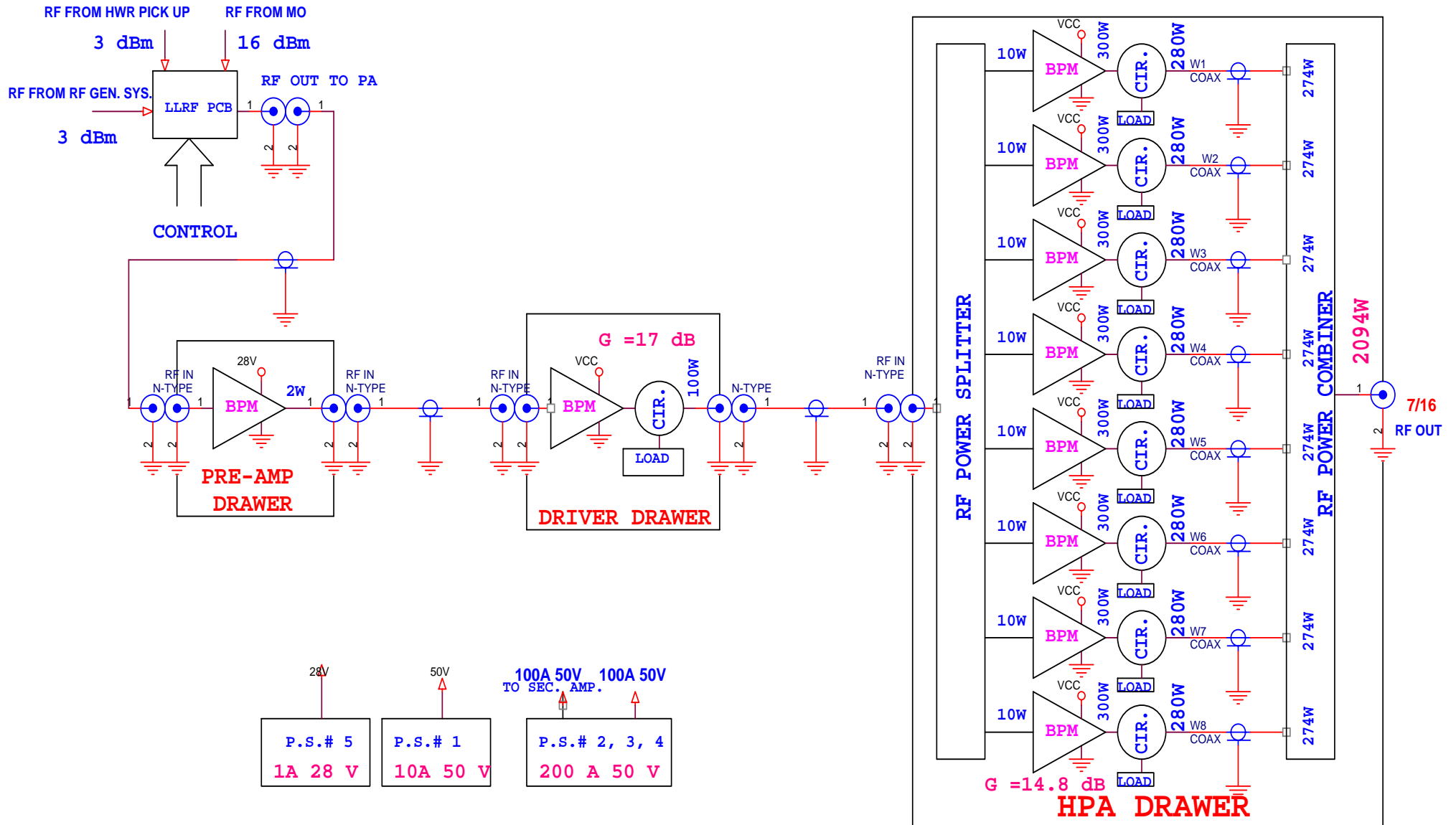


# The RF and LLRF systems

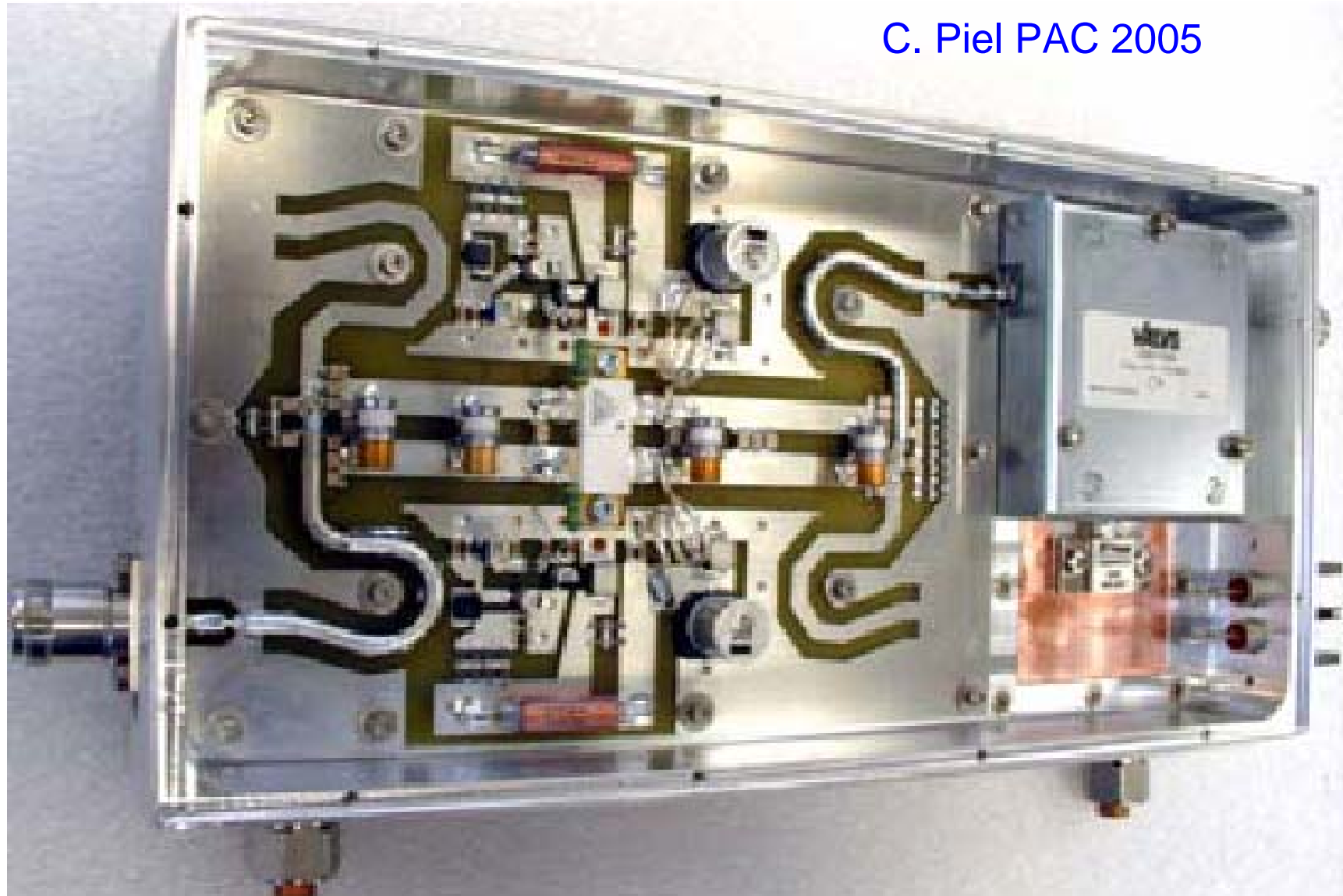
24/10/2007 DAPNIA visit to SARAF

Israel Fishman

# PSM-RF Amplifier

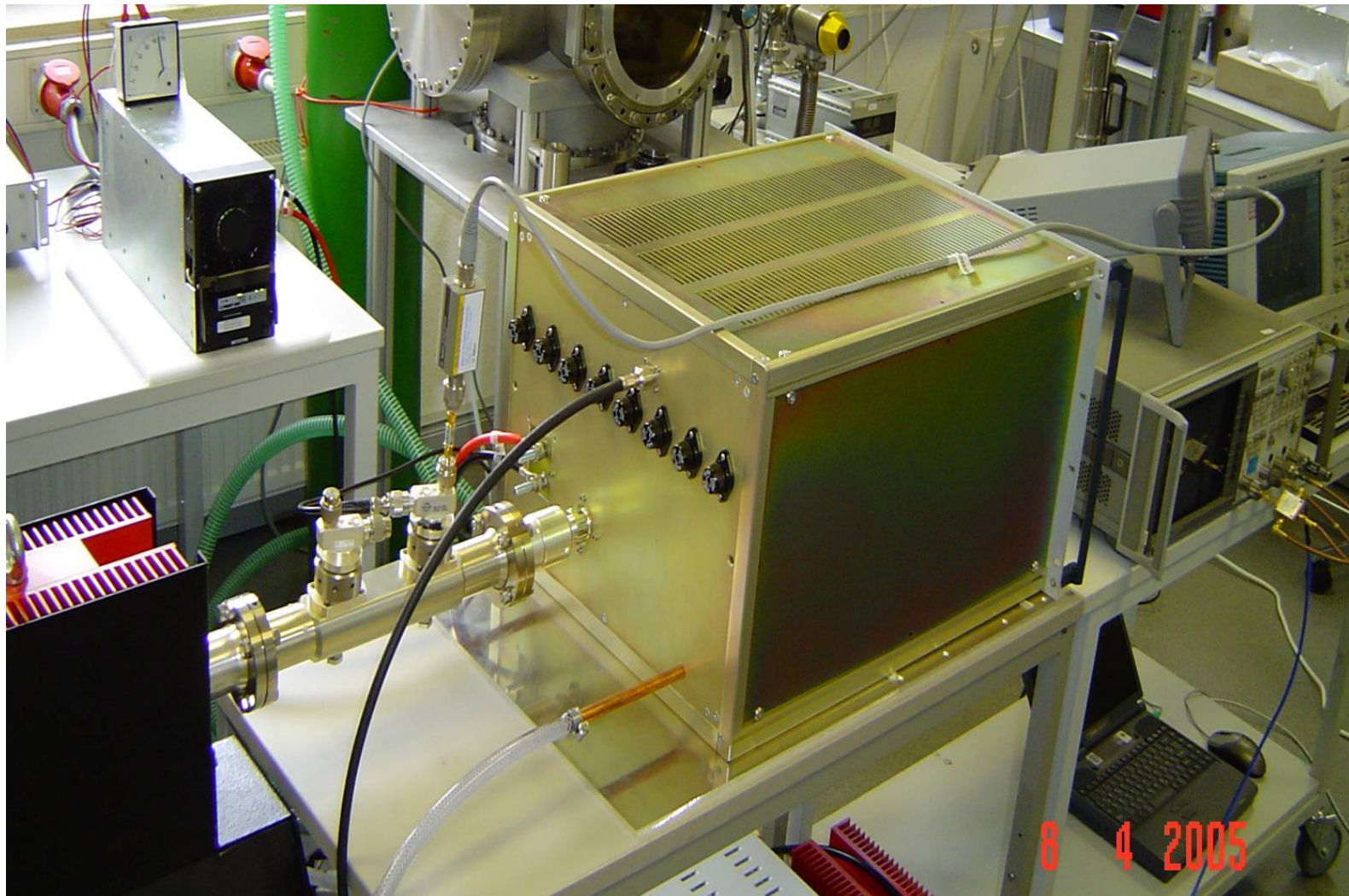


# PSM-RF BASIC MODULE VIEW



C. Piel PAC 2005

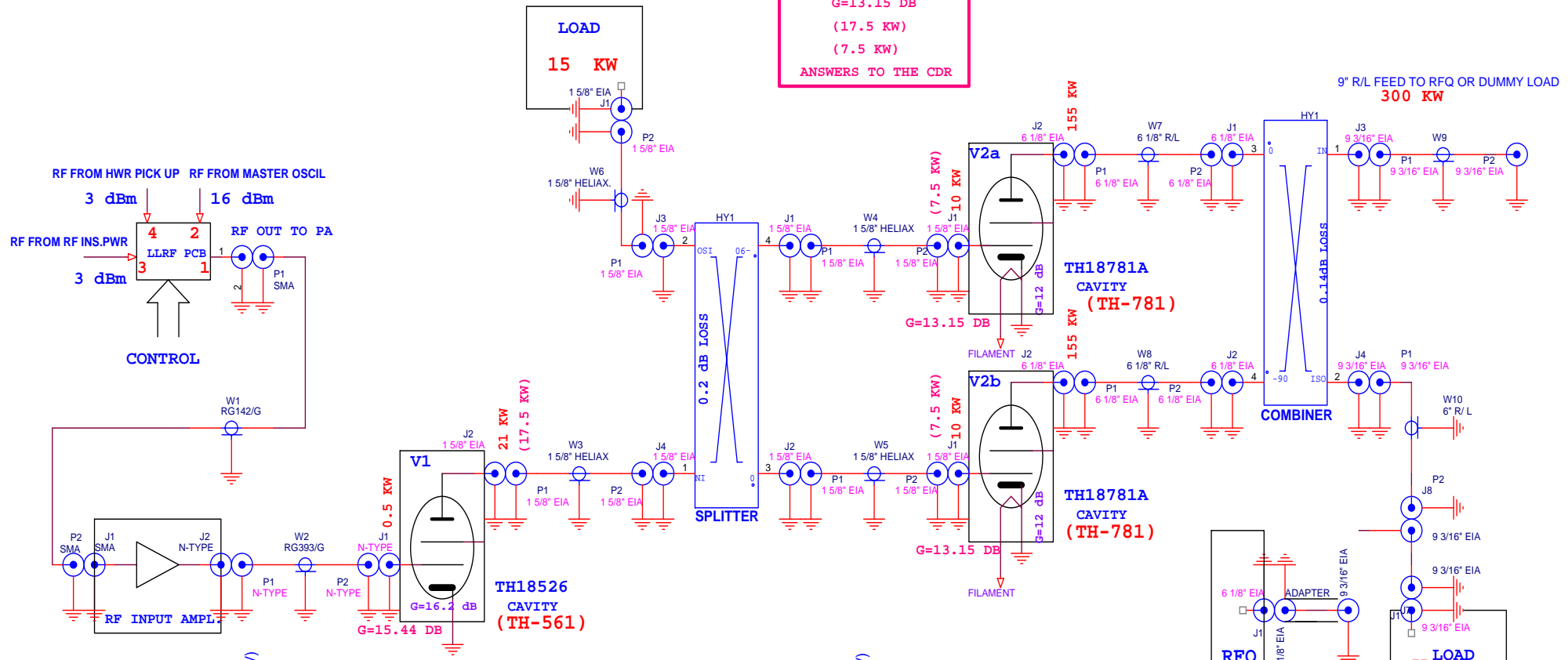
# HPA- Test setup



C. Piel PAC 2005

# RFQ-RF Amplifier

125 KW  
 10 KW  
 G=15.44 DB  
 G=13.15 DB  
 (17.5 KW)  
 (7.5 KW)  
 ANSWERS TO THE CDR



FILAMENT (7V 140A)  
 FILAMENT (7V 140A)  
 CONTR.GRID (-160V)  
 SCREEN GRID (+750V)  
 ANODE (7000V 6A)

**DRIVER POWER SUPPLIES**  
 FILAMENT  
 CONTR. GRID  
 SCREEN GRID  
 ANODE VOLTAGE

ANODE VOLT.FS-1 (16KV 24A)  
 ANODE VOLT.FS-2 (16KV 24A)

**FINAL STAGES ANODE POWER SUPPLY (PSM)**

FILAMENT (10V 320A)  
 FILAMENT (10V 320A)  
 CONTR. GRID (-400V)  
 SCREEN GRID (+1300V)

**FINAL STAGE - 1 POWER SUPPLIES**  
 FILAMENT  
 CONTR. GRID  
 SCREEN GRID

FILAMENT (10V 320A)  
 FILAMENT (10V 320A)  
 CONTR. GRID (-400V)  
 SCREEN GRID (+1300V)

