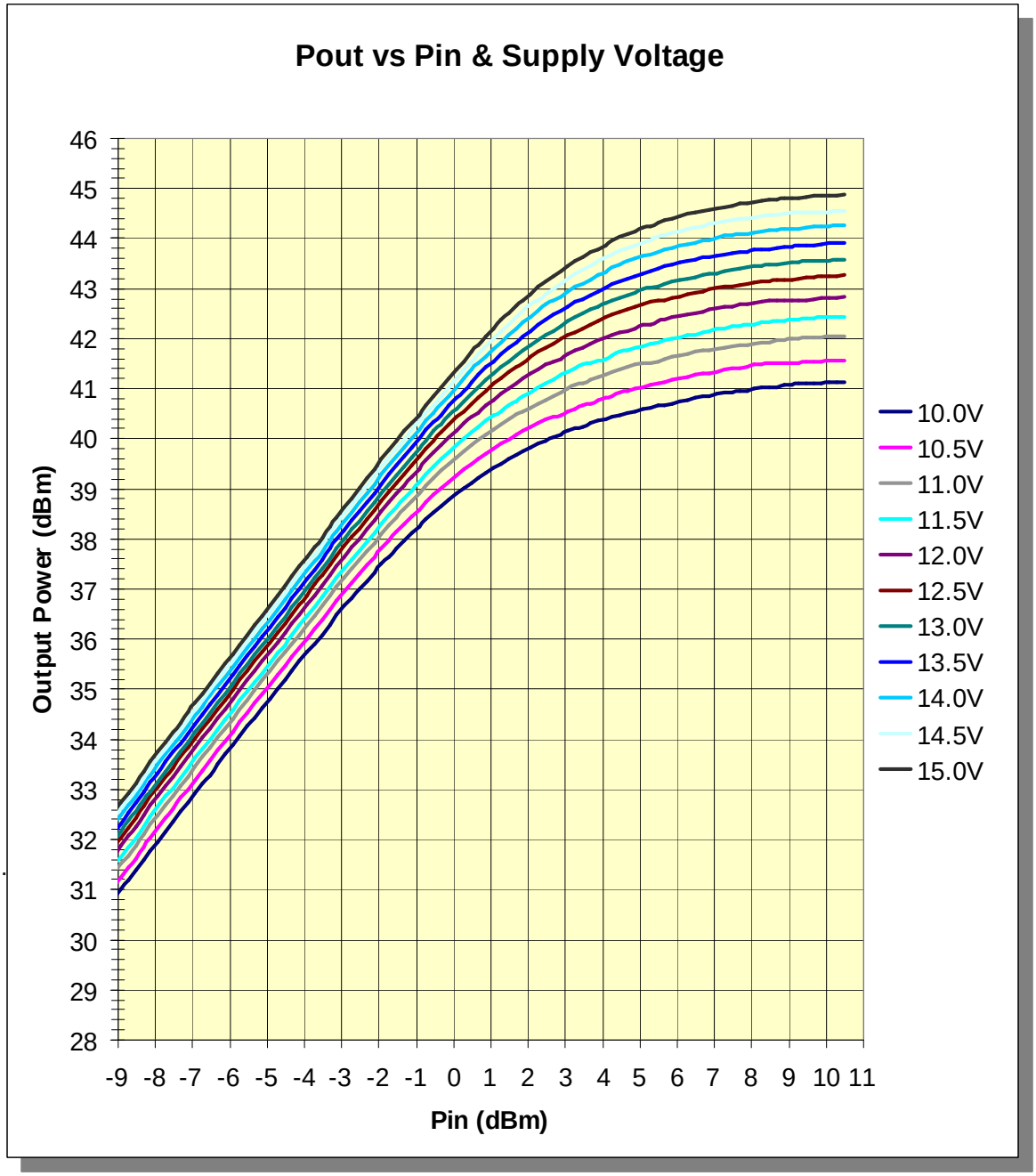
The first graph shows bias current, I_{DD}, versus voltage on the bias pin, VBIAS. The more interesting second chart shows what happens to the RF output as the Vgg changes. For this test the RF generator was set to +10dBm, so after the first stage gain, the input power to the module was about 24dBm. When Vgg is increased above the MOS threshold voltage the RF output increases substantially. The RF output power can be kept very low for safe Tx / Rx switching but the VBIAS must be kept below threshold, about 2.5 Volts.

