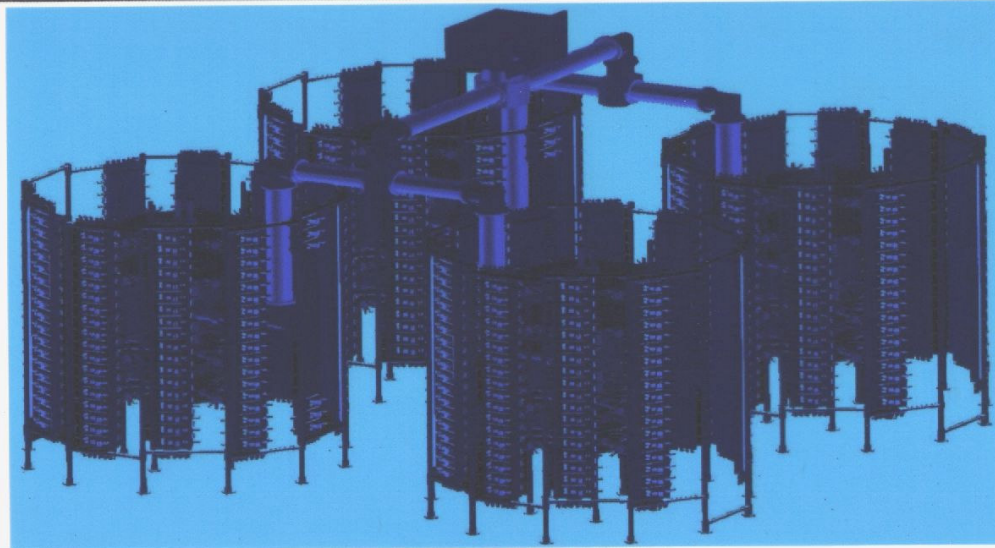


200 kW 352 MHz Amplifier Design for Soleil



Ti RUAN

Robert Lopes

Patrick Marchand

Jean Polian

Fernand Ribeiro

Catherine Thomas-Madec

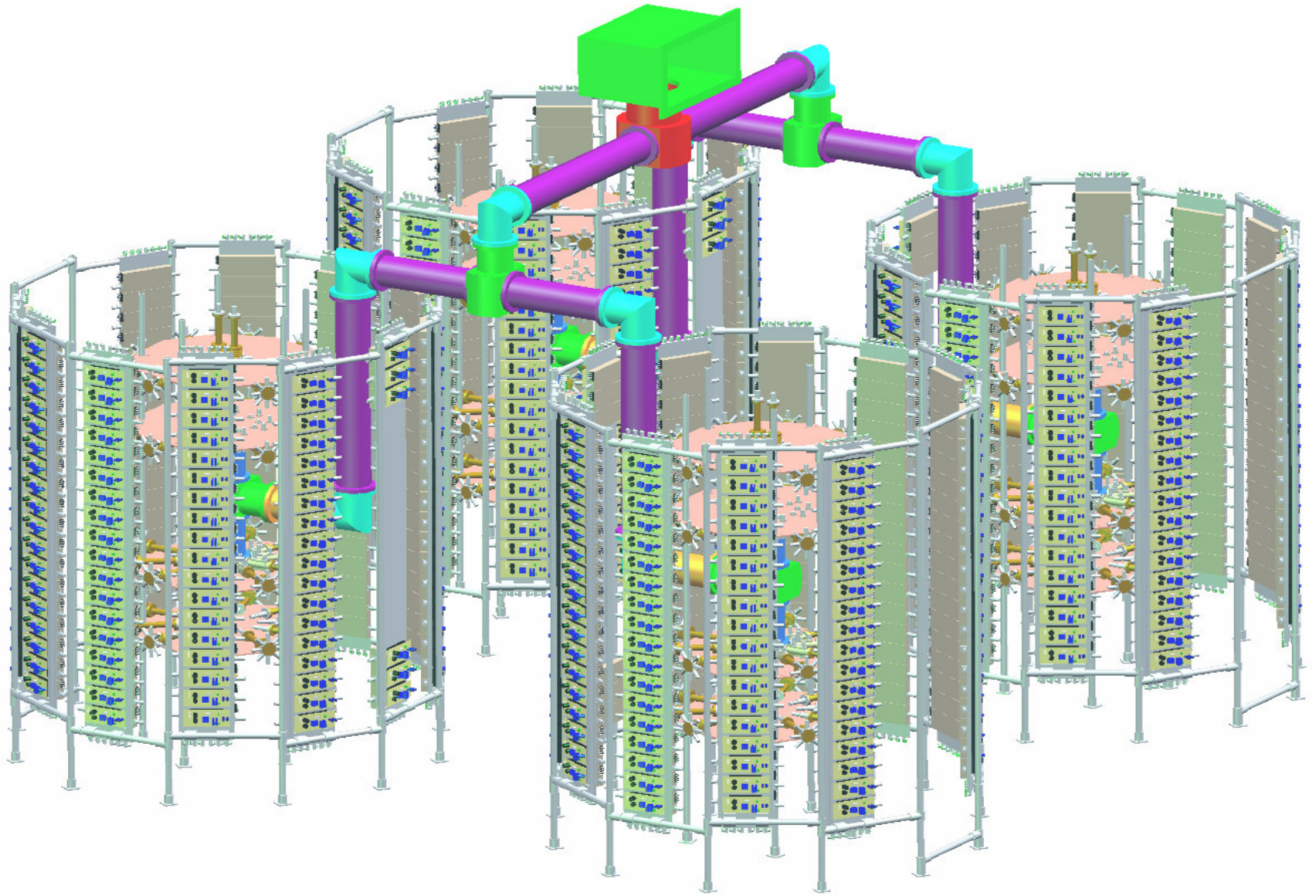
ESLS 7th – 16/10/2003



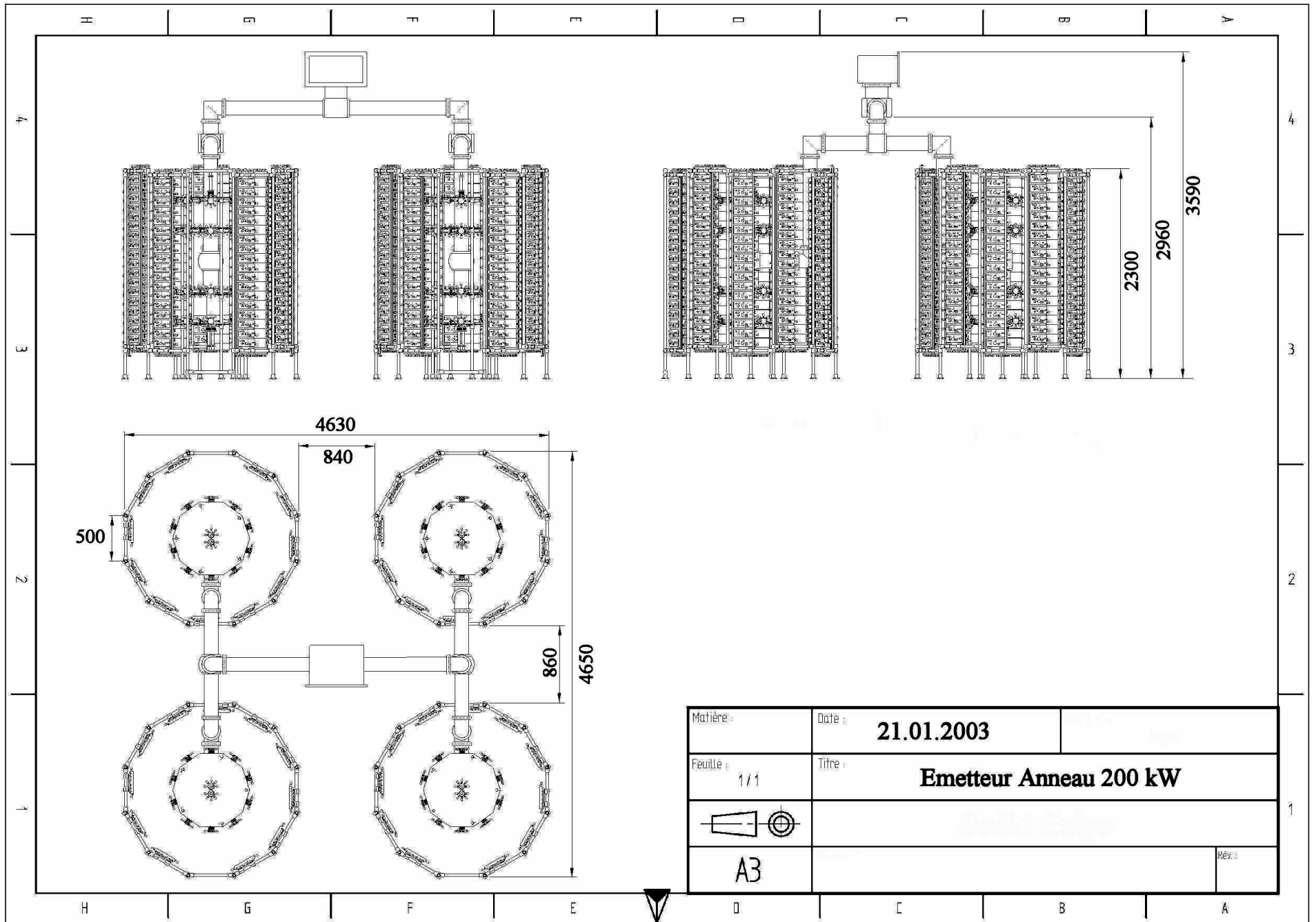
200 kW 352 MHz Amplifier Design for Soleil