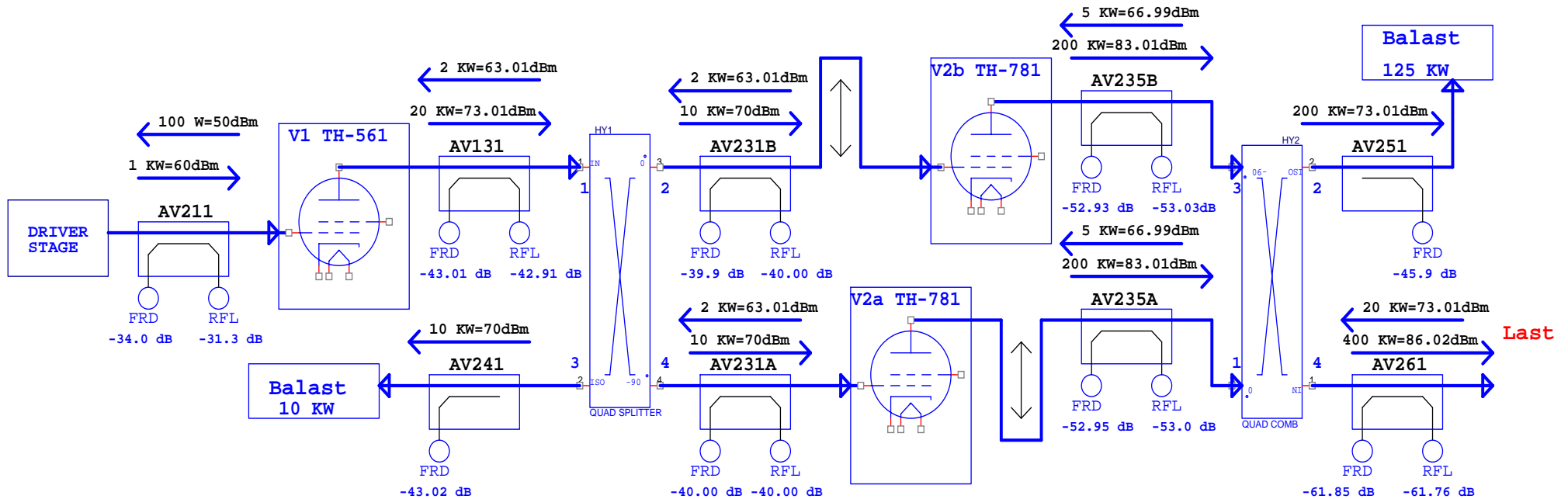
**FINAL STAGE - 2 POWER SUPPLIES**  
 FILAMENT  
 CONTR. GRID  
 SCREEN GRID

SOREQ - LINAC		
Title	<b>300 KW AMPLIFIER FOR RFQ</b>	
Size	Document Number	Rev
B	<b>RF BLOCK DIAGRAM</b>	0
Proprietary SoREQ NRC		

# RFQ-RF Metering

DIREC. COUPLER	NAME	ATTENUATOR
DRIVER	AV211 FRD	17
	AV211 REV	10
V1 OUT	AV131 FRD	21
	AV131 REV	11
V2A IN	AV231A FRD	21
	AV231A REV	14
V2B IN	AV231B FRD	21
	AV231B REV	14
SPLITTER LOAD	AV241 FRD	20

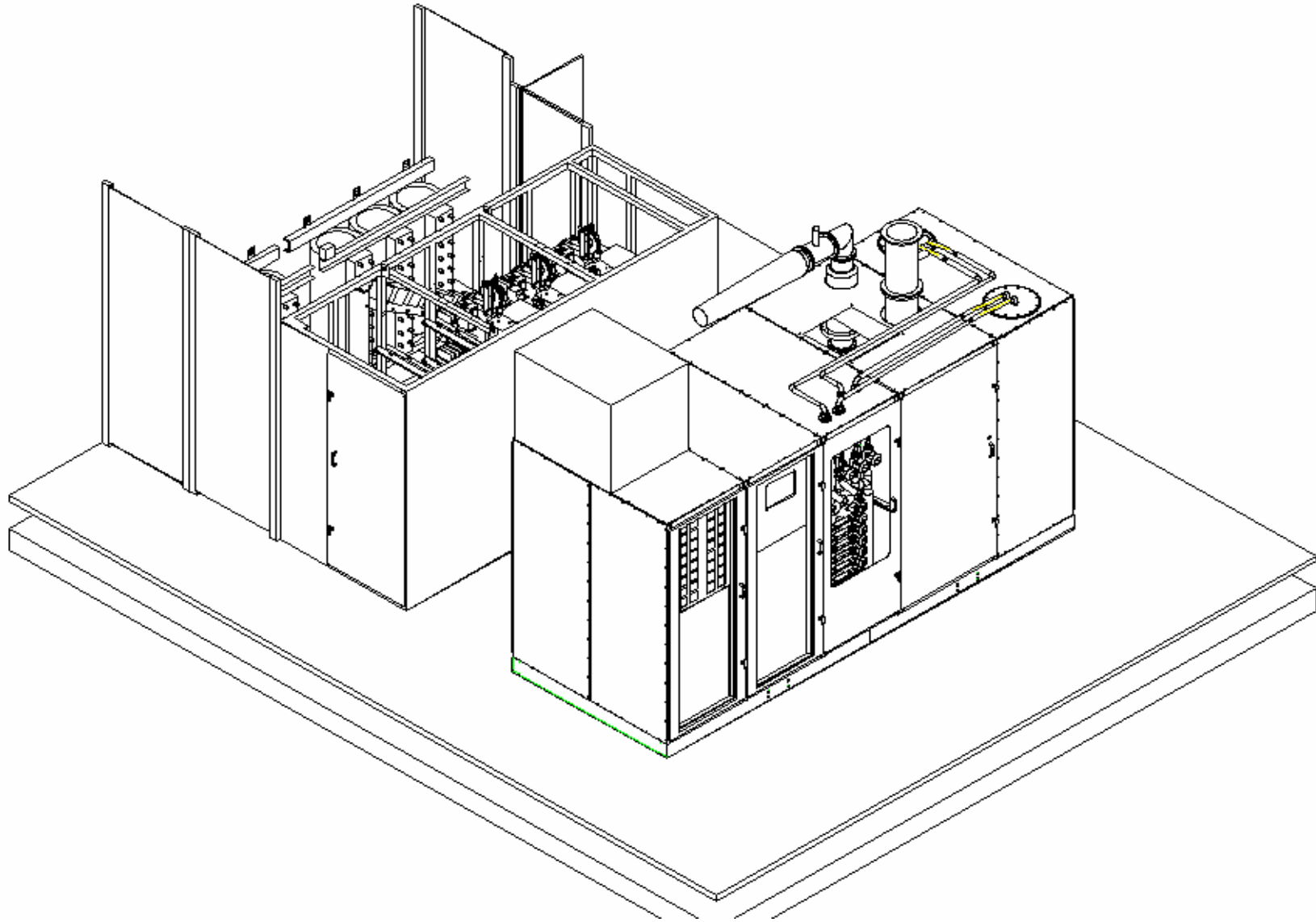
DIREC. COUPLER	NAME	ATTENUATOR
V2A OUT	AV235A FRD	21
	AV235A REV	5
V2B OUT	AV235B FRD	20
	AV235B REV	5
COMBINER LOAD	AV251 FRD	28
OUTPUT	AV261 FRD	15
	AV261 REV	2