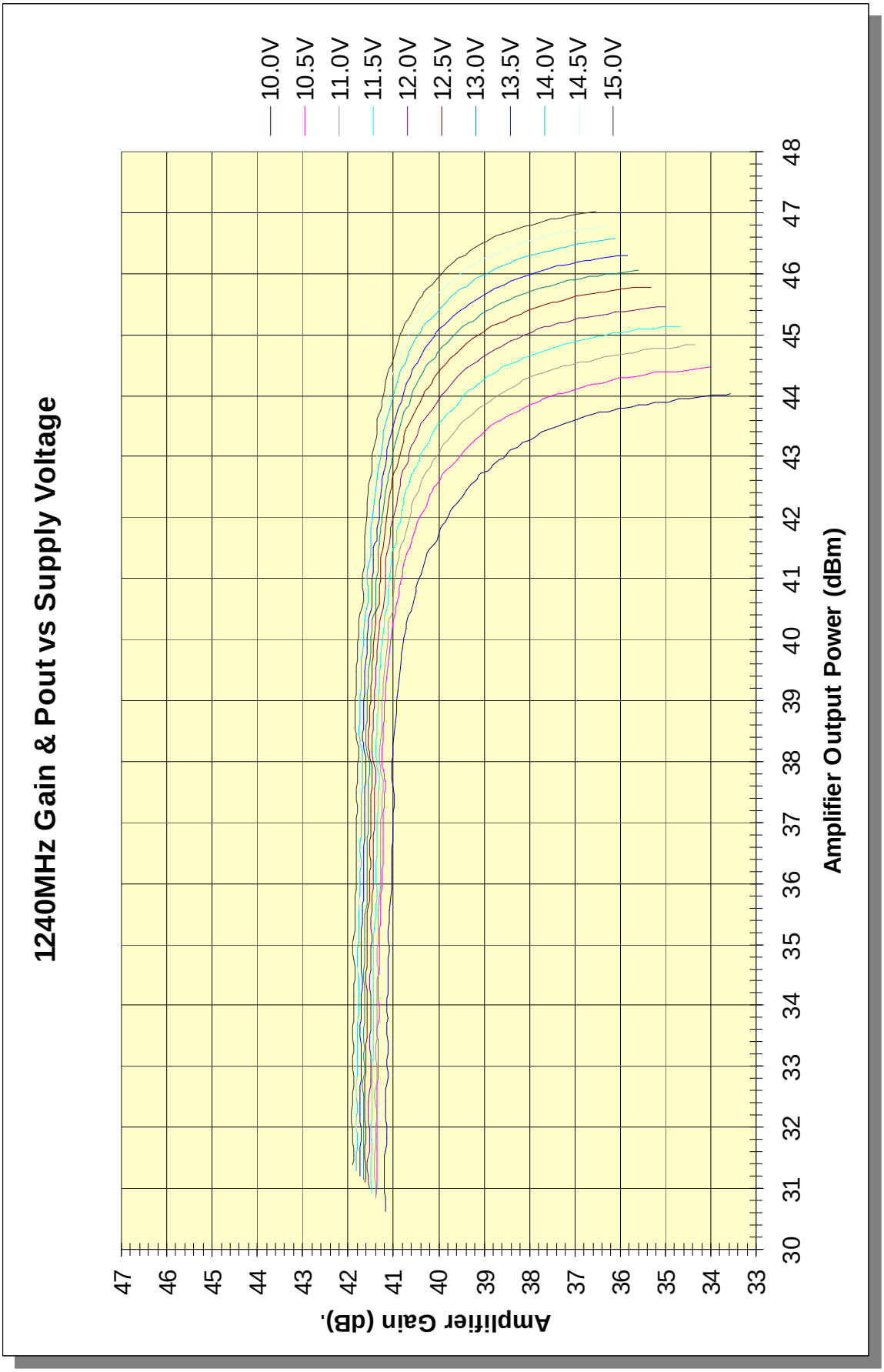


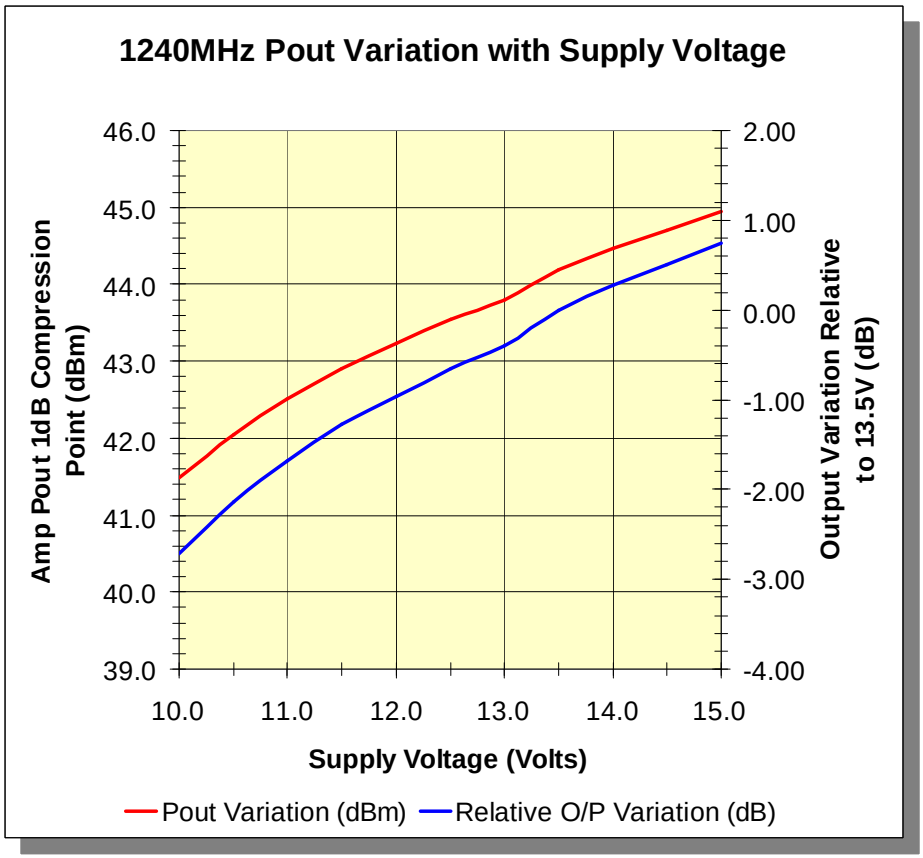


