**EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**
**ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE**

**CERN - PS DIVISION**

**PS/RF/ Note 2001-005**

# 3 KW, 0.1-35 MHZ PULSED AMPLIFIER PS-RF/HC3289

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# 3 kW, 0.1-35MHz Pulsed Amplifier PS-RF/HC3289

## 1 - Description

The power amplifier is composed of two cascaded drivers and a power stage. The drivers cover the frequency range 50 kHz to 100 MHz (-3 dB) and provide 4 W and 30 W CW power respectively (fig.1 and fig.2). The output stage is constructed around a pulsed mode basic module which can provide a 2 ms rf burst of more than 450 W in the frequency range 0.1- 90 MHz with about 18 dB gain. The maximum allowed duty-cycle is ~0.5%. Two times four of these modules have been coupled together to provide 3 kW on 12.5 Ω from a 50 Ω source (fig.3 and fig 4). To reduce the harmonic distortion and increase output power and gain, the bias point is pulsed so as to operate the devices in class A. The bias transition takes about 1 ms when going from low to high gain but is smoother (~10 ms) when going in the opposite direction. The amplifier rest current is limited to less than 15 A and rises to some 40 A when the maximum CW power (200 W) is delivered to the load. In this condition the power dissipated by the power mosfets is very high so, to increase reliability, the supply voltage should possibly be reduced. This can either be obtained by programming the supply voltage or adjusting the power supply current limit so that the voltage drops to ~ 45~50 V. During the high power rf burst, the total supply current increases to about 160 A and the energy is furnished by a storage capacitor ( 0.1F). The short pulse-length and the low duty-cycle are such that the capacitor charge-up current is negligible allowing the use of a reduced size power supply.