SOREQ - LINAC			
Title	DIRECTIONAL COUPLERS CALIBRATION		
Size	Document Number	Rev	
Custom	BLOCK DI AGRAM	0	
Date:	Monday, September 18, 2006	Sheet	1 of 1

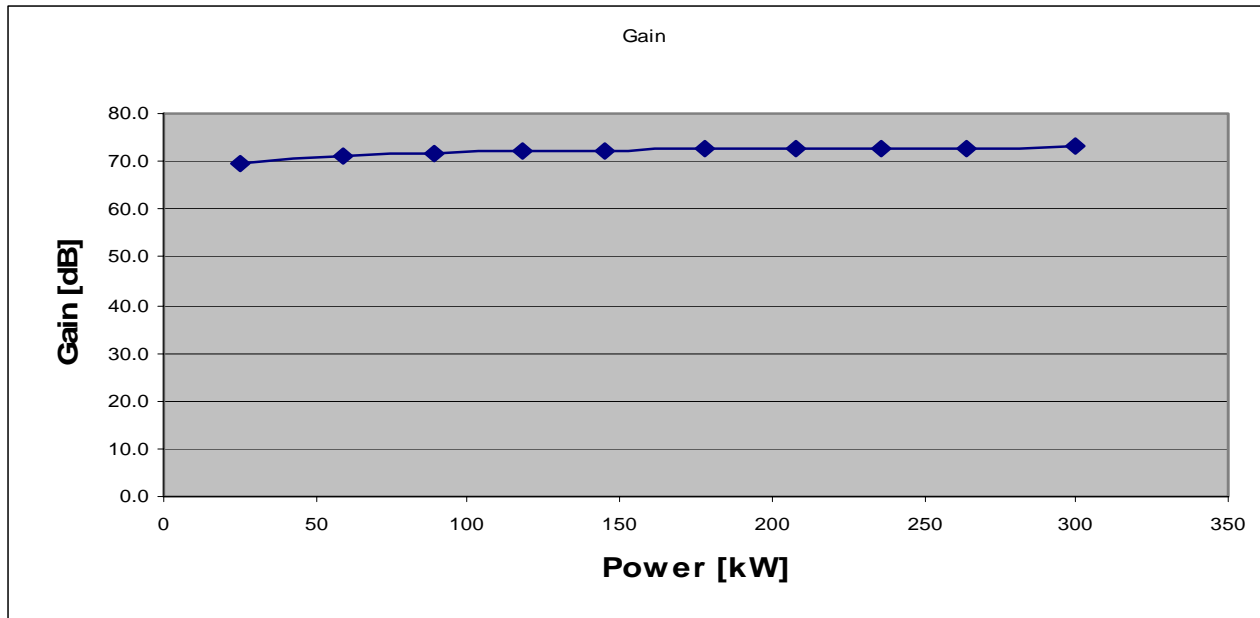


# RFQ-RF General View



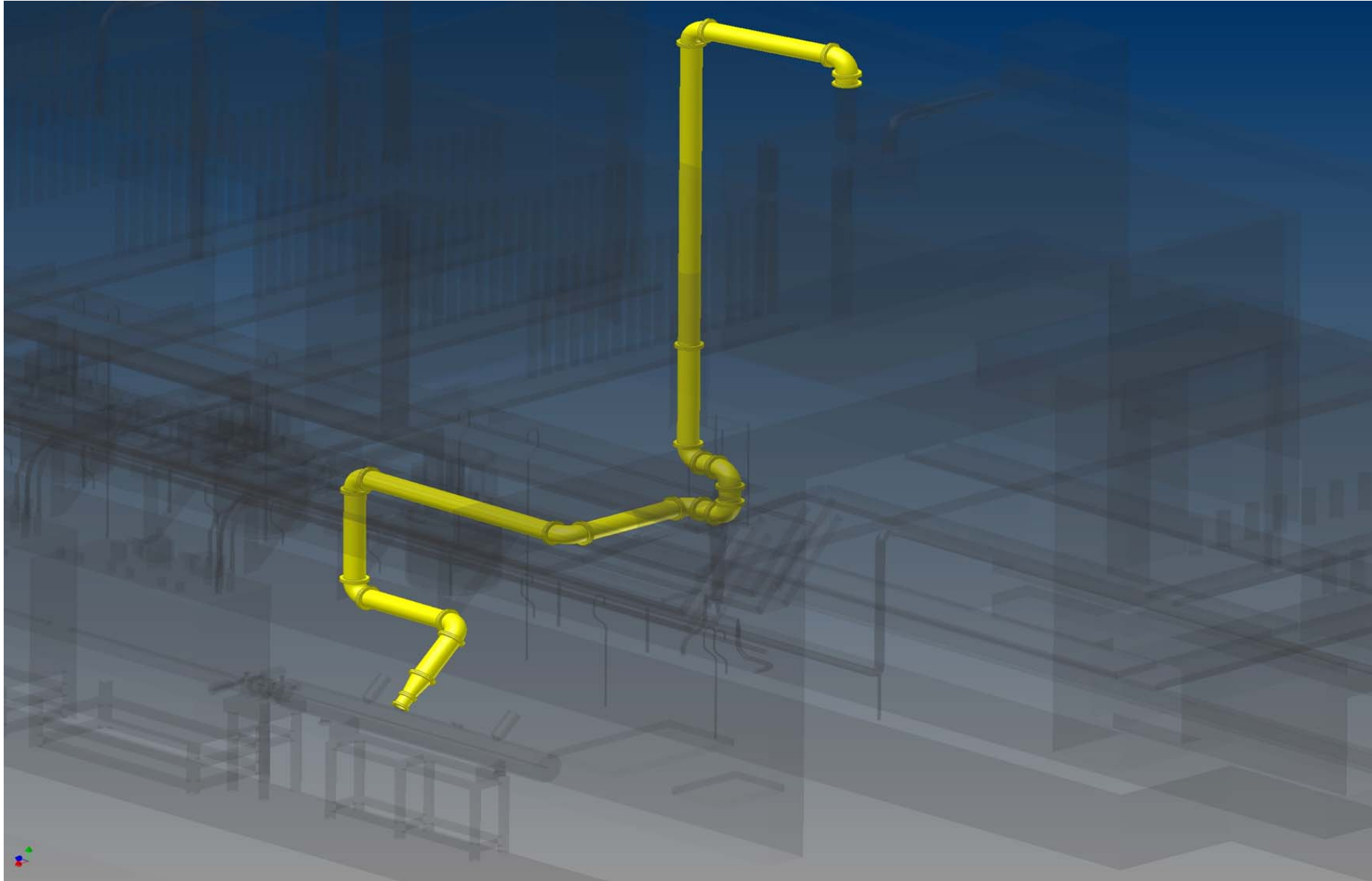
# RFQ-RF LINEARITY TEST

Output power level [kW]	Output power level [dBm]	input power level [dBm]	Gain [dB]
300	84.8	11.7	73
264	84.2	11.3	72.9
236	83.7	10.8	72.9
207	83.2	10.3	72.9
178	82.51	9.8	72.7
145	81.61	9.2	72.4
117	80.7	8.5	72.2