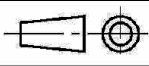
1) Configuration

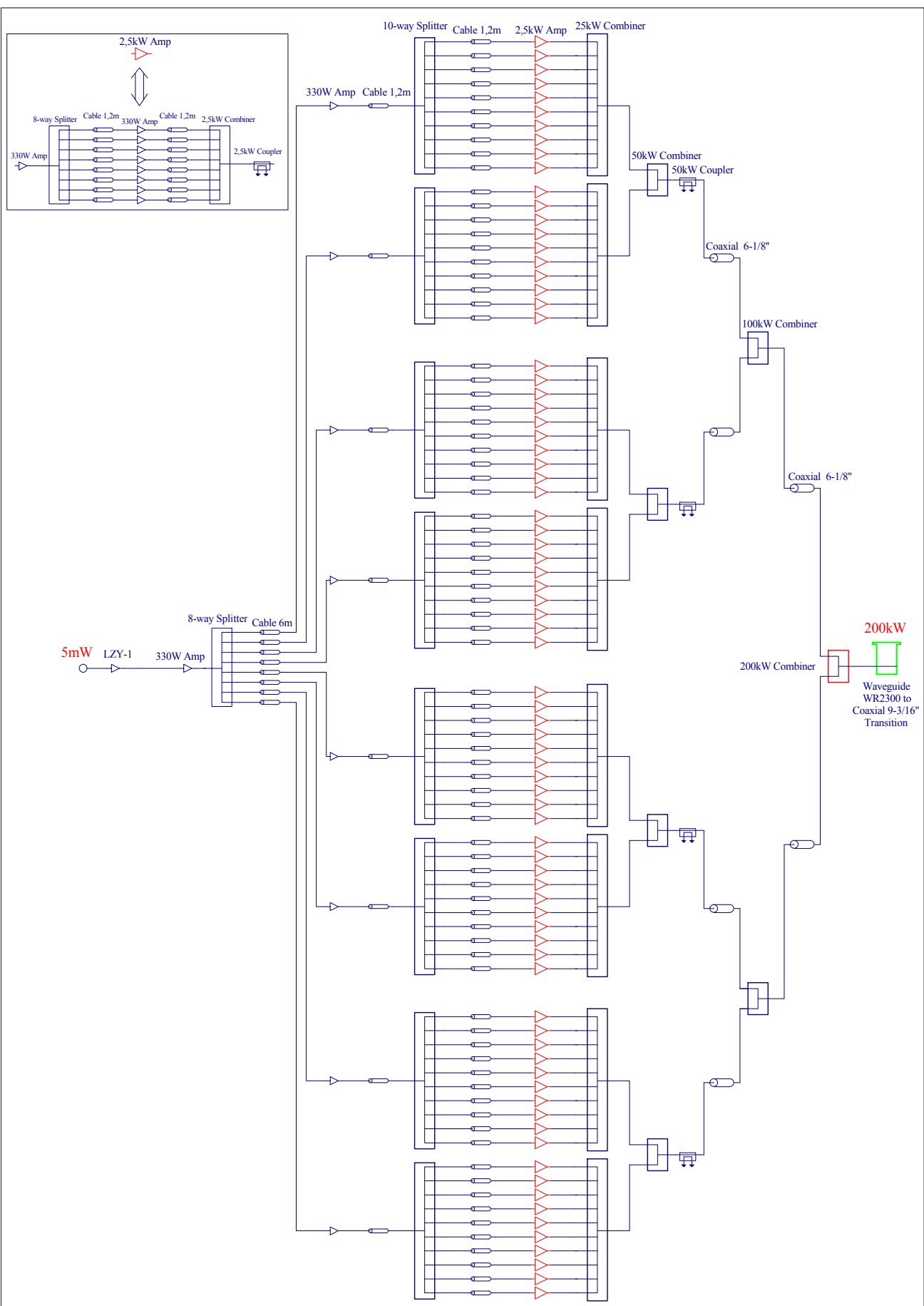
- 4 X 50 kW instead of 5 X 40 kW
 - 200 kW Combiner: 2 X 100 kW instead of 5 X 40 kW
- Higher TE₁₁ Mode Cut-off Frequency (8.63% at least)**
50 Ohms 9-3/16" Right Angle Connector is used for only 380 MHz (close to 352 MHz).
Combiner has lower Cut-off frequency than its
- **12-angular Prism instead of 9-angular Prism**
One side for enter (easy assembling); One kind of cooling bar (also for preamplifier and stand-in modules with DC/DC converter)
 - **Increase 2 sets of 100 kW Combiner, but Decrease 10 sets of 6-1/8 Elbow for each 200 kW Amplifier**



200 kW 352MHz Amplifier



Matière :	Date :	21.01.2003	
Feuille :	Titre :		
1/1	Emetteur Anneau 200 kW		
			
A3			Rev. :