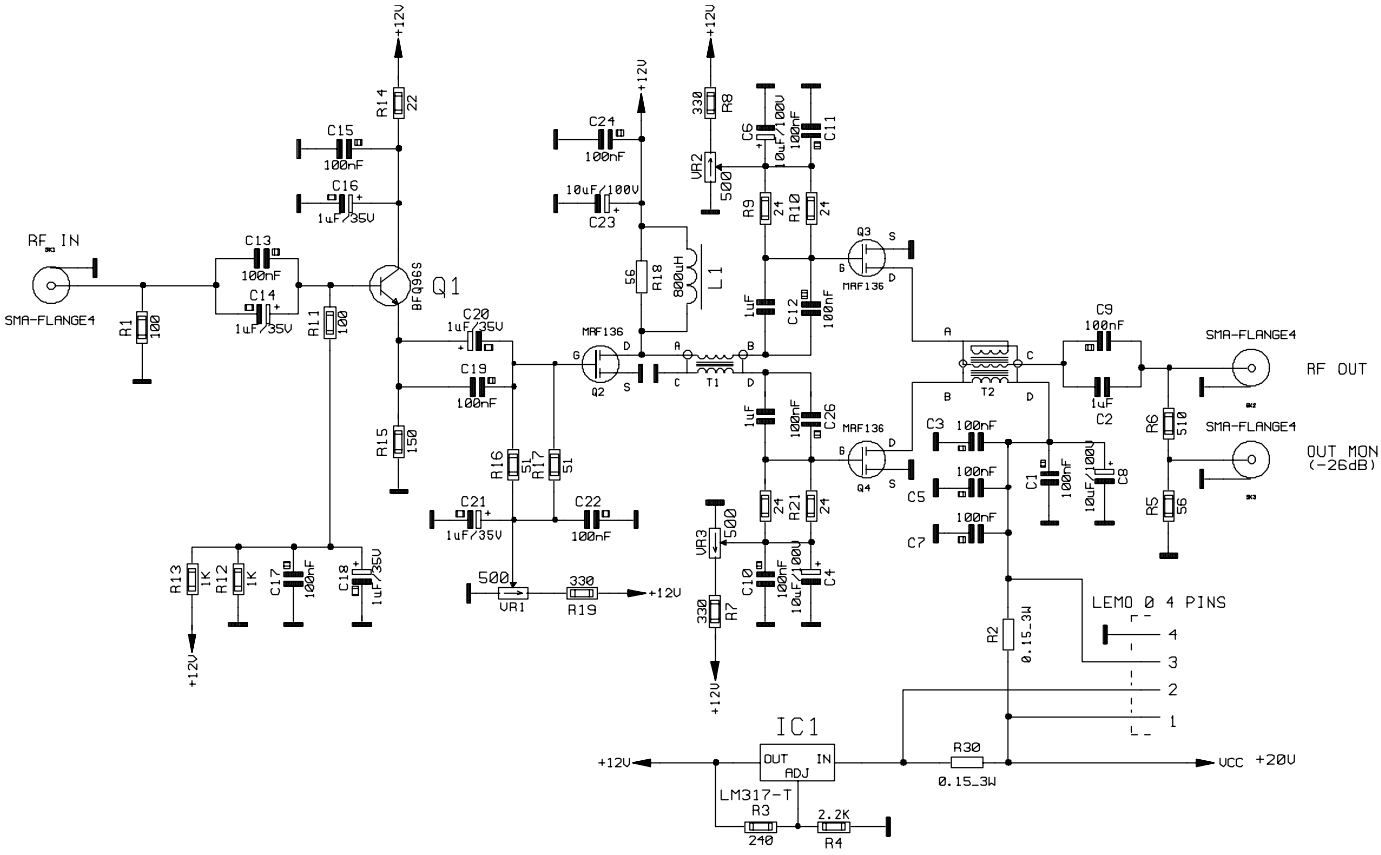


**Figure 1 – 4 W Amplifier (PS/RF-HC3256)**

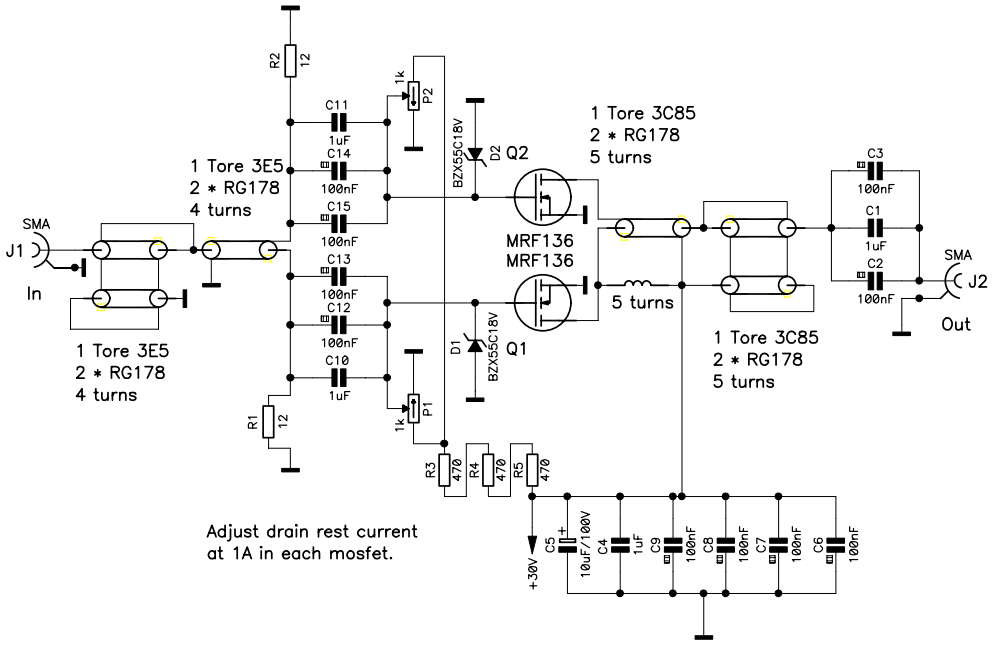


**Figure 2 – 30 W Amplifier (PS/RF-HC3288)**

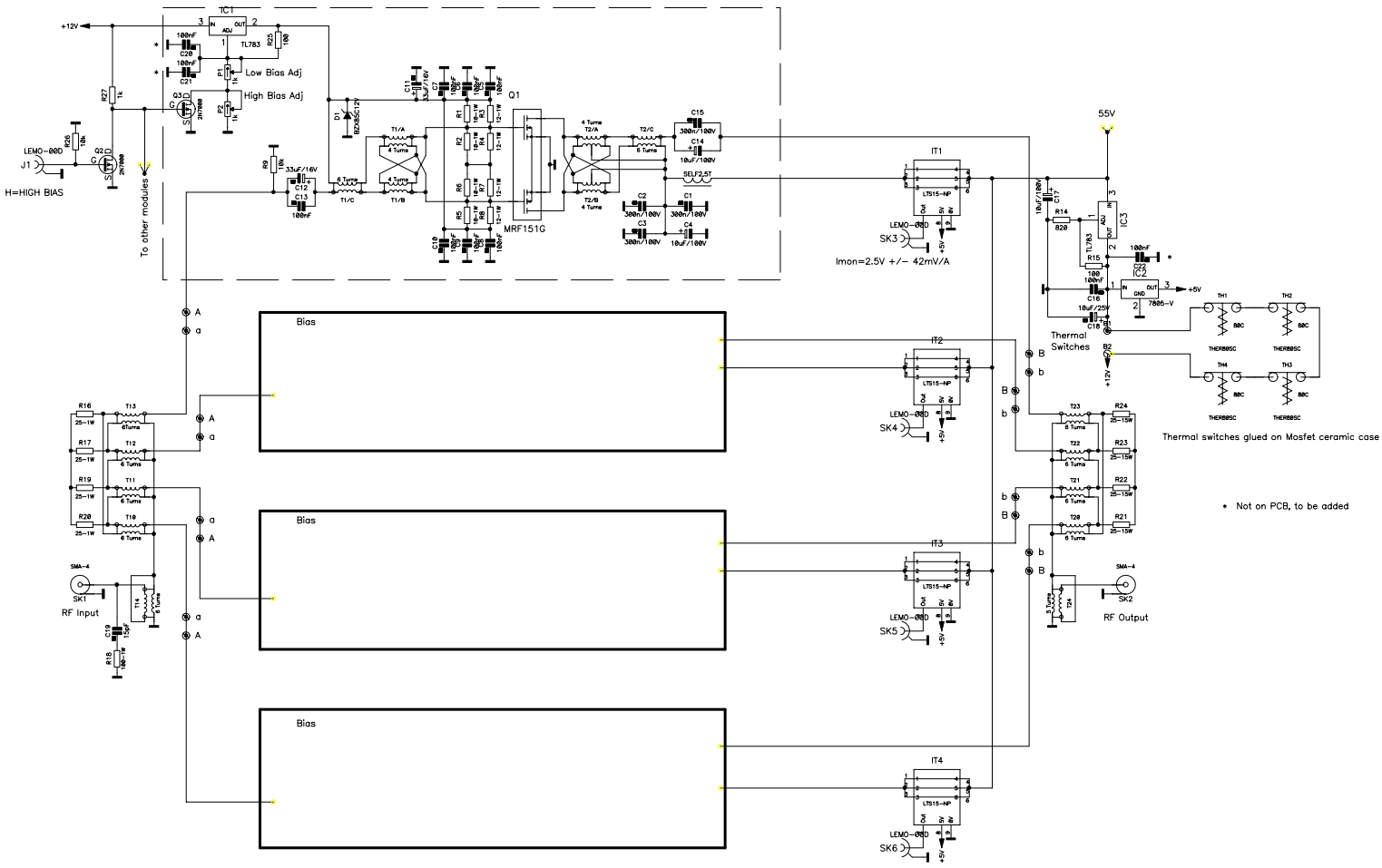


**Figure 3 – 1500 W Amplifier (PS/RF-HC3286)**

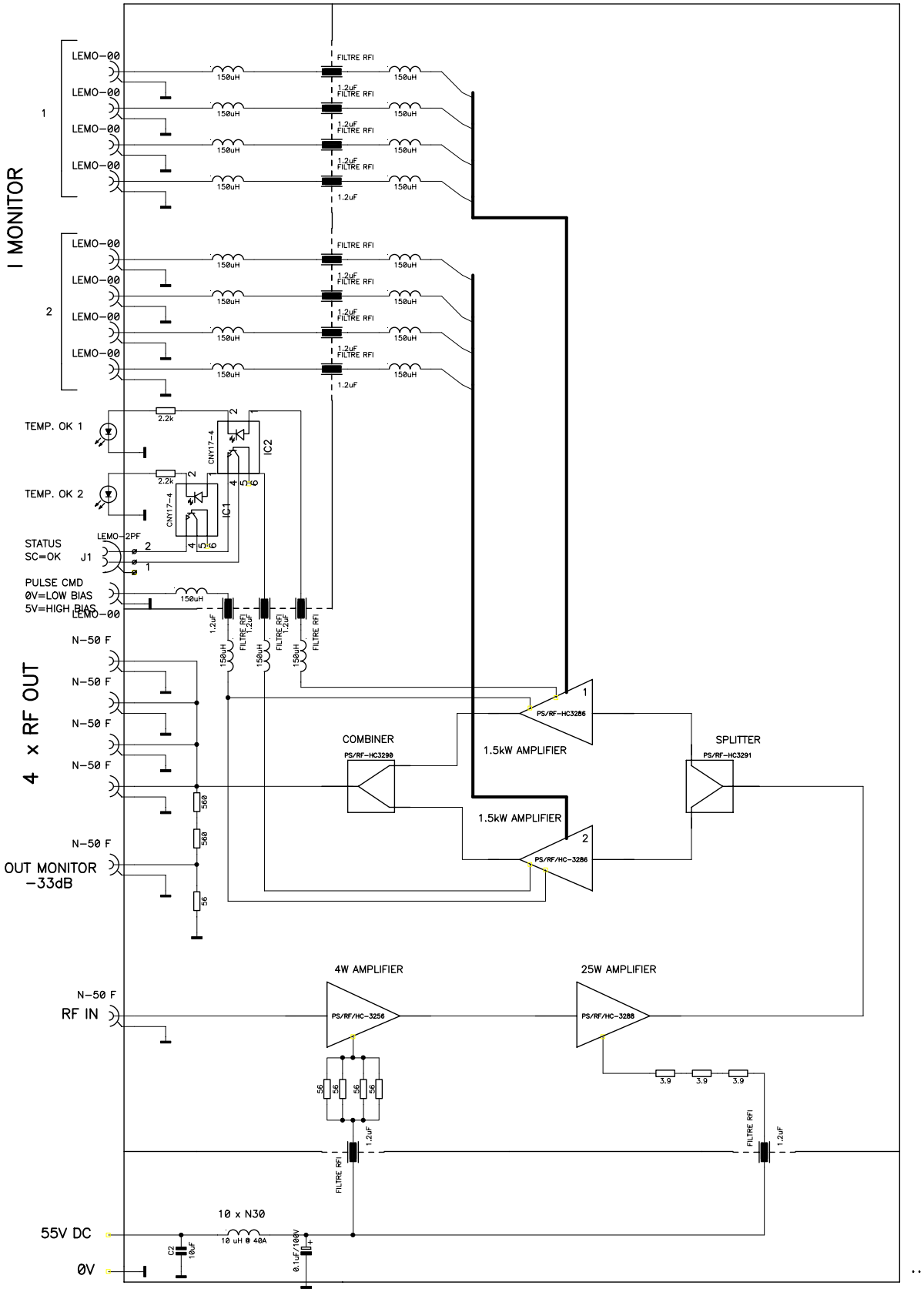


**Figure 4 – 3000 W Amplifier (PS/RF-HC3289)**

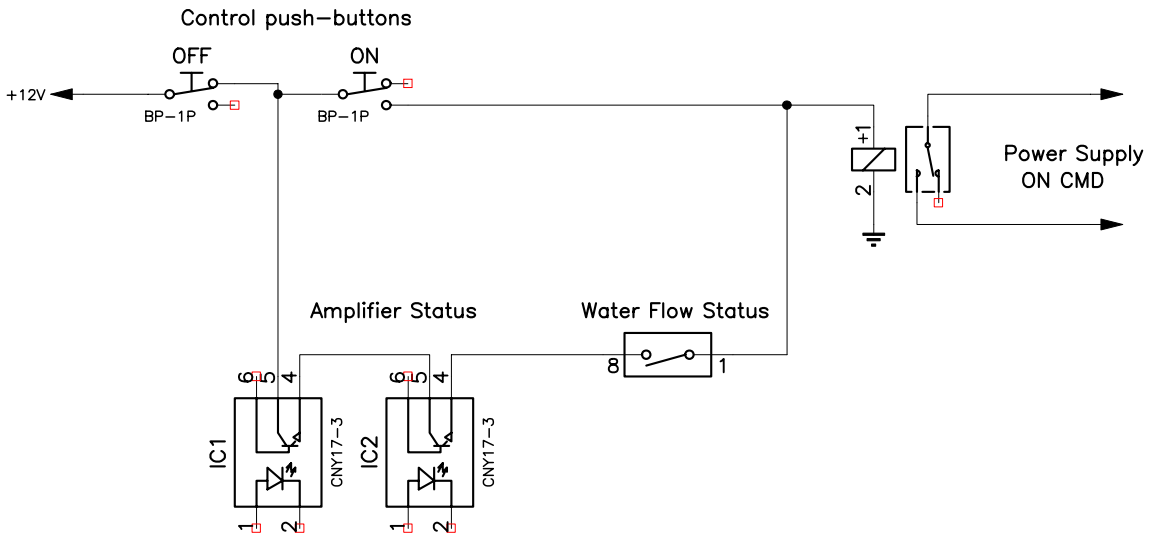