89	79.5	7.7	71.8
59	77.7	6.5	71.2
25	74.0	4.3	69.7

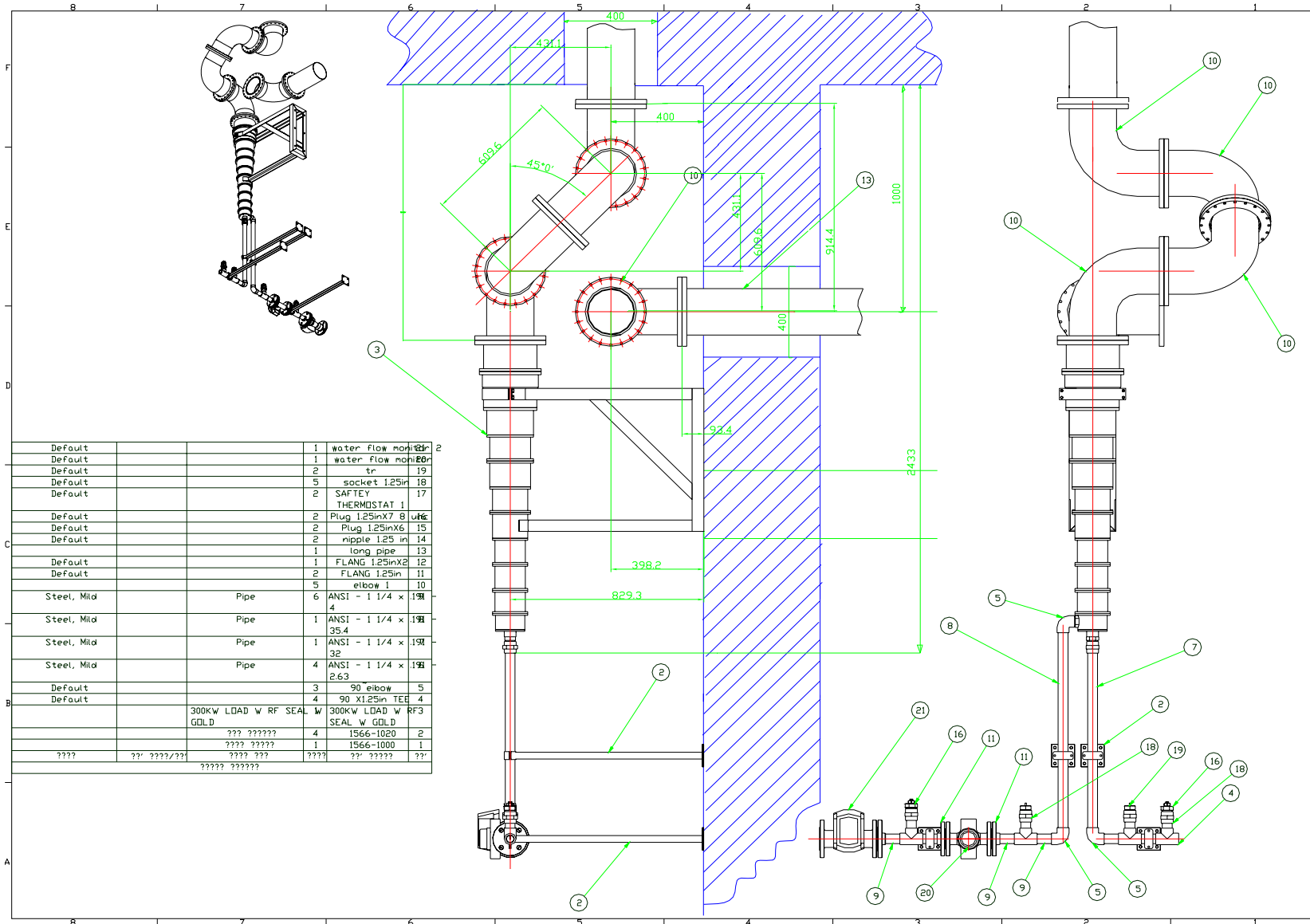




# 9" RIGID LINE



# Dummy Load / RFQ Switching



# LLRF system

## 2.1 PSM Superconducting Cavity

**Table 2-1-1, Cavity Control Parameters**

Parameter	Value	Unit	Comment
Nominal RF frequency	176	MHz	
RF power	≤ 2.4	kW	Full scale power
Amplitude stability	+/- 0.5	%	RMS
Phase control range	+/- 180	deg	
Phase resolution	0.5	deg	Over phase control range
Phase stability	+/- 0.5	deg	RMS

