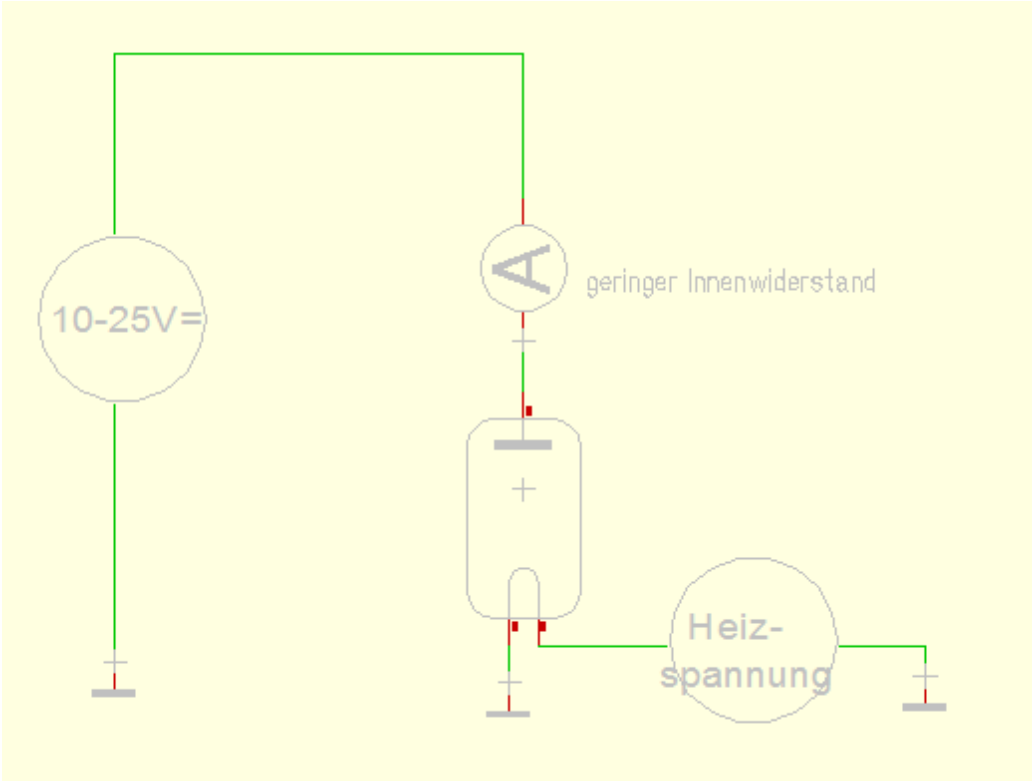
Testing of rectifier tubes
- Methods of the Neuberger tube measuring devices RPM370, RPM375 -
Using the results for the RoeTest

The Neuberger measuring devices use two different methods for testing of rectifier tubes:

1. Measuring using low DC voltages

Tube measurement is done the same way as for normal amplifier tubes. This method allows to make an exact statement about the emission capability of the tube. Further it is possible to record a characteristic curve of the tube - depending on the anode voltage. Some tube data sheets also specify such type of curves so the tube can be well compared (with manufacturer's data). As there are no grids for rectifier tubes that could limit the current, measuring is done using a low anode voltage. The tube is operated without a series resistor (there is only the negligible inner resistance of the measurement device).