**Figure 5 – Suggested ON/OFF control principle**

**2 – Amplifier Characteristics**

| | | |
|---|---|---|
| Frequency Response | 100kHz – 35MHz<br>100kHz – 80MHz | High Bias Mode Pout=3kW<br>Low Bias Mode Low Level |
| Input Impedance | 50Ω | |
| Output Impedance | 12.5Ω | |
| 1dB Compression Output Power | >3kW<br>>2.2kW<br>200W | f>200kHz , 2ms RF Burst , 0.5% Duty-Cycle<br>f>100kHz , 2ms RF Burst , 0.5% Duty-Cycle<br>CW |
| Voltage Gain | 64dB<br>56dB | High Bias Mode<br>Low Bias Mode |
| Power Gain | 70dB<br>62dB | High Bias Mode<br>Low Bias Mode |
| Supply Voltage | 55V | |
| Supply Current | 40A | |
| Cooling Water | >3 litres/min | |
| Water Temperature | <30 °C | |

**Table 1 – Main Amplifier Characteristics**

| Freq. [MHz] | Saturated Power [W] | 1dB Comp. Point Power [W] | 2nd Harmonic Distortion @ 3kW [dBc] | 3rd Harmonic Distortion @ 3kW [dBc] |
|---|---|---|---|---|
| 0.1 | 3000 | 2200 | 25 | 18 |
| 0.2 | 3500 | 3200 | 25 | 20 |
| 0.5 | 4000 | 3600 | 30 | 20 |
| 1 | 4000 | 3600 | 30 | 20 |
| 5 | 4000 | 3600 | 30 | 20 |
| 10 | 3200 | 2800 | 30 | 15 |
| 20 | 4000 | 3300 | 25 | 20 |
| 35 | 3200 | 3000 | 25 | 20 |