**Table 2-1-2, Cavity tune control parameters**

Parameter	Value	Unit	Comment
Nominal RF frequency	176	MHz	
Tuning range	+/- 50	kHz	Cavity tuner max range
Tuning speed	Up to 1	kHz/s	
Tuner step	+/- 1	Hz	Cavity tuner min step
Sensitivity	+/- 2.0 – 6.0 (+/-1.7 – 5.1 for $Q_L=1.3 \cdot 10^6$ )	Hz (deg)	Programmable

## 2.2 RFQ LLRF

**Table 2-2-1, RFQ Control Parameters**

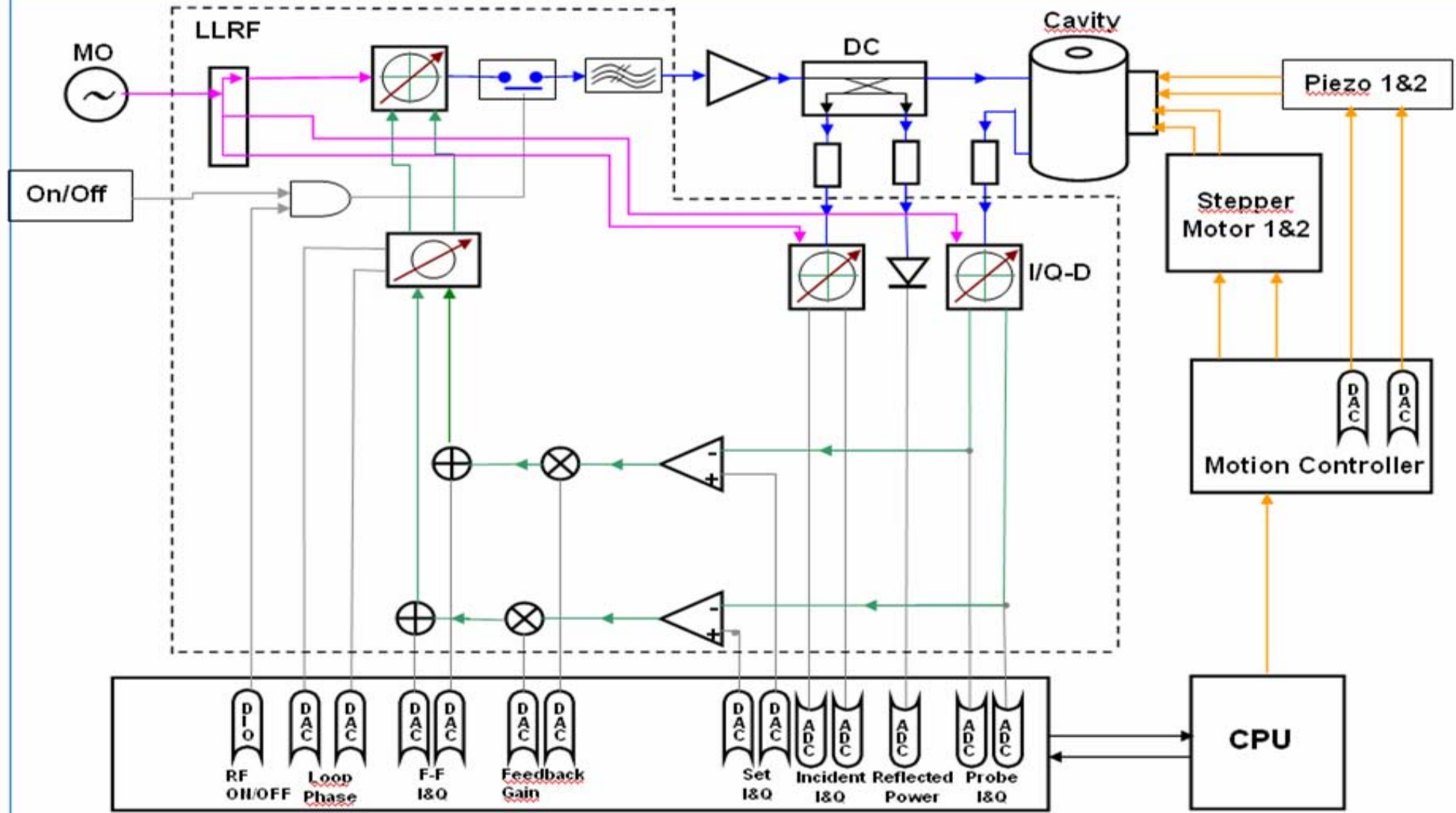
Parameter	Value	Unit	Comment
Nominal RF frequency	176	MHz	
RF power	$\geq 220$	kW	Full scale power
Amplitude stability	1	%	RMS
Phase control range	+/- 180	deg	
Phase resolution	0.5	deg	Over phase control range
Phase stability during CW operation	+/- 0.5	deg	RMS

**Table 2-2-2, RFQ tune control parameters**

Parameter	Value	Unit	Comment
Nominal RF frequency	176	MHz	
Tuning range	+/- 200	kHz	cavity tuner max range
Tuning speed	Up to 1	kHz/s	
Tuner step	+/- 75	Hz	cavity tuner min step
Sensitivity	+/- 150 – 3000 (+/-0.2 – 4.0 for $Q_L=2000$ )	Hz (deg)	Programmable