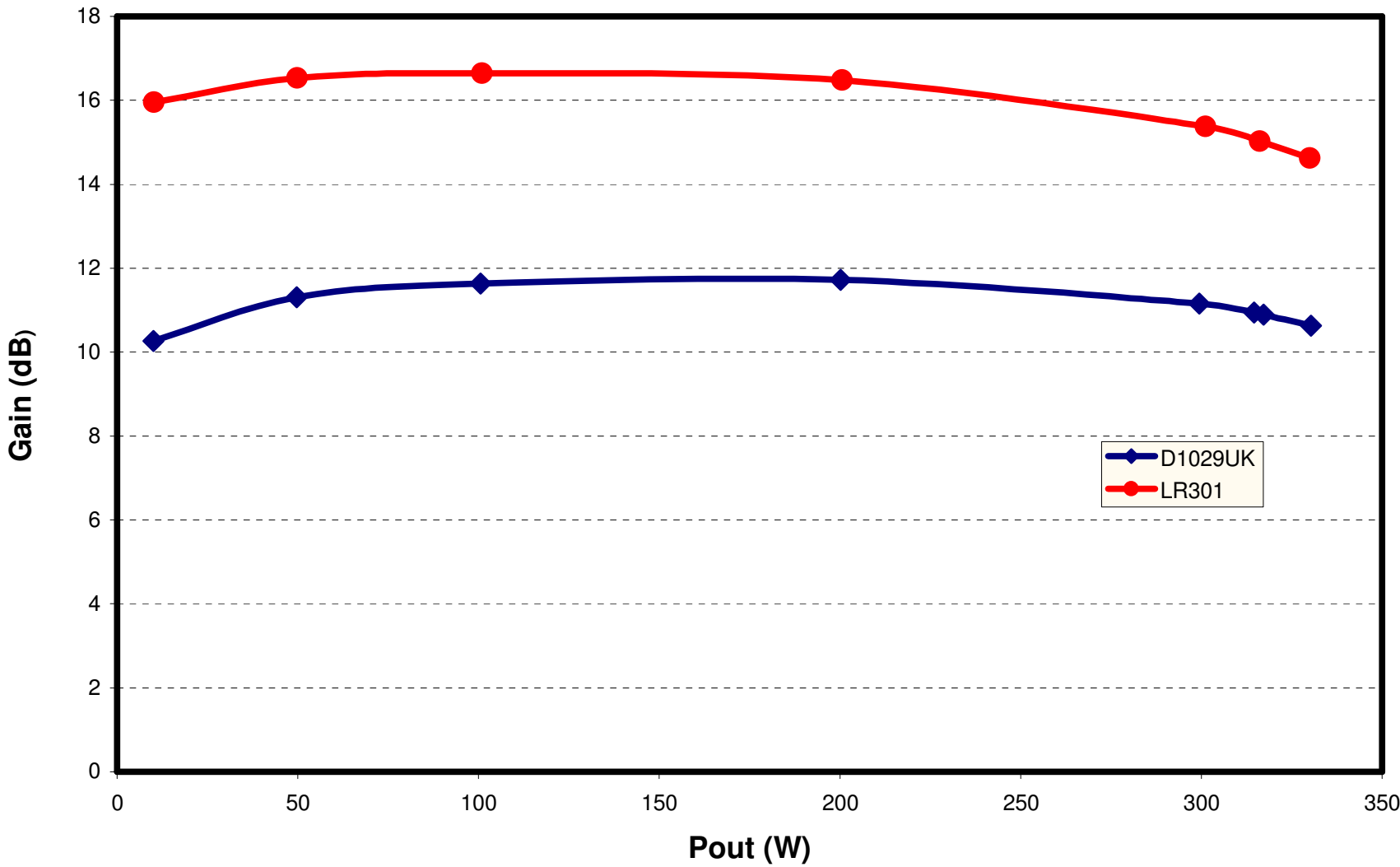


200 kW 352 MHz Amplifier

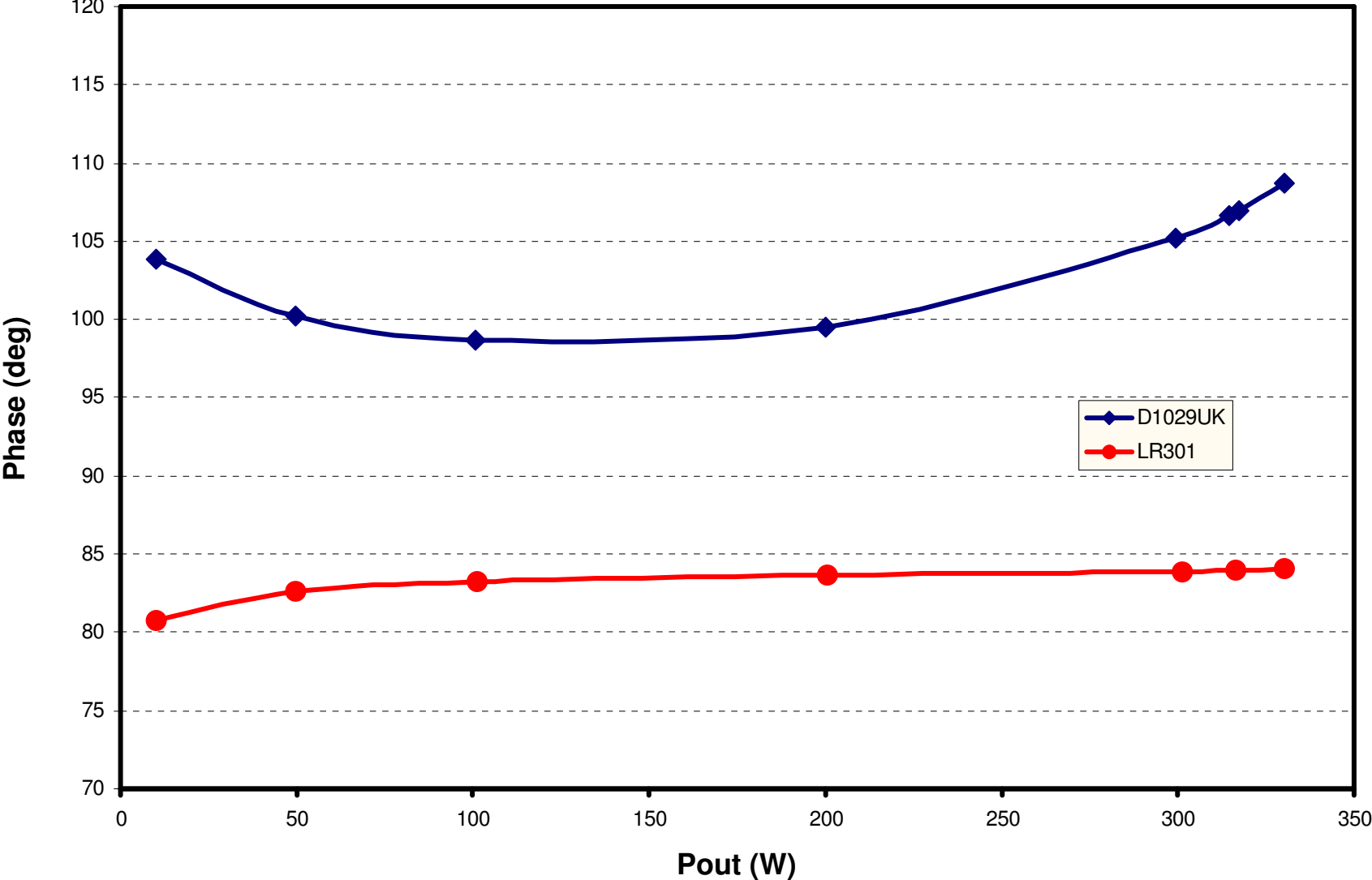
2) RF Transistor

- **DMOSFET (Diffuse Metal Oxide Semiconductor Field Effect Transistor)**
 - **VDMOS (Vertical) (MF, HF, VHF) (@1980)**
Point Nine D1029, Semelab D1029UK (@1994)
 - **LDMOS (Lateral) (UHF) (@1998)**
Polyfet LR301 (2003 Special for Soleil Project)
 - **Higher Gain @ 3 dB more (Lower Crss and Ls)**
 - **Phase Shift only 1° (Output Power 100 – 330 W)**
(VDMOS D1029UK Phase Shift: 10°, 4 stages: 40°)
 - **Bottom Side Source (No Toxic Ceramic BeO, Lower Cost of Package)**

Gain vs Output Power



Phase Shift vs Output Power



3) Amplifier Module

- Unconditional Stability (Accelerator Application)

Specification: Input Reflect Power < 500 mW instead of $S_{11} < -30$ dB at 330 W output

Oscillation Essential Condition for Feedback of Crss: Impedance imaginary parts $X_{gs} > 0$ and $X_{ds} > 0$.

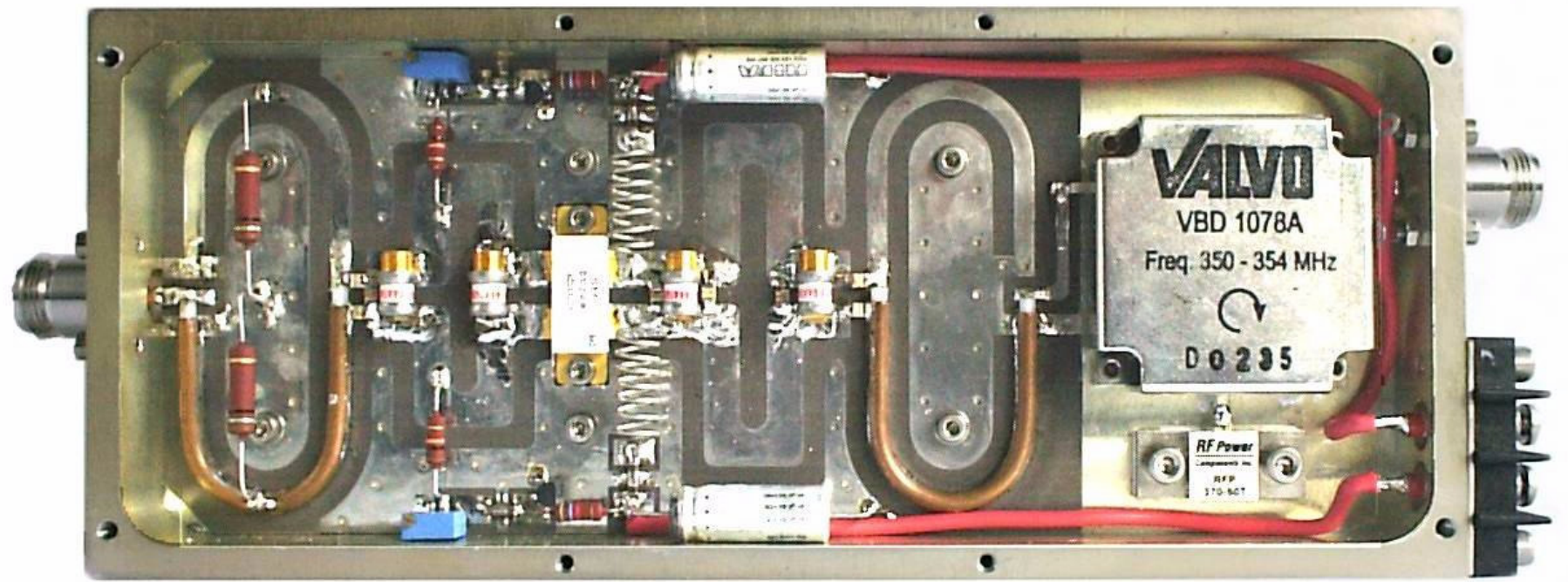
In our module with LR301, if we adjust $S_{11} < -30$ dB at 352 MHz, as the frequency decreases to @300 MHz, X_{gs} and X_{ds} become > 0 .

In order to get higher efficiency, impedance across D-S of transistor should be tuning at 352 MHz. We can't adjust it to improve stability.

But we can adjust capacitors in input circuit to decrease S_{11} to get sufficient stability, if a slight reflect power is allowed at 352 MHz. Such way is more simple and economical.