**Table 2 – Output Power and Harmonic Distortion**

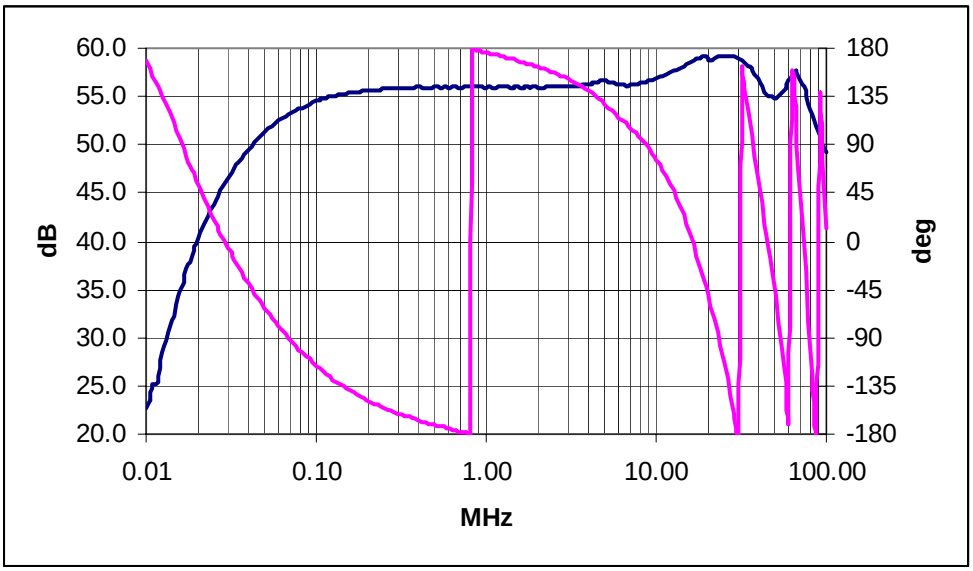


**Figure 6 – Amplifier Transfer Function in Low Bias Mode**

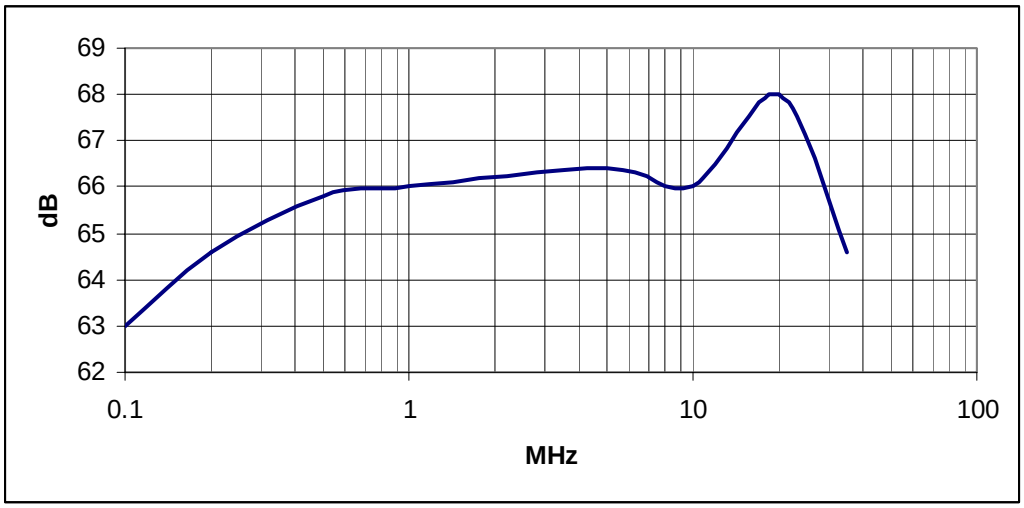


**Figure 7 – Amplifier Gain at 2 kW Output Power**

## 3 - Adjustment Procedure

| | |
|---|---|
| **1** | **<u>Preliminary Check</u>** |
| | |
| **1.1** | By visual inspection verify the amplifier does not present evident manufacture errors and that it is properly cleaned. |
| **1.2** | Supply the unit with cooling water (>3 litres/min). |
| **1.3** | Preset all VR1, VR2 pots in 1500 W modules (PS/RF-HC 3286) 15 turns CW. |
| **1.4** | Mount on each of the two 1500 W modules (PS/RF-HC 3286) 3 51 Ω resistor and a SMA connector between points ‘a’ and ground (see fig.3). |
| **1.5** | Mount on each of the two 1500 W modules (PS/RF-HC 3286) 3 51 Ω resistor and a SMA connector between points ‘B’ and ground (see fig.3). |

| 2 | **Drivers adjustment** |
|---|---|
| | |
| **2.1** | Disconnect power supply from 4 W module (PS/RF-HC 3256) and supply the module with 20 V from an external generator. |
| **2.2** | Adjust VR1 so as to read 46.5 mVacross R30. This corresponds to a 310 mA current in Q2. |
| **2.3** | Adjust VR2 so as to read 150 mVacross R2. This corresponds to a 1 A current in Q3. |
| **2.4** | Adjust VR3 so as to read 300 mVacross R2. This corresponds to a 1A current in Q4. |
| **2.5** | Disconnect power supply from 30 W module (PS/RF-HC 3288) and supply the module with 30 V from an external generator. |
| **2.6** | Adjust VR1 and VR2 so as to set the drain current in Q1 and Q2 to 1A |

| 3 | **Output Combiner Measurement** |
|---|---|
| | |
| **3.1** | Load with 50 Ω one of the SMA connectors mounted on 'B' points and use the other one as input for this measurement.<br>Load three of the amplifier outputs on 50 W and use the fourth one as output for the measurement.<br>Measure the transfer function (reference shown in fig. 8).<br>Repeat the measurement entering from the SMA connector mounted on the second 1500 W module. |
| **3.2** | Repeat 3.1 using the monitor connector and load all outputs on 50 Ω. Measurement reference is still figure 1 but output is now 33+/-0.5 dB lower (from 100 kHz to 40 MHz). |
| **3.3** | Remove all resistances and connectors from points 'B' and short circuit points 'b' 'B'. |