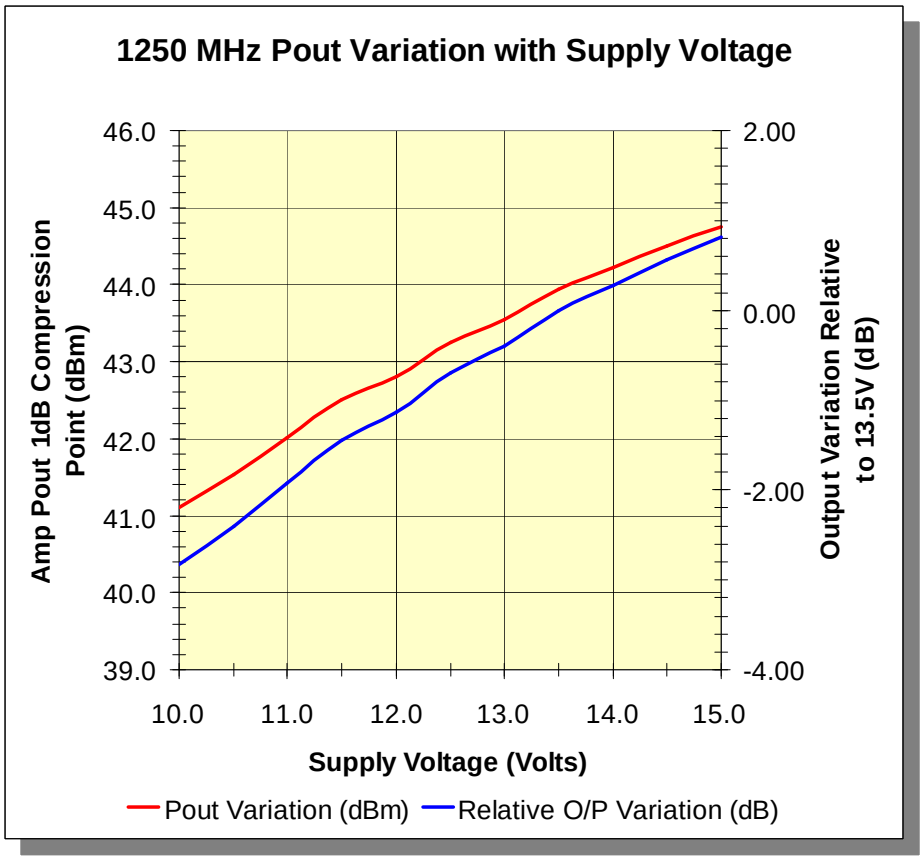
Amplifier Gain Change with Supply Voltage

