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CERN - PS DIVISION

PS/RF/ Note 2002-046

400W, 0.5 TO 80 MHZ, 54DB AMPLIFIER

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1. Circuit Description

This power amplifier (fig.1.1) is intended for use as driver stage in the PS C13/20 RF system and is mainly composed of modules previously developed for the PSB RF systems.

The input signal is applied to SK1 and amplified by the driver stage (PS/RF-HC3256). Monitoring of the signal at the driver output is provided on the amplifier's front panel (SK2) with 26dB attenuation. The signal is then applied to the splitter (PS/RF-HC3285B), the four 100W power stages (PS/RF-HC 3115) and combined (PS/RF-HC3285A) before reaching the front panel output connector (SK3). Monitoring of the RF output voltage is also available on the amplifier's front panel (SK4) with 40dB attenuation.

The driver stages active devices are operated in class A while the power stages are operated in class AB. Detailed description of the amplifier modules is provided in the following notes:

- PS/RF-HC3115 100W Module PS/RF/Note 94-32
- PS/RF-HC3256 4W Module PS/RF/Note 97-15

The amplifier is water-cooled and thermal protection insured by thermal switches mounted on the final stage power mosfets. Experience proved that the gate bias thermal compensation originally foreseen in the 100W modules is not required, so that the NTC sensors have been simply replaced by 10kΩ resistors.

Sensing of all supply voltages is performed after the protection fuses. Front panel indication of the power supplies and temperature status is provided.

A 19-pin burndy connector (SK6) allows remote acquisition of different current intensities in the modules, thermal protection and power supply status. It also allows the reduction of power stages gain by ~20dB via the 'GAIN ON/OFF'.

Connection to the power supply is done through a 12-pin burndy (SK5) connector that allows remote sensing.