| 4 | **Power Supply Check** |
|---|---|
| | |
| **4.1** | Load all amplifier outputs on 50 Ω/250 W loads. |
| **4.2** | Slowly rise the power supply to 55 V and check that the current drawn is <500 mA |
| **4.3** | Check that the voltage at IC3 output is 11.5 V+/-0.5 V. |
| **4.4** | Check that the voltage at IC2 output is 5 V+/-0.1 V. |
| **4.5** | Check that leds 'Temp1' and 'Temp2' are on. |
| **4.6** | Check that all MRF151G gate voltages are <2.0 V |
| **4.7** | Bring voltage down from 55 V to 0 V and reconnect the power supply to the 4 W and 30 W modules. |
| **4.8** | Rise the voltage up to 55 V and verify the 4 W supply voltage is 23 V+/-1 V while the 30 W supply voltage is 30 V+/-1 V. |

| 5 | **Drivers Measurement** |
|---|---|
| | |
| **5.1** | Load on 50 Ω the SMA mounted on one of 'a' points and use the other one as output for the measurement. |
| **5.2** | Entering on the amplifier input connector, measure the drivers chain transfer function (Reference shown in figure 9).<br>Repeat using the second SMA connector as output. |
| **5.3** | Remove all resistances and connectors from points 'a' and short circuit points 'a' 'A`'. |

| 6 | **Final Stages Adjustment and Measurement** |
|---|---|
| | |
| **6.1** | Load amplifier input on 50 Ω |
| **6.2** | Verify that all Imon outputs are 2.5 V+/-25 mV |
| **6.3** | Adjust all VR1 so as to increase the Imon voltage by 42 mV+/-3 mV.<br>This corresponds to a 0.5 A rest current in each mosfet. |
| **6.4** | Measure the amplifier transfer function in low bias mode (Reference shown in figure 6). |
| **6.5** | Apply on the 'Pulse CMD' input a 5 V pulse with a length of 3 ms and a repetition rate of 1 s. |

| | |
|---|---|
| **6.6** | Using an oscilloscope connected on the 'Imon' outputs, adjust all VR2 on the 1500 W modules so as to get 3.33 V during the pulse (reference figure 10). |
| **6.7** | Using the rf burst mode test set-up shown in fig.11 measure the 1dB compression point at 200 kHz, 1 MHz, 10 MHz and 20 MHz (reference values in table 2). |
| **6.8** | Remove the 'Pulse CMD' signal. |

| | |
|---|---|
| **7** | **Labelling** |
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| **7.1** | Label the unit 'OK + Date' |