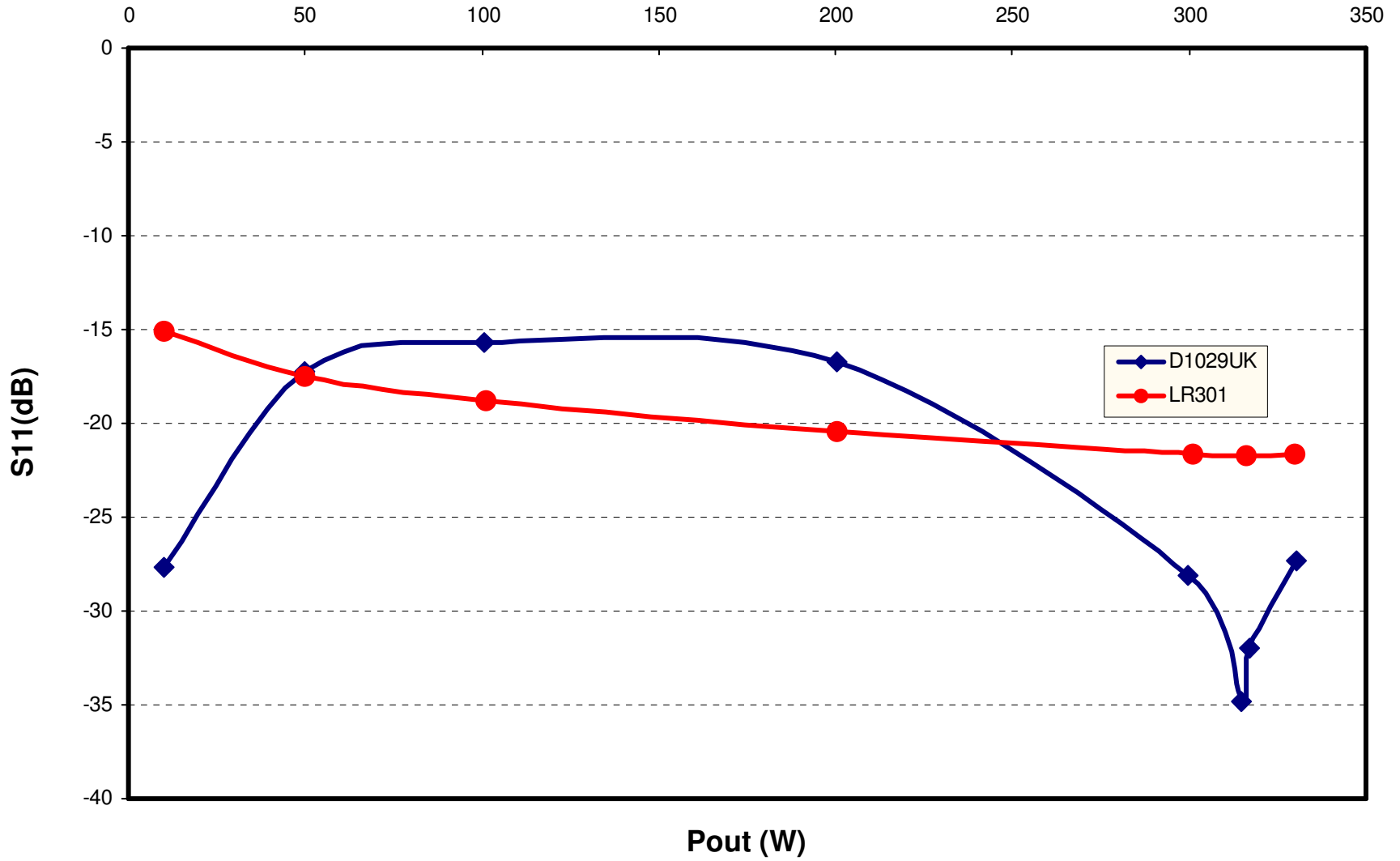
- Overcome Transistor Gain Drops

- Silver Conductive Grease (Thermal Conductivity 7.2 W/m.°C) instead of ZnO Silicon Grease (0.7 W/m.°C)**
- Insert a Cu Slug under Transistor (3D Thermal Simulation)**
- Increase Current I_{sat} of Transistor (Polyfet LR301)**