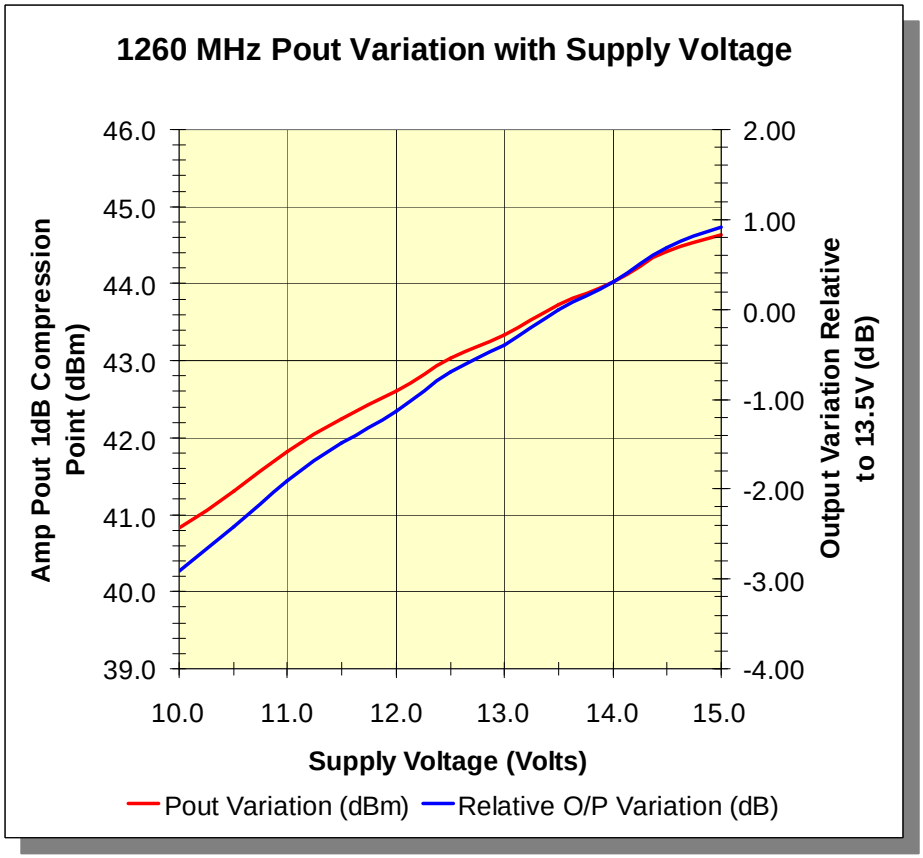
This amplifier is capable of operating across a supply range of 10 to 15 volts. The first stage amplifier's gain is held constant as its supply is derived from the nine volt LDO regulator. The RA18H1213G shows a more marked gain change over the supply voltage range. I've plotted the amplifier output power versus input power as well as gain and output power against supply voltage so that the 1dB gain compression point becomes easier to see. I've found the most useful plot however is the gain and 1dB compression point relative to a 13.5V reference. As the frequency increases the gain change and 1dB gain compression point variation over supply voltage becomes larger. At 1300MHz an additional 1dB gain can be realized by increasing the supply voltage to 15 volts, however there is a -3dB penalty in performance when operating at 10 volts.