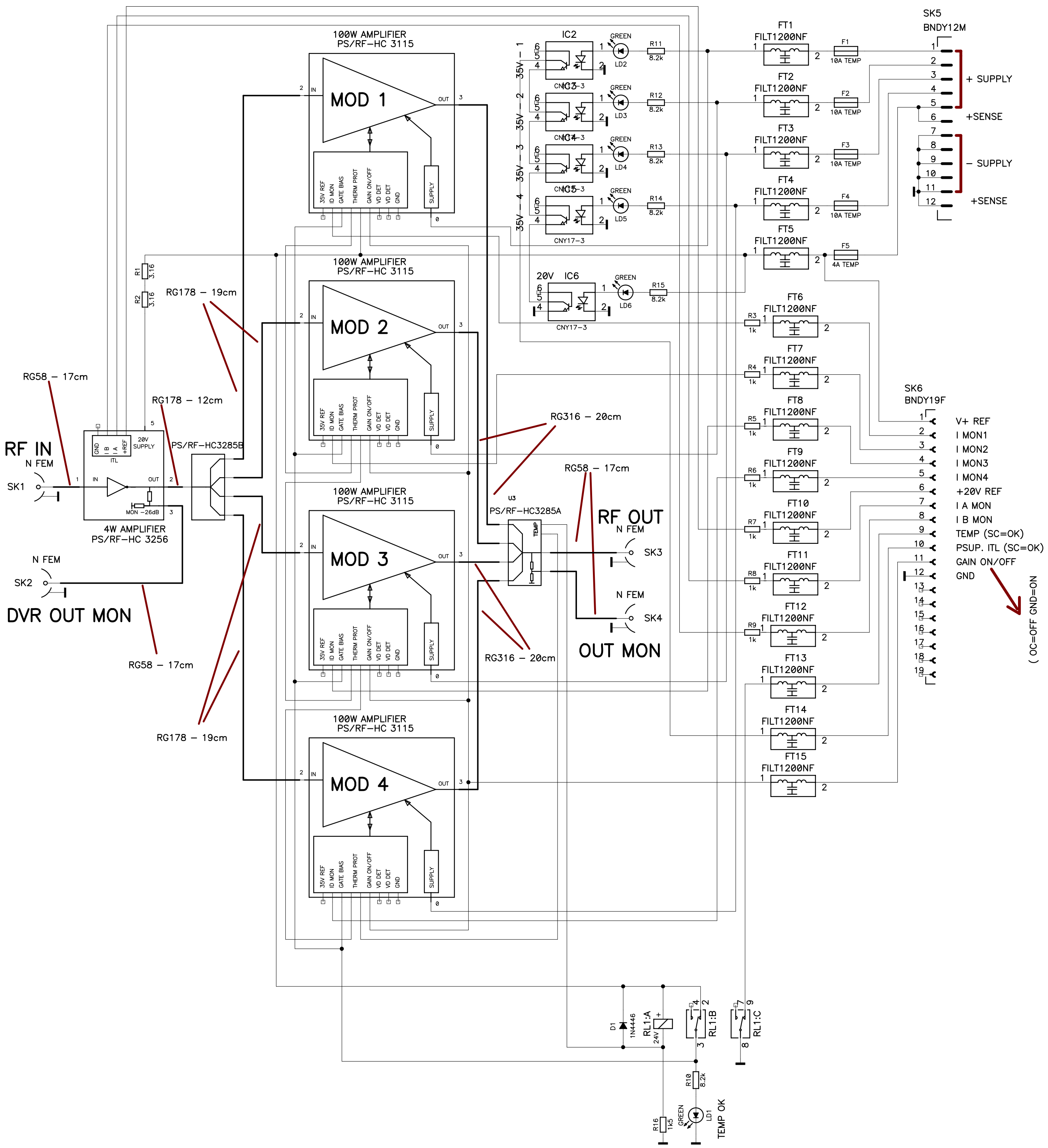


Fig.1.1 – 400W Amplifier

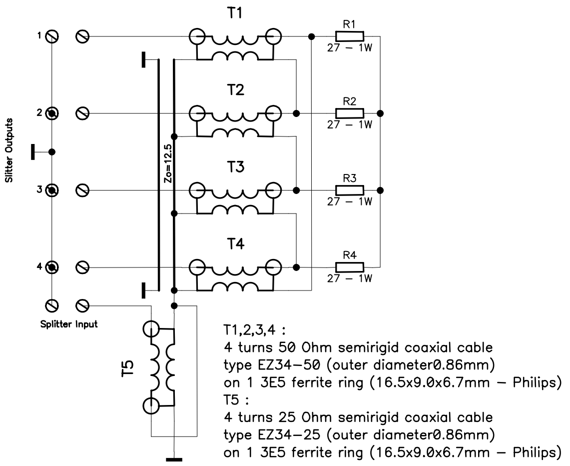


Fig.1.2 – RF Splitter

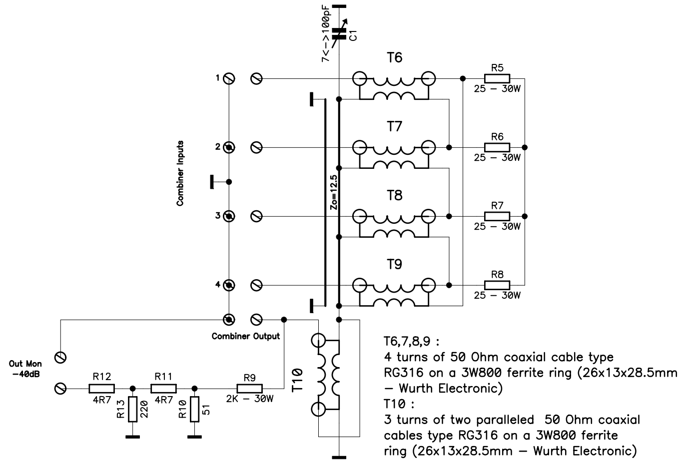


Fig.1.3 – RF Combiner

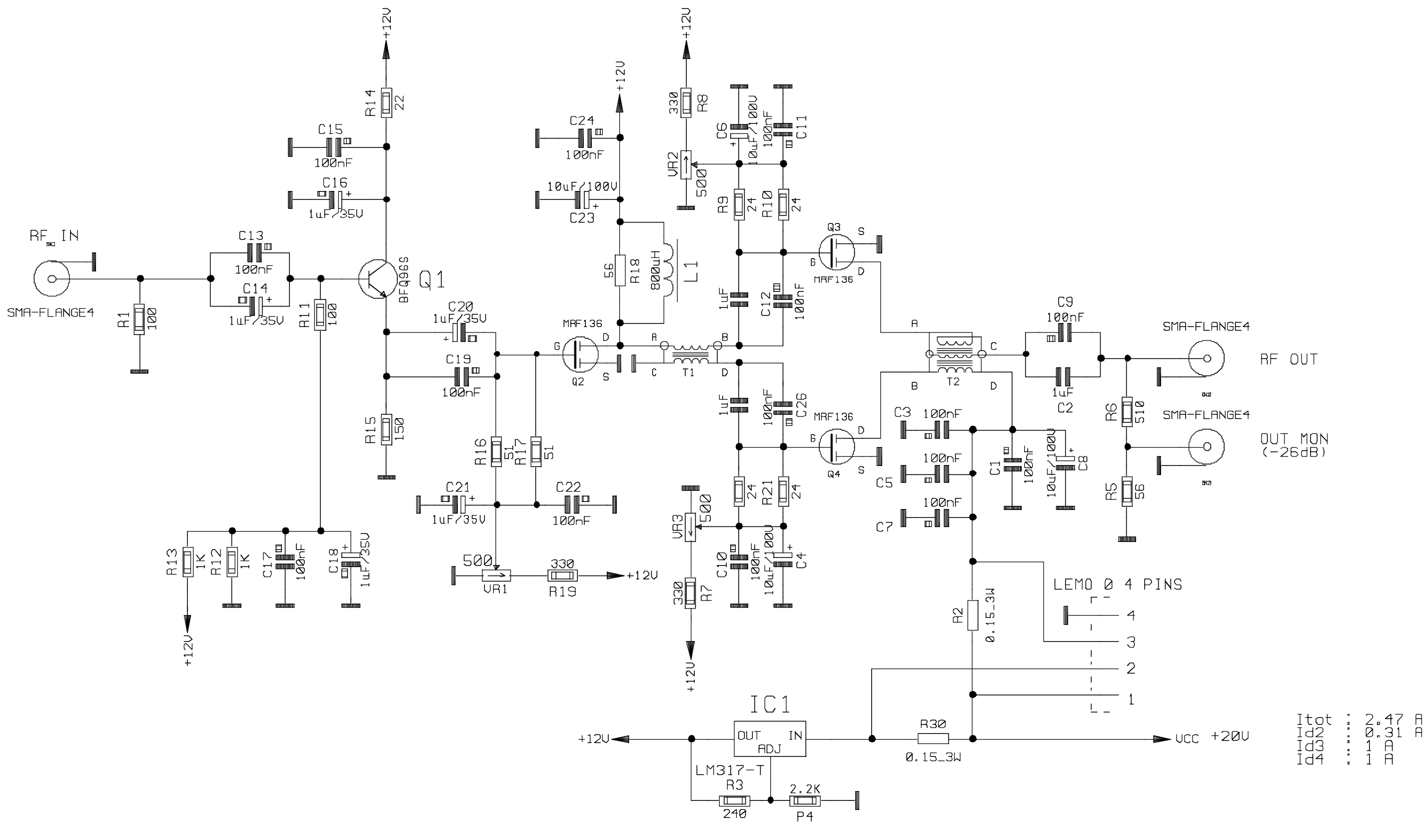


Fig.1.4 – Driver Stage

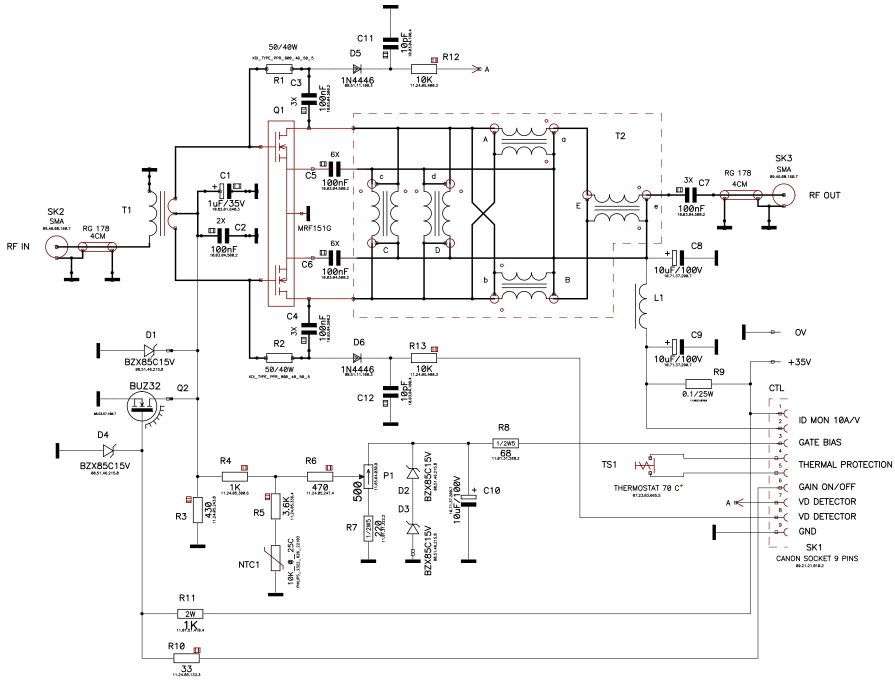


Fig.1.5 – Power Stage

2. Main Characteristics

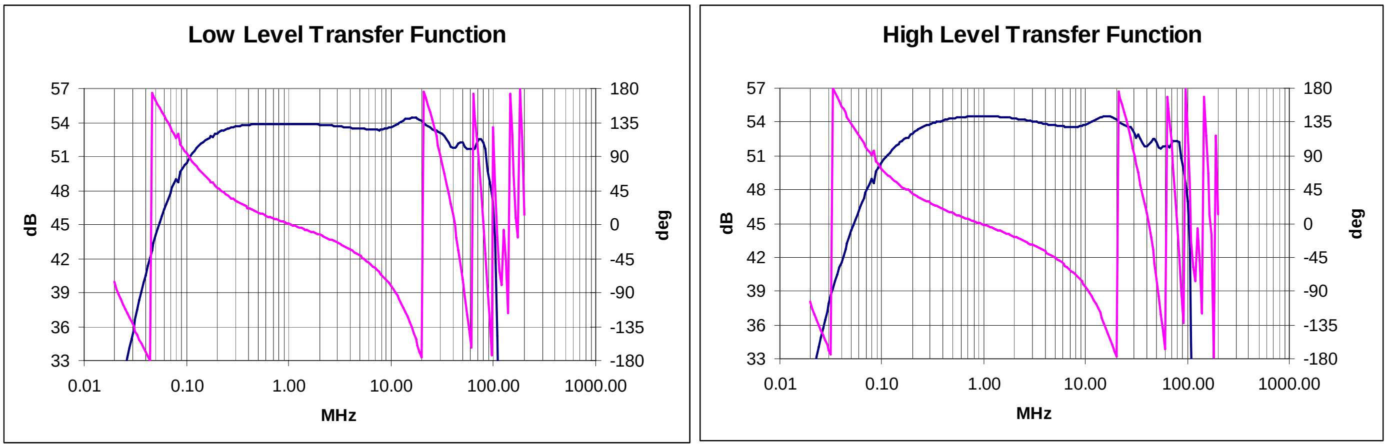


Fig. 2.1 – Low and High Level Transfer Functions

Table 2.1 – Main Amplifier Characteristics

Supply Voltage	:	35 V		
Supply Current	:	45 A max		
-3dB Bandwidth	:	150 kHz to 80 MHz		
Gain	:	54+/-1 dB		
Output Power	:	50W	CW	150 KHz to 80 MHz
		100W	CW	0.5 MHz to 80 MHz