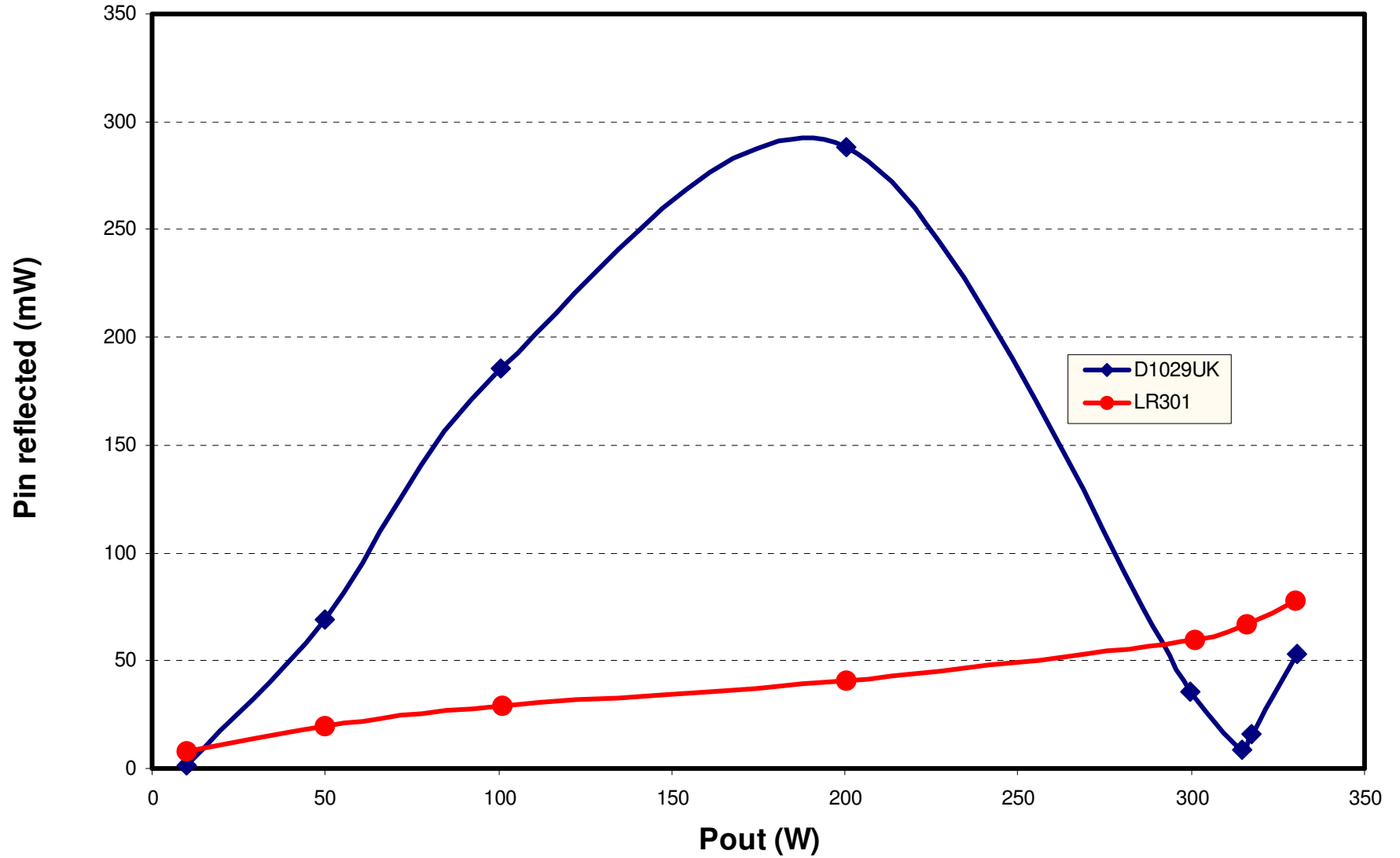


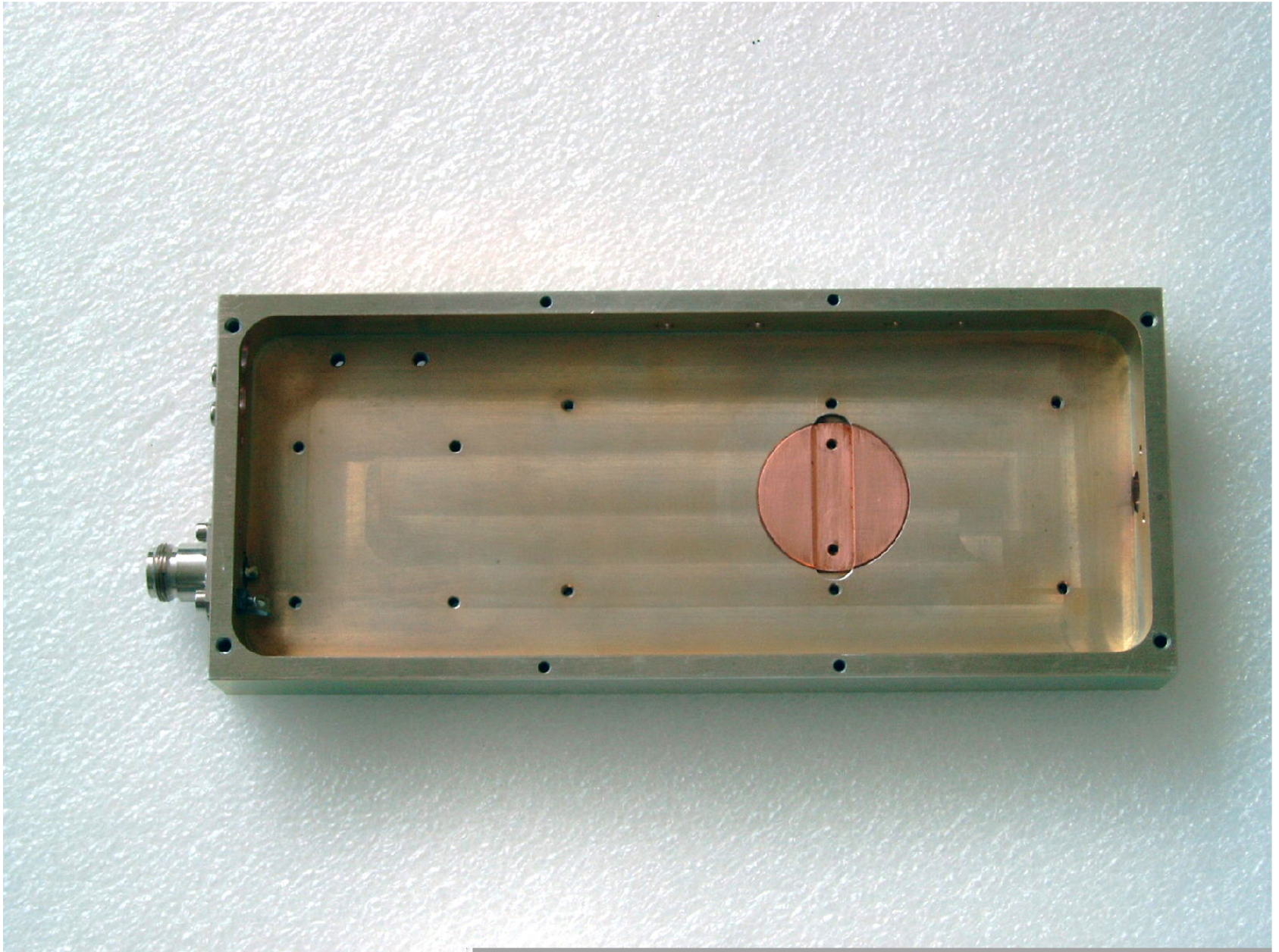
330 W 352 MHz Amplifier Module

S11 vs Output Power

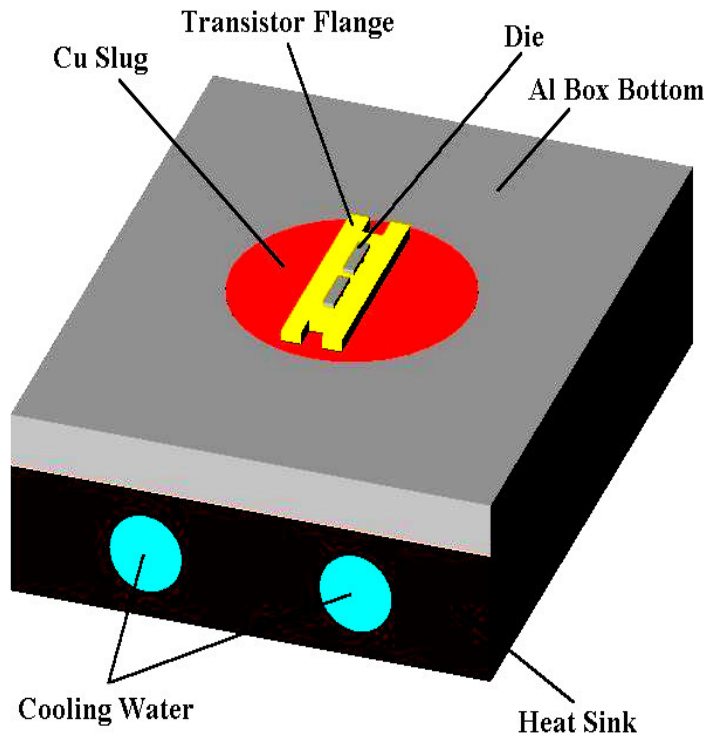


Input Reflect Power vs Output Power





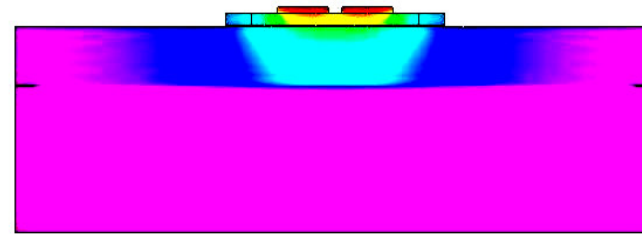
Aluminum Box with Copper Slug



Temp. Max. = 146 °C

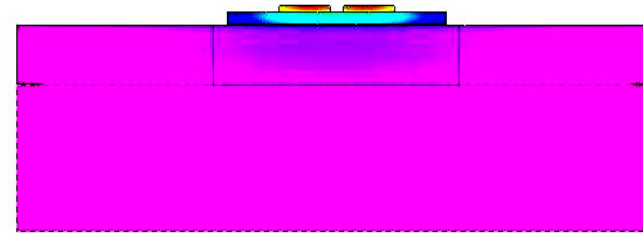
Transistor Dissipation : 200W

Water Temperature : 30°C

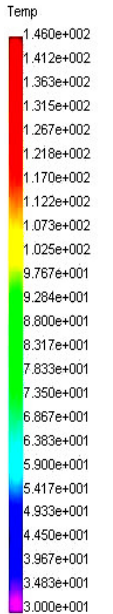


Al Box

Temp. Max. = 130.6 °C



Cu & Al Box



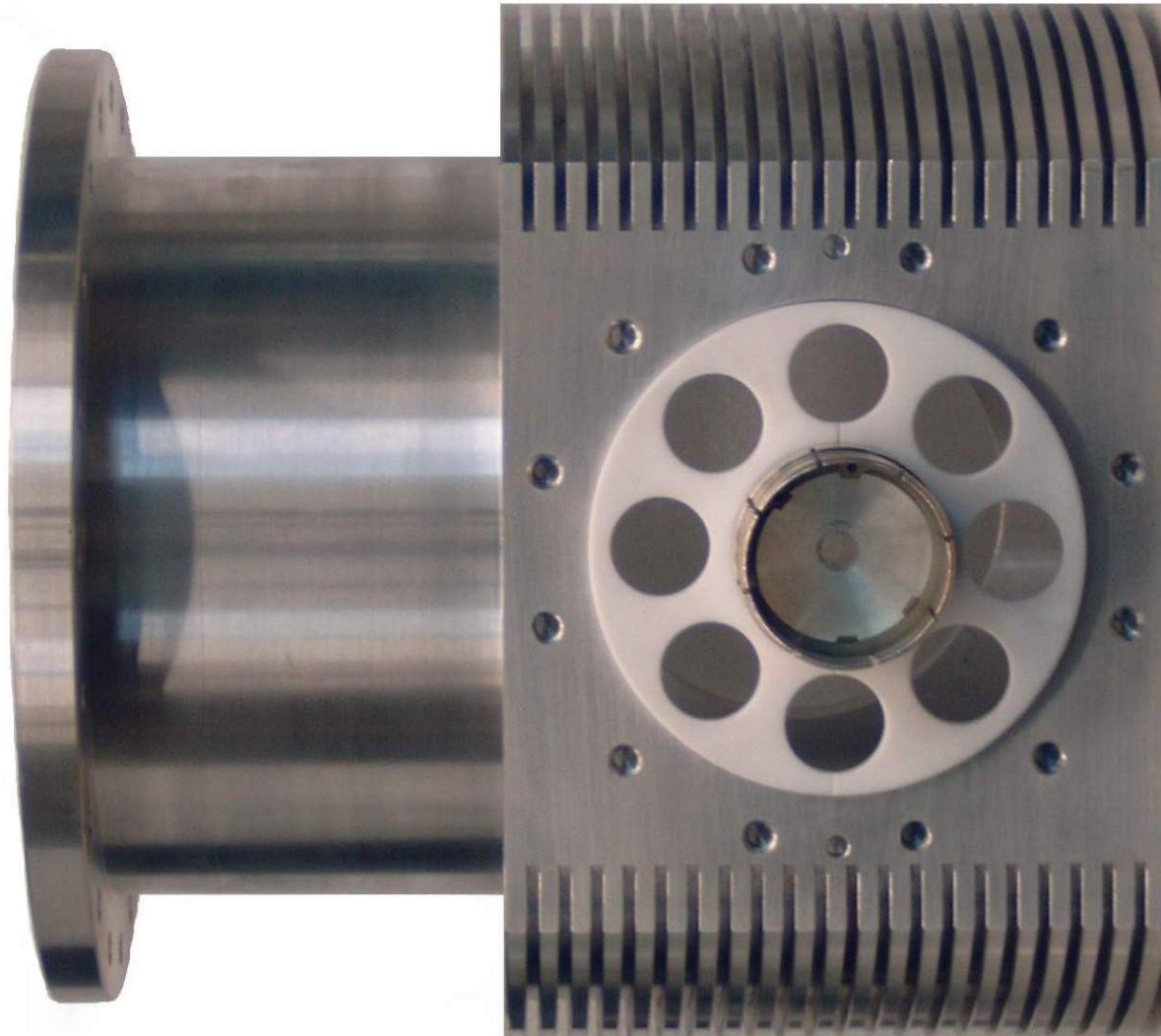
3D Thermal Simulation

4) Power Combiner (3D Simulation with HFSS)