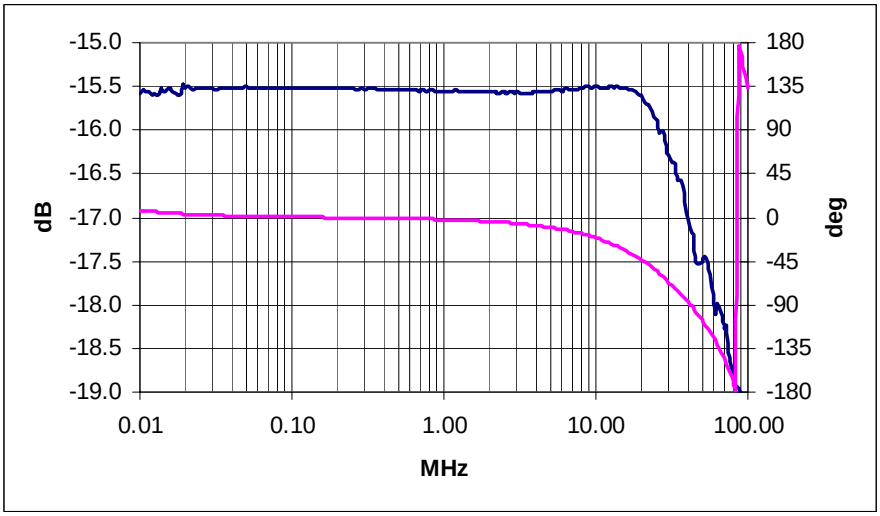


**Figure 8 – Output Combiner Transfer Function**

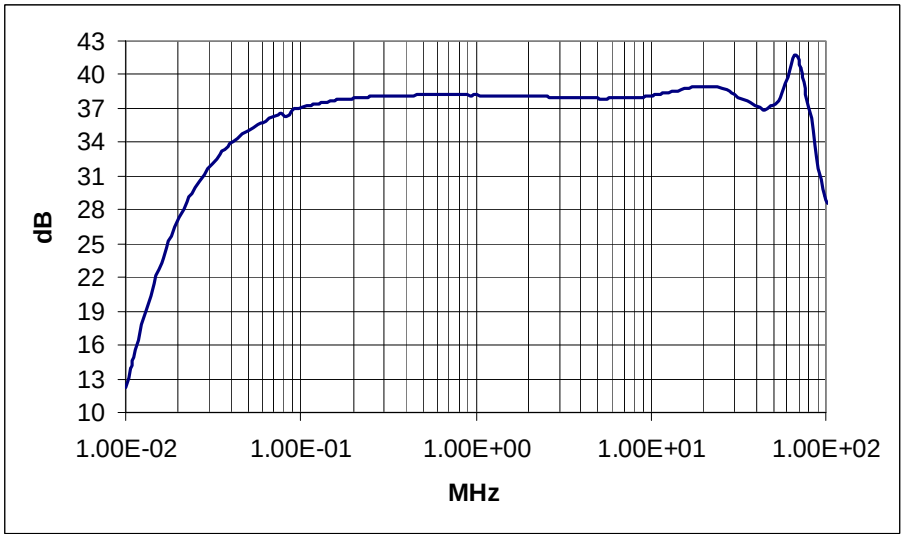


**Figure 9 – Input Drivers Transfer Function**

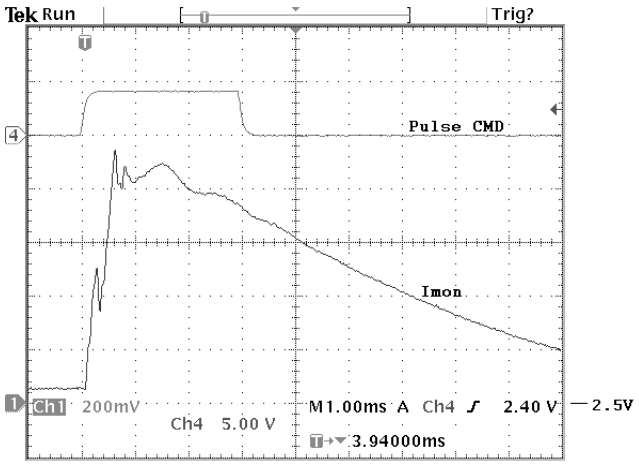


**Figure 10 – Bias Current Monitor**

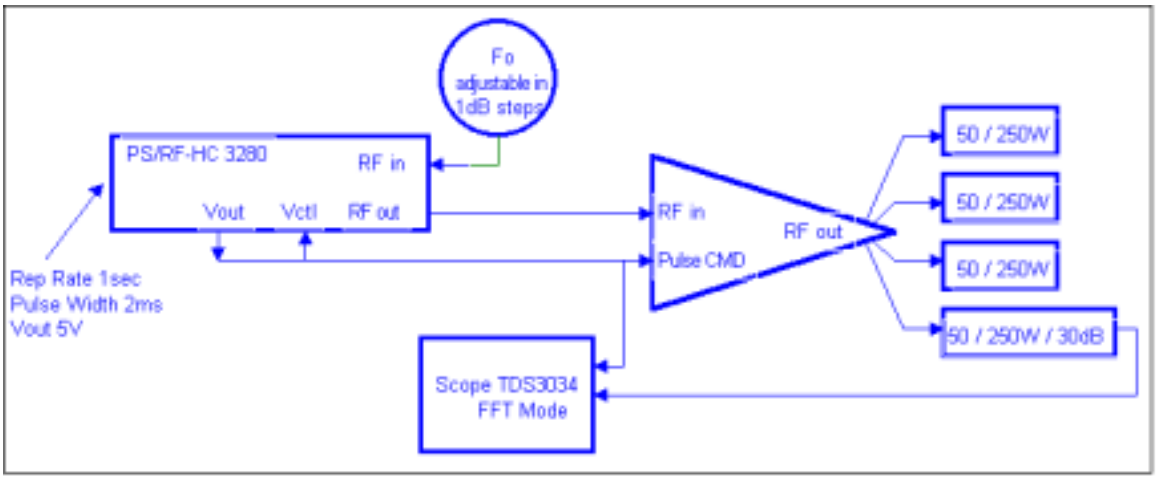


**Figure 11 – RF Burst Mode Test Set up**