		400W	Duty-Cycle 20%	0.5 MHz to 80 MHz
Harmonic Distortion	:	0.5 MHz	-35dBc@100W	-32dBc@400W
		1 MHz	-35dBc@100W	-32dBc@400W
		10 MHz	-35dBc@100W	-20dBc@400W
		20 MHz	-25dBc@100W	-20dBc@400W
		50 MHz	-30dBc@100W	-26dBc@400W
		80 MHz	-32dBc@100W	-28dBc@400W
Gain Linearity	:	+/-0.5 dB		
Group Delay	:	<30ns	f>3 MHz	
		<60ns	f>1 MHz	
		<150ns	f>500 kHz	
Input Impedance	:	50 Ω	Return Loss<20dB	
Output Impedance	:	50 Ω		
Cooling Water	:	Tmax 35°C		
		4 litres/min		
RF connectors	:	N		
Power Supply Connector	:	Burndy 12-pins male		
Remote Ctl/ST Connector	:	Burndy 19-pins female		
RF Monitors	:	Output Voltage [–40dB]		
		Driver Output [–26dB]		
Other Monitors	:	Driver Input Stage Current [6.67A/V]		
		Driver Output Stage Current [6.67A/V]		
		Power Stage Current [10A/V]		
		Supply Voltage		
		20V Supply		
		Temperature Protection Status		
		Power Supply Status		

Adjustment Procedure

1	**Preliminary Check**
1.1	By visual inspection verify that the amplifier does not present evident manufacture errors and is properly cleaned.
1.2	Remove all fuses
1.3	Turn water on (4 litres per minute minimum)
1.4	Preset potentiometers as follows: • VR1, VR2, VR3 in driver module (PS/RF-HC 3256) 15 turns CW. • P1 in power stages (PS/RF-HC 3115) 15 turns CCW.
1.5	Load RF Output connector with 1kW, 50Ω load.
1.6	Load RF Input connector with 50Ω load.