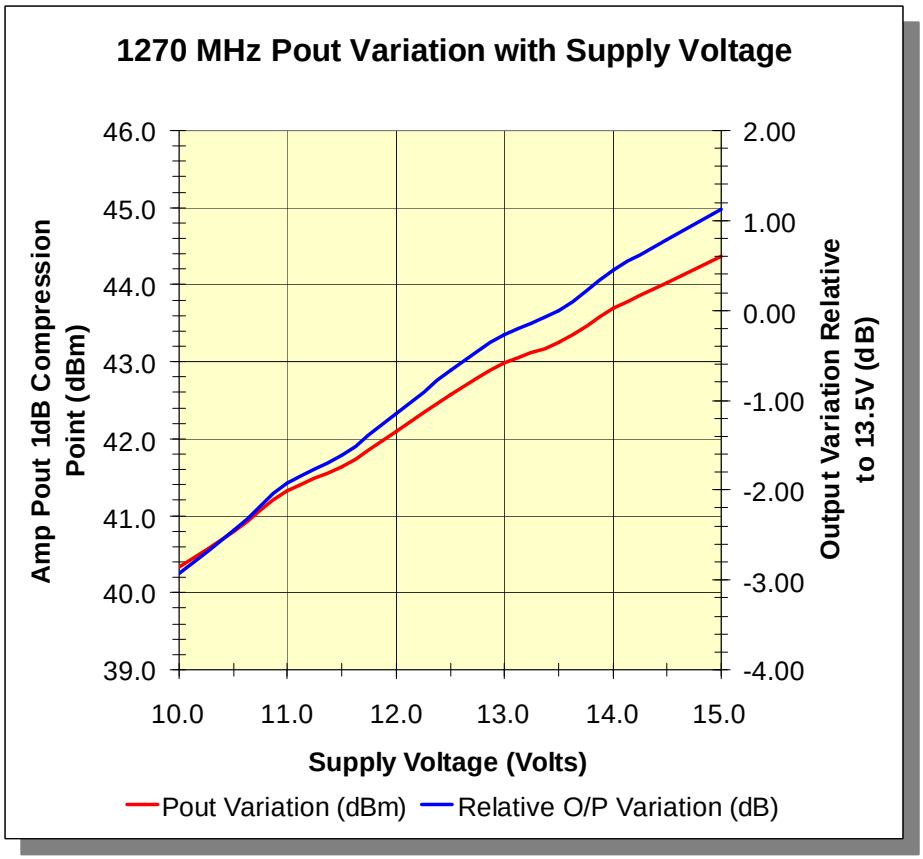


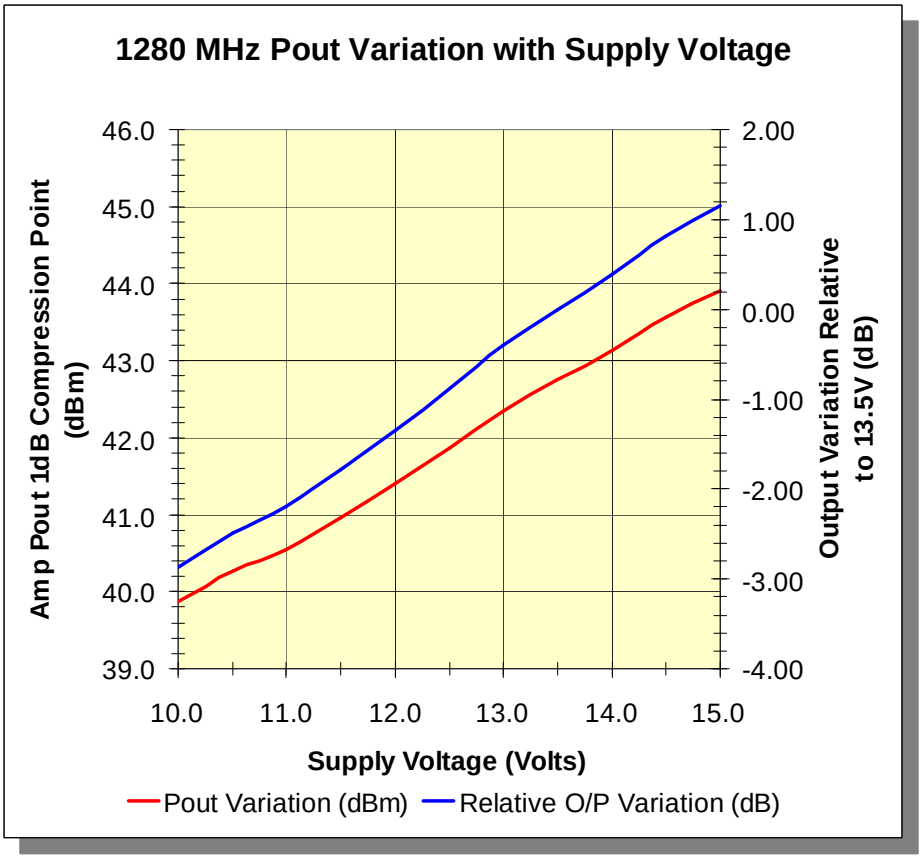

1240MHz Gain & Pout vs Supply Voltage
10.0V
10.5V
11.0V
11.5V
12.0V
12.5V
13.0V
13.5V
14.0V
14.5V
15.0V
Amplifier Gain (dB).
47 46 45 44 43 42 41 40 39 38 37 36 35 34 33
Amplifier Output Power (dBm)
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