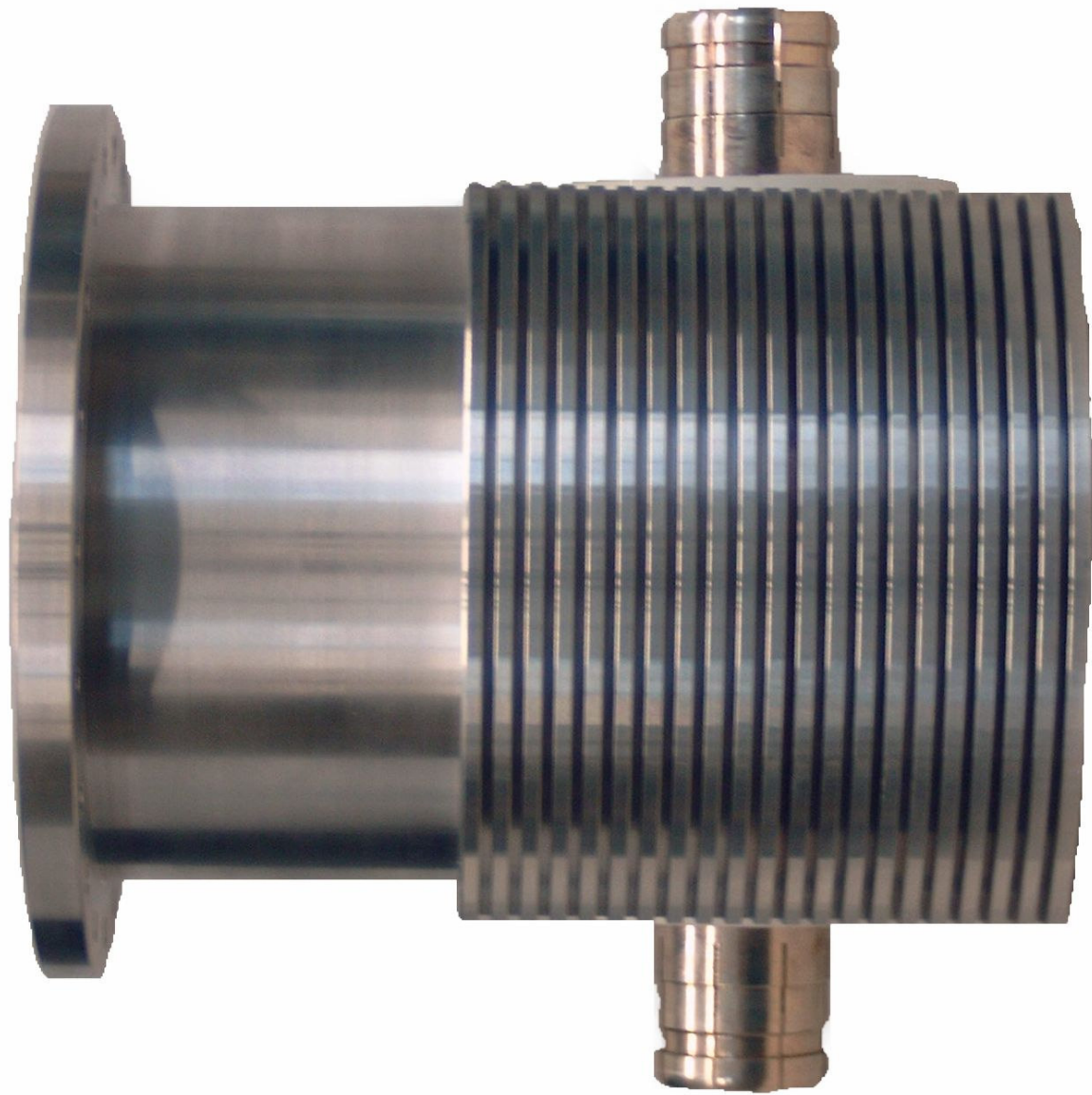
- **2-way 200 kW Power Combiner (6-1/8" to 9-3/16")**
- **2-way 100 (50) kW Power Combiner (6-1/8" to 6-1/8")**
- **10-way 25 kW Power Combiner (7/8" to 6-1/8"**
- **8-way 2.5 kW Power Combiner (N Connector to 7/8")**
- **Aluminum Conductors with Silver plated for all High Power Combiners**

5) Power Splitter

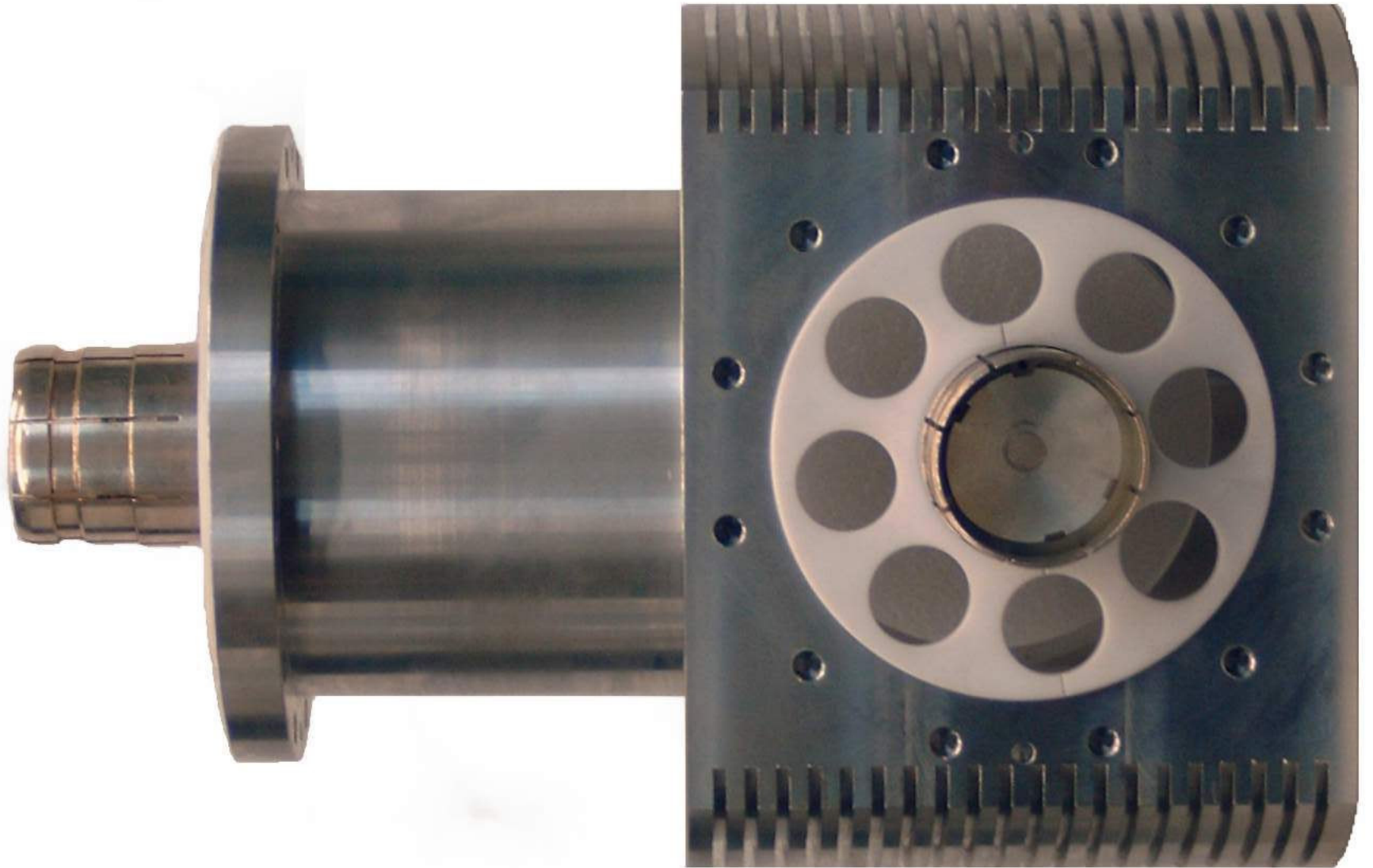
- **8-way and 10-way Microstrip splitter**
- **Wilkinson Hybrid under Development**