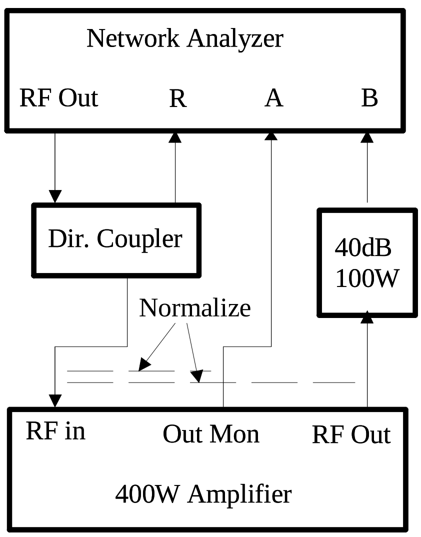
2	**Driver Adjustment**
2.1	Insert F5 (4A)
2.2	Sort circuit the two 3.16Ω resistors in series with the driver supply connection (R1, R2 of PS/RF-HC3296).
2.3	Slowly rise the supply voltage to 20+/-0.5V always verifying that the current stays below 200mA.
2.4	Verify the 12V supply in the driver module is precise within +/- 1V.
2.5	Verify that Q3, Q4 drain voltage corresponds to the input voltage.
2.6	Adjust VR1 so as to obtain 63+/-1mV between measure points 1 and 2. This corresponds to a current of 420mA at IC1 output and 330mA of Q2 drain current.
2.7	Adjust VR2 so as to obtain 150+/-2mV between measure points 1 and 3. This corresponds to 1A current in Q3 drain.
2.8	Adjust VR3 so as to obtain 300+/-2mV between measure points 1 and 3. This corresponds to 1A current in Q4 drain.
2.9	Switch power supply off.
2.10	Remove short circuit across the two 3.16Ω resistors.

3	**Final Stages Adjustment**
3.1	Insert F1, F2, F3, F4 (10A)
3.2	Slowly rise the supply voltage to 35+/-0.5V always verifying that the current stays below 3A.
3.3	Verify that the driver supply voltage is 20+/-1V.
3.4	Adjust P1 in each power stage so as to read 100mV+/-10mV across the corresponding 100mΩ resistor.
3.5	Readjust P1 after some minutes so as to compensate for temperature changes.
3.6	Switch power supply off.

4	**Amplifier Response Adjustment**
4.1	Prepare test set-up as shown in fig. 3.1.
4.2	Turn on the power supply (35V)
4.3	Measure the amplifier transfer function with an RF input level below-10dBm. Reference is given in fig. 2.1. If necessary adjust C1 in the output combiner so as to obtain the required response.
4.4	Verify that the signal at the output monitor does not deviate more that +/-0.5dB in comparison with the output signal.
4.5	Switch power supply off.

5	**Amplifier Output Power Measurement**
5.1	Prepare test set-up as shown in fig. 3.1.
5.2	Turn on the power supply (35V)
5.3	Set generator centre frequency to the values listed in fig. 2.1 at the harmonic distortion specification and measure at the two power levels. Note: Operation as to be limited in time according to the output power specification listed in the table mentioned above.
5.4	Switch power supply off.

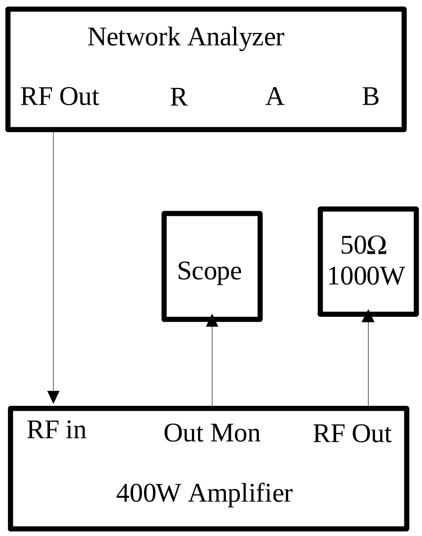
6	**Labelling**
6.1	Put a drop of paint on each potentiometer.
6.2	Label the module ‘Date+OK’.



Settings:

- Log sweep 20kHz to 200MHz
- Pout –6dbm
- Measure A/R and B/R
- Note that measured values for B/R give actual gain while measured values for A/R are 40dB below.

Fig. 3.1 Transfer Function Measurement Set-up



Settings:

- Use Tektronix TDS300 series with 300MHz bandwidth or equivalent.
- Use network analyzer as fixed frequency generator (set span to 1 Hz).
- Scope input impedance 50Ω
- Measured values on the scope have to be scaled to 100V/V (100Vpeak – 100W, 200Vpeak – 400W).
- Use FFT function to check harmonic distortion

Fig. 3.2 Output Power Measurement Set-up