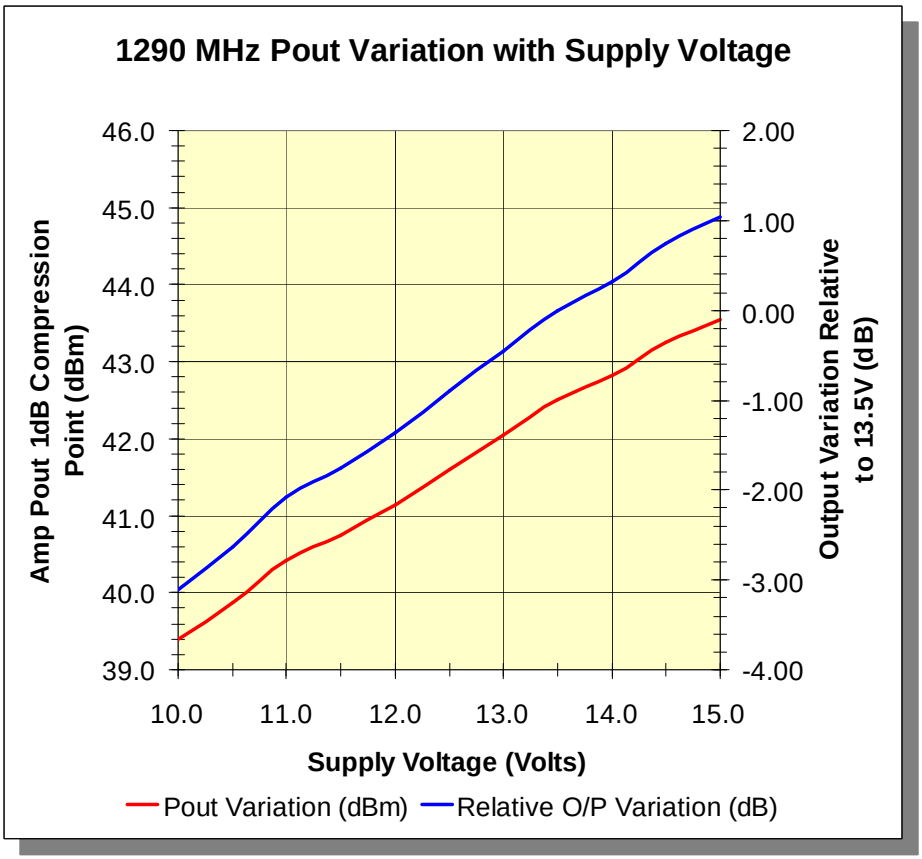

1240MHz Pout Variation with Supply Voltage
Amp Pout 1dB Compression Point (dBm)
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
Output Variation Relative to 13.5V (dB)
10.0
11.0
12.0
13.0
14.0
15.0
Supply Voltage (Volts)
Pout Variation (dBm)
Relative O/P Variation (dB)