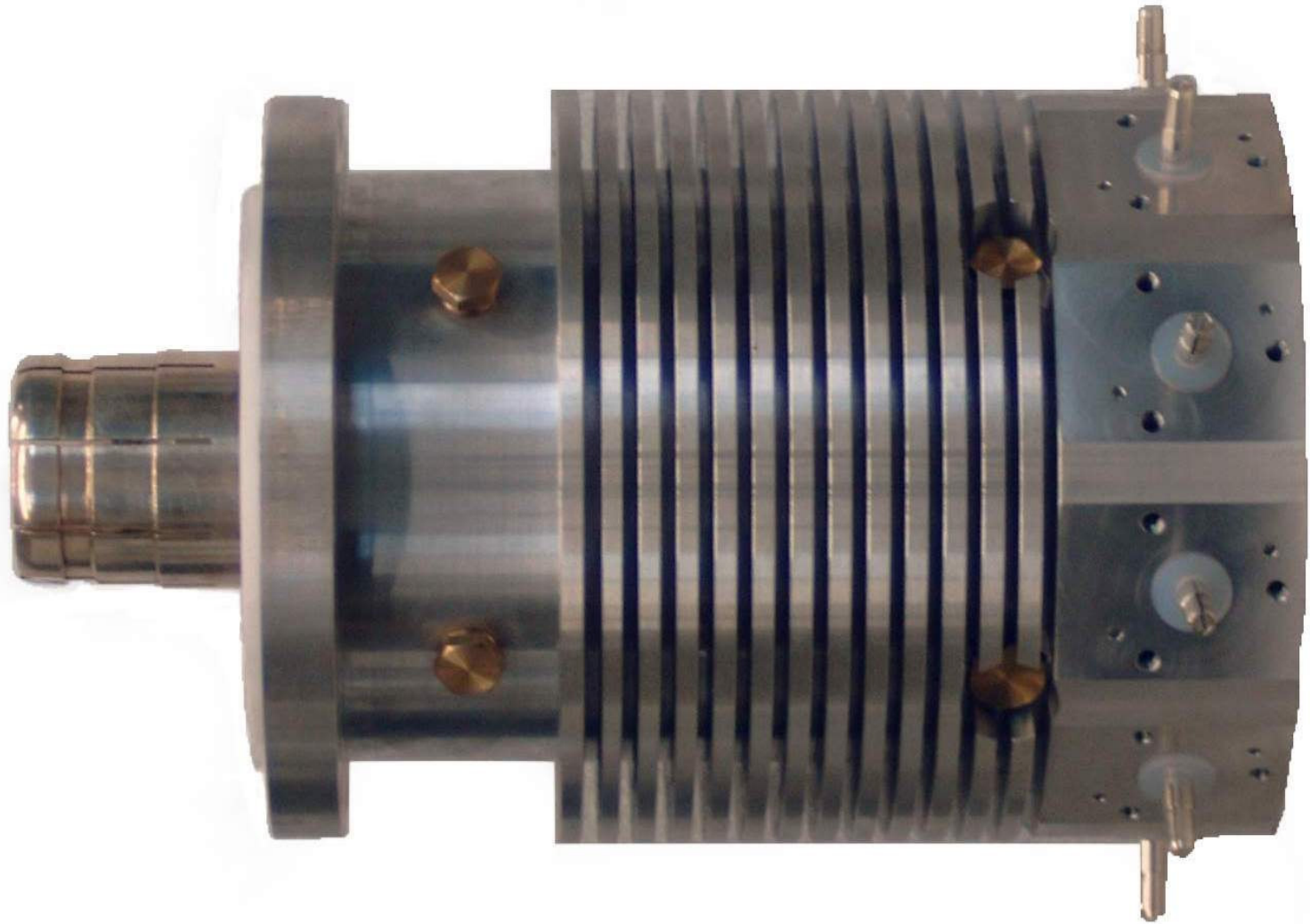
2-way 200 kW Combiner



2-way 200 kW Combiner



2-way 100 kW Combiner



10-way 25 kW Combiner



Combiners for 200 kW Amplifier



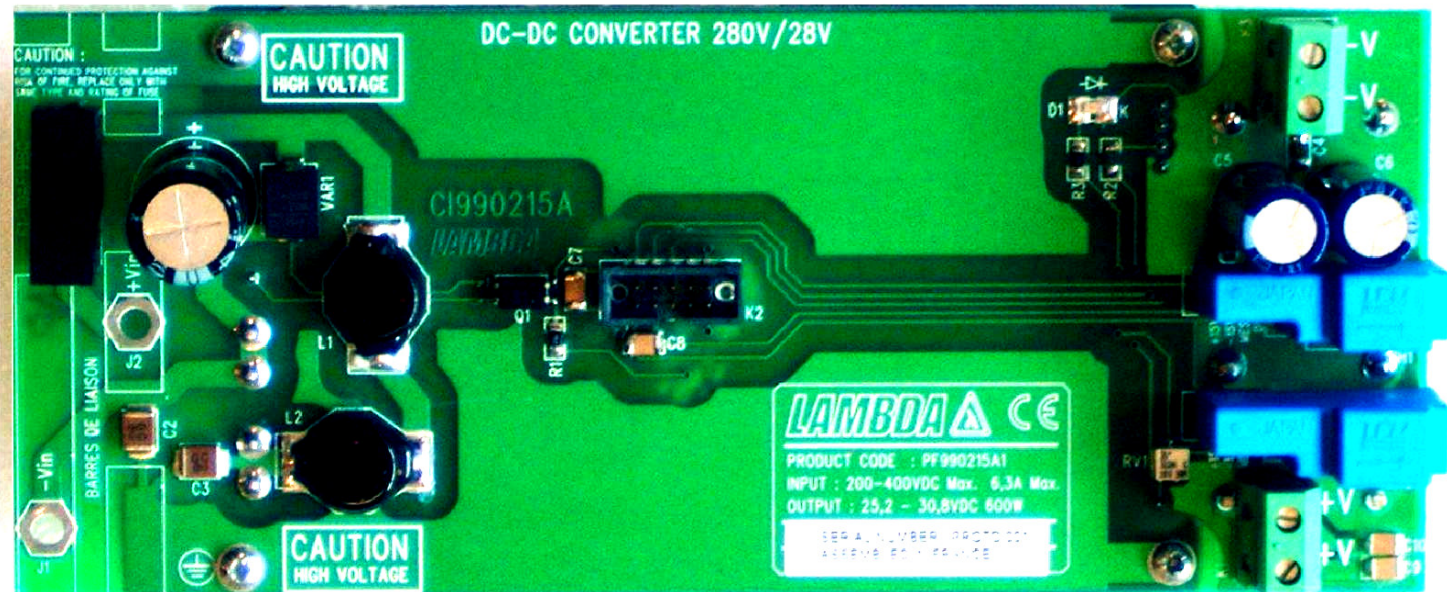
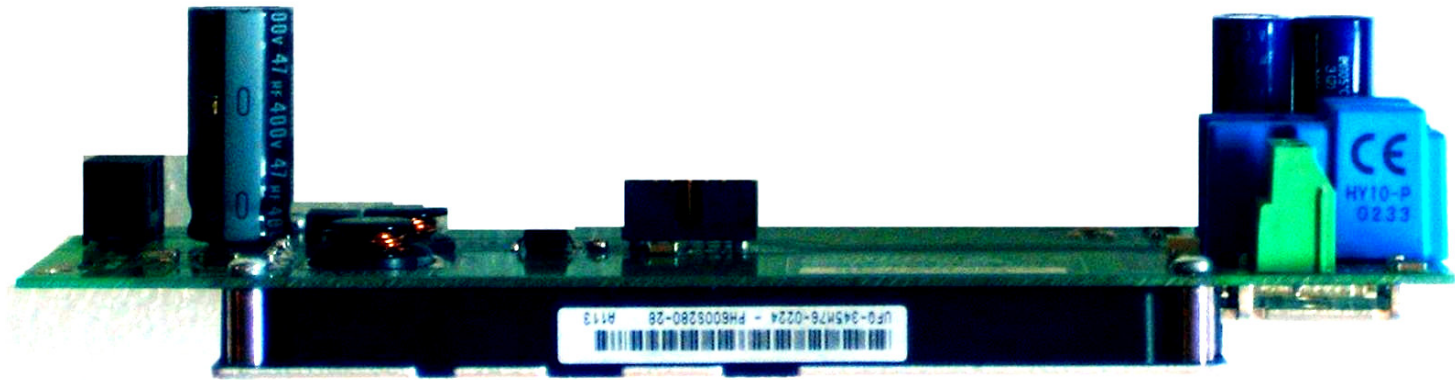
10-way and 8-way Microstrip Splitter