# PSM-RF: LLRF Principle Block Diagram

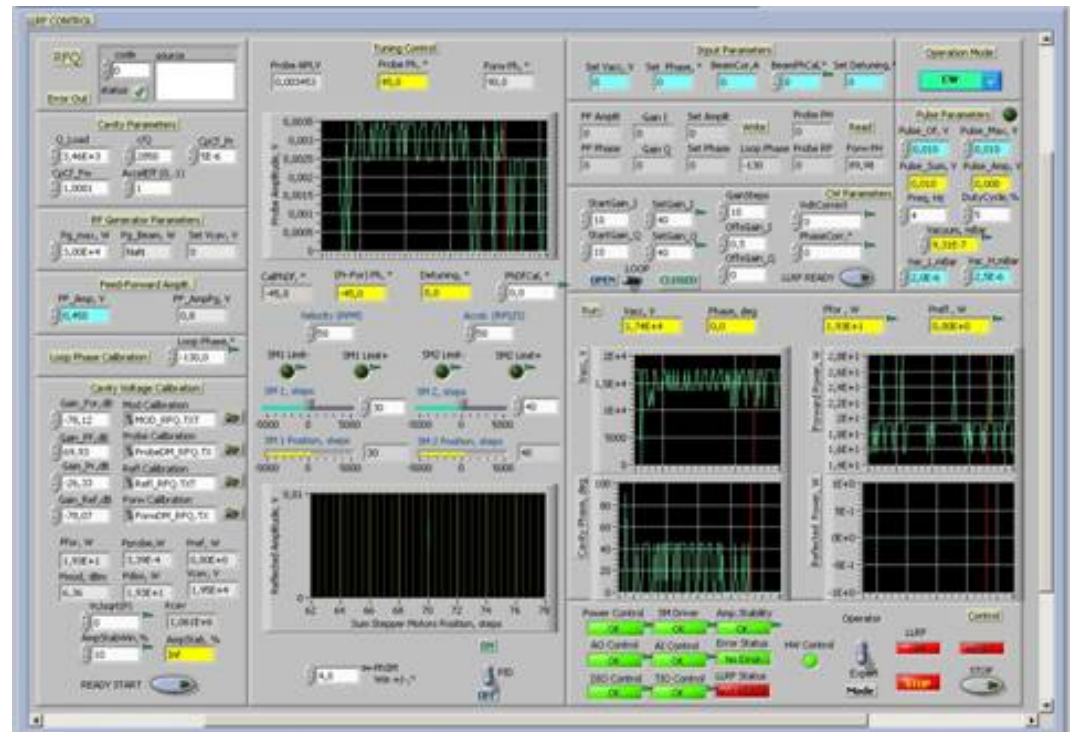


M. Pekeler PAC 2005

# LLRF System



LLRF user panel



LLRF expert panel



# LLRF: Control Interface CW Regime

The screenshot displays the LLRF Control Interface CW Regime software. The interface is divided into several functional panels:

- Cavity Parameters:** Contains fields for r/Q, fo, MHz, Qext\_Inc, Qext\_PickUp, Qo, Pg\_max, W, Pg\_flat, W, and Power Control (OK).
- Cavity Pretuning:** Includes Pick I, Pick Q, Inc I, Inc Q, Pick Amp, V, Pick Ph, °, Inc Amp, V, and Inc Ph, °. It features a graph of PickUp Amp vs. Phase (PickUp-Inc, °).
- Set Parameters:** Contains Grad, V, GrCorr, V, I\_Set, V, I\_FeedF, V, Phase, °, Q\_Set, V, and Q\_FeedF, V. It includes a Phase Loop Calibration graph.
- Cavity Filling:** Includes Quench\_Factor, FF\_Ampl, V, FF\_Fill\_I, FF\_Fill\_Q, and FF\_Fill\_I.
- Gradient & Phase Calibration:** Includes Gain\_Inc, dB, Gain\_PickUp, dB, Gain\_Ref, dB, Pinc, W, P\_PickUp, W, Pref, W, Pdis, W, Vcav, V, Vcav/V\_PickUp, BeamPhCal, °, and Cavity Simulator (Supercond Cavity).
- Cavity Detuning:** Includes Detuning, °, Stepper Position Control, Stepper Position Indicator, Piezo Position Control, and Piezo Position Indicator.
- Run Mode:** Includes Gradient, V (0.5006), PickUp\_I, PickUp\_Q, Pinc, W (1.808), Pref, W (0.1611), Frequency, Hz (5), Points (20), Dirty Cycle, % (50), I\_FF\_Ps (0.5), I\_FF\_Ps (S) (0), and Quench Control (OK).
- Set Parameters (Right):** Includes device AO, digital channel, AO channels, group AO, input limits, device AI, and AI channels.
- Phase Loop Calibration (Right):** Includes LOOP (OPEN, CLOSED), SetGain\_I, SetGain\_Q, I\_Pick\_G, Q\_Pick\_G, Cav Grad, V, Cav Ph, °, and Feed-back Gain.
- Pulsed Operation (Right):** Includes a graph of PickUp Amp vs. Phase and Frequency, Hz (5).
- Quench Control (Right):** Includes CW and PULSED buttons, and Operation Mode (CW, RUN LLRF).

Yellow callout boxes on the left and right sides of the interface identify key sections:

- Left side callouts:** Cavity Param., Cavity Filling, Grad. & Phase Calibr.
- Right side callouts:** Set Parameters, Phase Loop Calibration, Cavity Pretuning, Run Mode, Cavity Detuning.

The bottom status bar shows the RT Target: 192.168.92.14 and the system tray with various application icons and the time 10:26.



# PSM-RF: LLRF Hardware

Analog Low Level RF System Unit : Front and Back View

