

## Custom designed Dummy Loads for HV Pulsed Power Modulator Testing

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### Abstract

As a manufacturer for industrial, medical and scientific pulsed power applications we are frequently confronted with testing new, custom designed power modulators, i.e. pulse generators. In the purposed applications these modulators are often intended to be used on extremely expensive RF tubes like Klystrons. Therefore, it became necessary for us as well as for our customers to develop corresponding dummy loads to avoid testing modulators on these expensive devices directly.

In order to test the modulators in accordance with the actual operating parameters ( $U_{peak} < 150$  kV;  $I_{peak} < 150$  A;  $PAV < 160$  kW), the dummy loads need to fulfill the same power requirements as the intended Klystrons. Although the Klystron's perveance is not linear and furthermore depends on the applied voltage, it is sufficient to use resistive loads as a dummy. However, such a replacement load requires an appropriate high voltage, cooling and safety design.

Our basic idea was to create a modular dummy solution which can be matched easily to certain load specifications. Each module was designed as a 40 kW average power, water cooled high voltage resistive load, based on commonly used standard power resistors. Depending on the specific application up to four modules can be connected in parallel or series. For protection against high voltage the full dummy was put into a surrounding grounded cage which also contains a manifold for deionized water distribution.

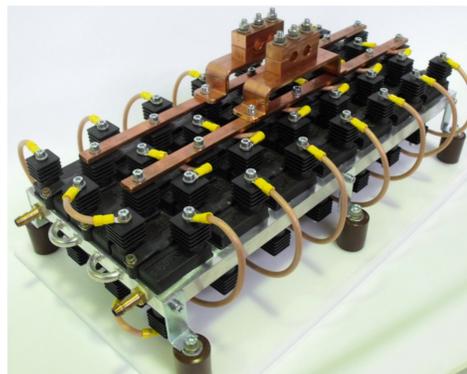
At first those kind of high power dummy loads were used for factory and site acceptance tests. By time those dummies also became attractive for our customers to drive long term tests on new modulator principles or to test new purchased modulators on site.

### Dummy Load Specifications

120 kW, 10 kV Dummy Load	
Pulse Voltage	10 kV
Pulse Current	1600 A
RMS Current	138 A
Average Power	120 kW
Insulation Level	18 kV
Load Resistance	6.25 $\Omega$
Stray Inductance	150 $\mu$ H
Repetition Rate	5 Hz
Duty Cycle	0.75 %
Water Flow	120 l/min



Mobile Test Load



Low Voltage Test Load

### Low Voltage Dummy Load Specifications

30 kW, 5 kV Dummy Load	
Pulse Current	190 A
Average Power	30 kW
Insulation Level	5 kV
Load Resistance	5.14 $\Omega$
Water Flow	10 l/min

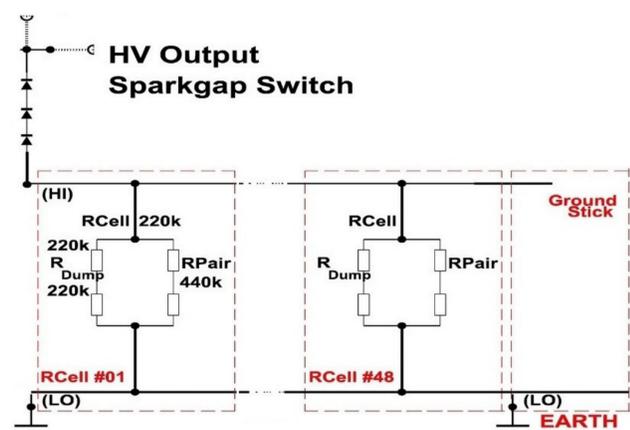
### Klystron Dummy Specifications

161 kW, 115 kV Klystron	
Pulse Energy Input per 2.8 ms Pulse	8050 J at 20 Hz
Pulse Rise Time	0.30 ms
Average Power Input per Element	0.84 kW
Total Average Power Input	161 kW
Total Dummy Resistance	4600 $\Omega$
Pulse Voltage	-115 kV at 2.8 ms / 20 Hz
Water Flow for 160 kW Power Input	4 x 80 l/min
VE- Water Flow (Total)	320 l/min = 19 m <sup>3</sup> /h
Tin / Tout	< 20°C / < 35°C
Maximum Temperature Difference	15°C
Differential working pressure	6 bar @ 35°C

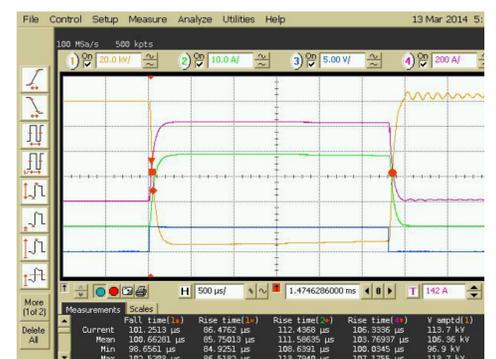


Klystron Replacement Dummy at Modulator Commissioning Site

### Dummy Load Circuit Diagram Principle



Three Resistor Modules in HV Housing



FAT Measurements at full -115 kV Test Voltage