6) Power Supply

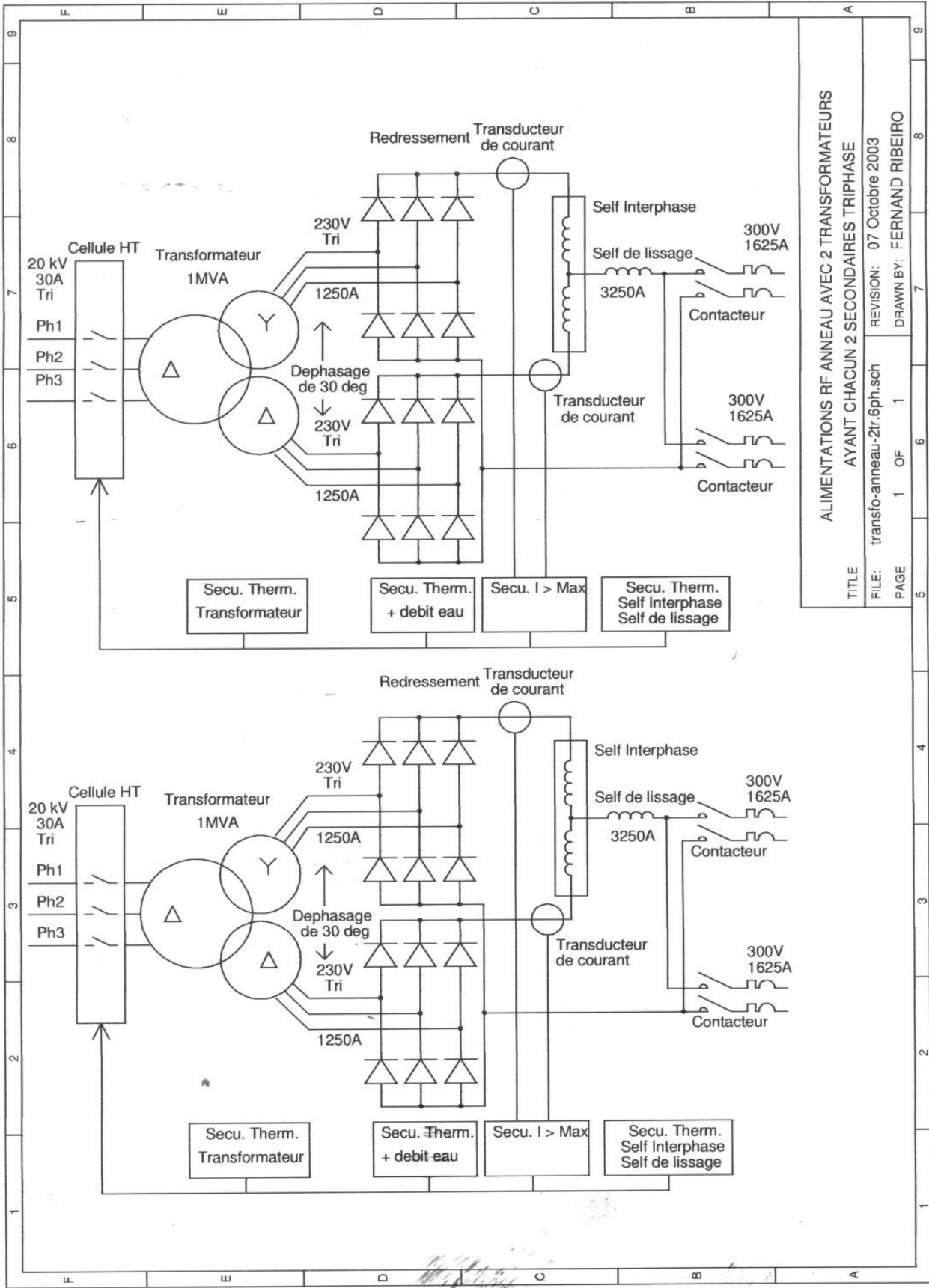
- **Lambda 600 W DC/DC Converter Module with PCB Prototype (Tested Efficiency: 92 % at Output 30 V and 20 A DC)
3000 Pieces will be Manufactured**
- **1 MW or 500 kW 300 V Industrial Rectifier (Input 20 kV AC 3-Phase, Output 300 V DC)**

7) Cooling

- **Water Cooling Extruded Heat Sink Pada 8391 Modified (35 litre/min @ 7 – 1.5 Bar)**
- **Amplifier and DC/DC Converter Modules are Fixed on Double Face of Heat Sink Directly**



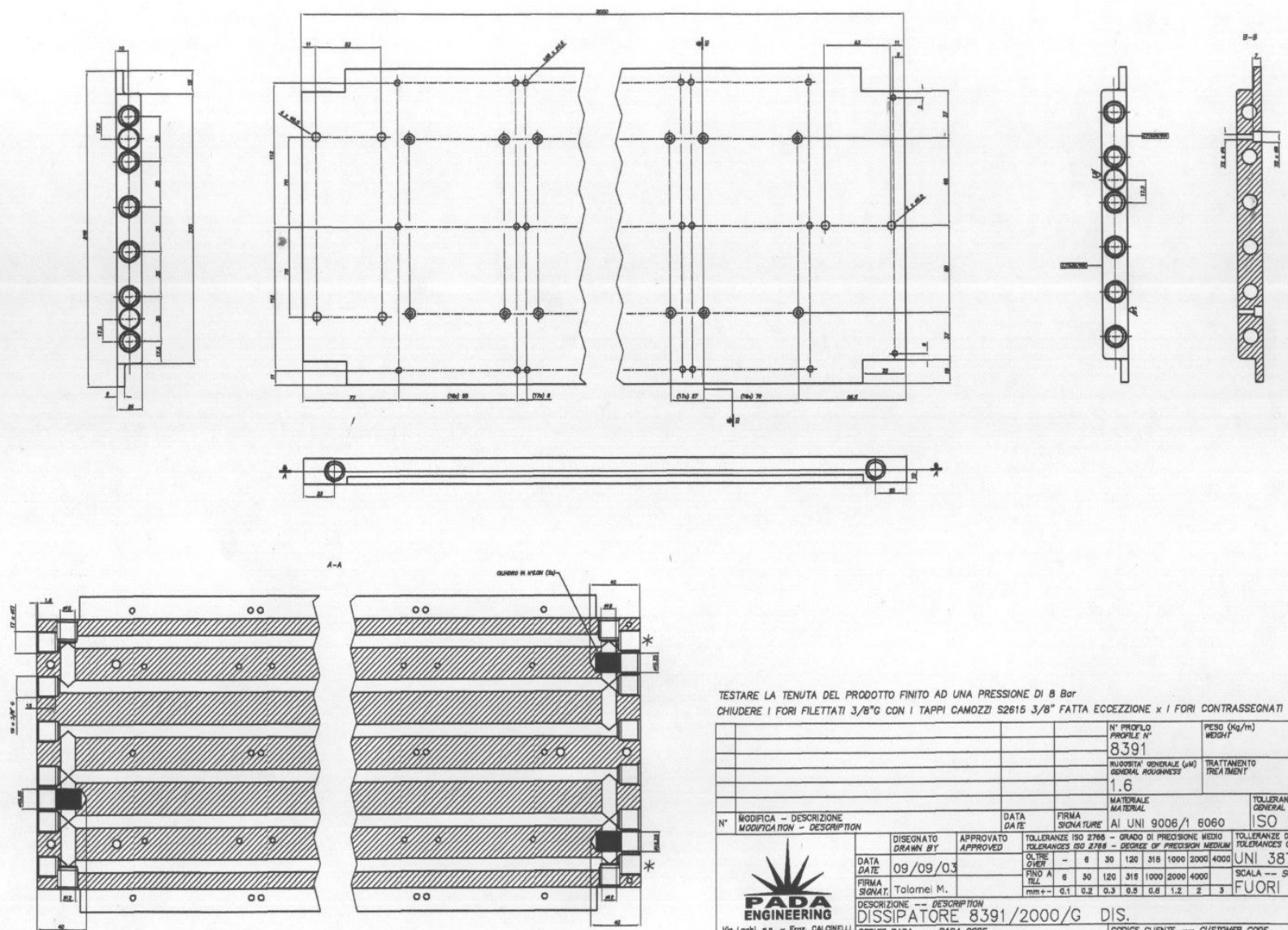
600 W DC/DC Converter Module



ALIMENTATIONS RF ANNEAU AVEC 2 TRANSFORMATEURS
 AYANT CHACUN 2 SECONDAIRES TRIPHASE

TITLE
 FILE: transfo-anneau-2tr.6ph.sch
 PAGE 1 OF 1

REVISION: 07 Octobre 2003
 DRAWN BY: FERNAND RIBEIRO



TESTARE LA TENUTA DEL PRODOTTO FINITO AD UNA PRESSIONE DI 8 Bar
 CHIUDERE I FORI FILETTATI 3/8" G CON I TAPPI CAMOZZI S2615 3/8" FATTA ECCEZIONE X I FORI CONTRASSEGNAI CON *

N° MODIFICA - DESCRIZIONE MODIFICATION - DESCRIPTION		DATA DATE	FIRMA SIGNATURE	MATERIALE MATERIAL	TOLLERANZE GENERALI GENERAL TOLERANCES
				Al UNI 9006/1 6060	ISO 2768-m
DISEGNATO DRAWN BY		APPROVATO APPROVED	TOLLERANZE ISO 2768 - GRADO DI PRECISIONE MEDIO TOLERANCES ISO 2768 - DEGREE OF PRECISION MEDIUM	TOLLERANZE DI ESTRUSIONE TOLERANCES OF EXTRUSION	
DATA DATE		09/09/03	CLIENT FINO A TOLL.	8 30 120 315 1000 2000 4000	UNI 3879 DIN 1748
FIRMA SIGNATURE		Tolomei M.	mm ±	0.1 0.2 0.3 0.5 0.8 1.2 2 3	SCALA -- SCALE FUORI S.
DESCRIZIONE -- DESCRIPTION DISSIPATORE 8391/2000/G DIS.		CODICE PADA -- PADA CODE		CODICE CLIENTE -- CUSTOMER CODE	
		14900001		FILE 14900001.dwg	

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1 2 3 4 5 6 7 8

8) Current Status

- 3050 pieces of Circulator VBD1078A Contract has been Signed, Delivery 150 pieces / each month**
- 190 pieces of Pada Heat Sink Contract has been Signed, Delivery in 2003**
- We are calling for Tender for 3000 Amplifier Modules**
- Power Combiner Prototypes have been Completed, 200 kW Power Combiner will be tested in ESRF**
- Microstrip Power Splitter Prototypes are being Modified**
- DC/DC Converter with PCB Prototype has been Tested**
- Micro-controller Supervisor under Development**

9) Milestones (4 Sets of 200 k W Amplifier for Soleil Storage Ring)

- Oct. 2004, Complete all Components and Modules for 2 sets of 200 kW Amplifier**
- Dec. 2004, Assemble 2 sets of 200 kW Amplifier**