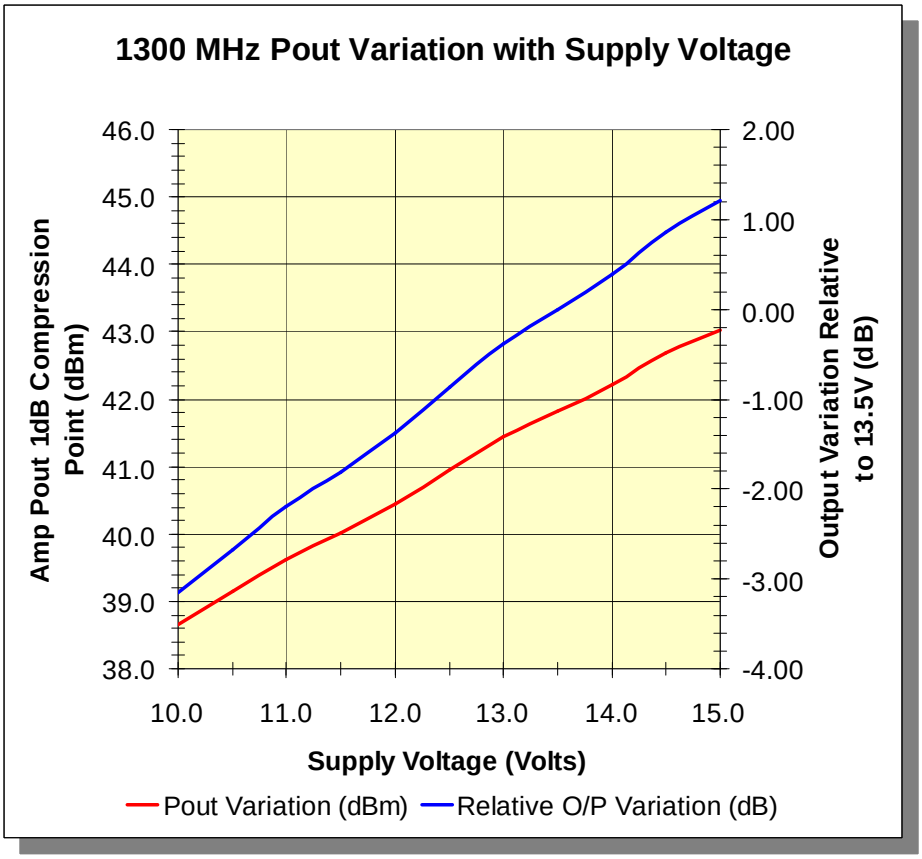

1250 MHz Pout Variation with Supply Voltage
Amp Pout 1dB Compression Point (dBm)
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
2.00
0.00
-2.00
-4.00
Output Variation Relative to 13.5V (dB)
10.0
11.0
12.0
13.0
14.0
15.0
Supply Voltage (Volts)
Pout Variation (dBm)
Relative O/P Variation (dB)


1260 MHz Pout Variation with Supply Voltage
Amp Pout 1dB Compression Point (dBm)
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
Output Variation Relative to 13.5V (dB)
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
10.0
11.0
12.0
13.0
14.0
15.0
Supply Voltage (Volts)
Pout Variation (dBm)
Relative O/P Variation (dB)


1270 MHz Pout Variation with Supply Voltage
Amp Pout 1dB Compression Point (dBm)
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
Output Variation Relative to 13.5V (dB)
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
10.0
11.0
12.0
13.0
14.0
15.0
Supply Voltage (Volts)
Pout Variation (dBm)
Relative O/P Variation (dB)


1280 MHz Pout Variation with Supply Voltage
Amp Pout 1dB Compression Point (dBm)
Output Variation Relative to 13.5V (dB)
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
10.0
11.0
12.0
13.0
14.0
15.0
Supply Voltage (Volts)
Pout Variation (dBm)
Relative O/P Variation (dB)


1290 MHz Pout Variation with Supply Voltage
Amp Pout 1dB Compression Point (dBm)
Output Variation Relative to 13.5V (dB)
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
10.0
11.0
12.0
13.0
14.0
15.0
Supply Voltage (Volts)
Pout Variation (dBm)
Relative O/P Variation (dB)


1300 MHz Pout Variation with Supply Voltage
Amp Pout 1dB Compression Point (dBm)
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
38.0
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
Output Variation Relative to 13.5V (dB)
10.0
11.0
12.0
13.0
14.0
15.0
Supply Voltage (Volts)
Pout Variation (dBm)
Relative O/P Variation (dB)