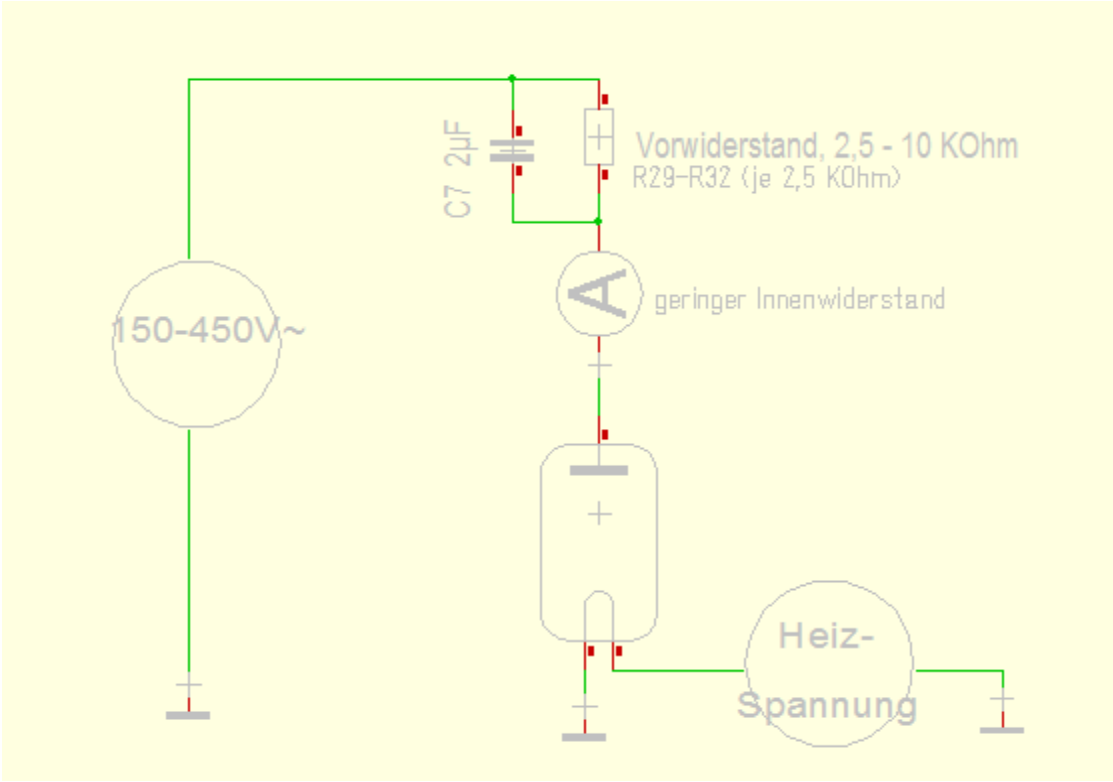


2. Measuring using high anode AC voltage and a series resistor

In this case a “real” circuit is simulated. In series with the rectifier a resistor of 1.5, 5 or 10 kilo ohm is connected (there is also a 7.5 kohm resistor present but that is not used). Further a capacitor of 2 µF is connected in parallel to the series resistor.

This method also allows to estimate the emission capability. A comparison of the measured data is only possible with the data from the Neuberger devices' test cards, not with the manufacturer's data, as the “real” circuit in most cases will differ from the circuits of the data sheets. The characteristic curve would be not meaningful.

Advantage of this method: It is also tested if there are voltage flashovers in the tube in the blocking state.



3. Which method to use for which tube?

In the following I have made a list from the Neuberger test cards (without claim of completeness). There you can see which method is used for which tube.

Tube	**High voltage ~**	**V**	**mA**	**Rvor (Kohm)**	**indirect/ direct**	**UacrossR**	wrong	W
1005	yes	150	40	2,5	d	100		4
1007	yes	300	45	5	d	225		10,125
117L7GT	no	10	75	0	i	0		0
12Z3	yes	250	40	5	i	200		8
25A7G	yes	150	25	5	i	125		3,125
25y5	no	10	50	0	i	0		0
25Z6	no	10	50	0	i	0		0
2X2A	no	50	6	0	d	0		0
35W4	no	10	85	0	i	0		0
35Z3	no	10	75	0	i	0		0
35Z4	no	10	85	0	i	0		0
5R4GY	no	25	65	0	d	0		0
5T4	no	25	100	0	d	0		0
5U4G	no	25	65	0	d	0		0
5V4G	no	10	50	0	d	0		0
5W4	no	25	45	0	d	0		0
5X4G	no	25	65	0	d	0		0
5Y3G	no	25	35	0	d	0		0
5y3GB	yes	350	70	2,5	d	175		12,25
5Y4G	no	25	35	0	d	0		0
5Z3	no	25	65	0	d	0		0
5Z4	no	10	50	0	i	0		0
6AX4GT	no	10	40	0	i	0		0
6AX5GT	yes	300	45	5	i	225		10,125
6U4	no	10	80	0	i	0		0
6X4	no	10	20	0	i	0		0
6X5	no	10	20	0	i	0		0
6Y5	yes	350	50	10	i	500	x	25
6Z4	yes	300	45	5	i	225		10,125
7Y4	yes	300	45	5	i	225		10,125
AX50	yes	300	70	2,5	d	175		12,25
AZ1	no	25	45	0	d	0		0
AZ11	no	25	45	0	d	0		0
AZ12	no	25	75	0	d	0		0
AZ2	yes	300	65	2,5	d	162,5		10,5625

AZ21	no	25	45	0	d	0		0
AZ31	no	25	45	0	d	0		0
AZ4	no	25	75	0	d	0		0
AZ41	no	25	32	0	d	0		0
AZ50	no	25	110	0	d	0		0
CY1	yes	250	45	5	i	225		10,125
CY2	yes	250	40	5	i	200		8
EY51	no	25	2,2	0	i	0		0
EY80	yes	300	50	5	i	250		12,5
EY81	no	10	75	0	i	0		0
EY86	no	15	1	0	d	0		0
EY91	yes	300	50	5	i	250		12,5
EZ1	no	10	25	0	i	0		0
EZ11	no	10	25	0	i	0		0
EZ12	no	25	120	0	i	0		0
EZ150	yes	350	80	2,5	i	200		16
EZ2	no	10	26	0	i	0		0
EZ3	no	25	120	0	i	0		0
EZ40	no	10	24	0	i	0		0
EZ40	no	10	24	0	i	0		0
EZ41	no	11	30	0	i	0		0
EZ80	no	10	22	0	i	0		0
EZ81	yes	300	45	5	i	225		10,125
FZ1	no	10	25	0	i	0		0
GZ32	no	10	65	0	d	0		0
GZ41	yes	300	45	5	i	225		10,125
LG12	yes	300	45	5	i	225		10,125
PY80	no	10	90	0	i	0		0
PY81	no	10	75	0	i	0		0
PY83	no	10	90	0	i	0		0
PY88	no	18	220	0	i	0		0
R120B	yes	150	1,3	10	d	13		0,0169
RG105	yes	400	90	2,5	d	225		20,25
RG62	yes	350	80	2,5	d	200		16
RGN1064	yes	300	45	5	d	225		10,125
RGN1404	yes	300	45	5	d	225		10,125
RGN1503	yes	300	45	2,5	d	112,5		5,0625
RGN1882	yes	300	45	5	d	225		10,125
RGN1883	yes	300	45	5	d	225		10,125
RGN2004	yes	300	75	2,5	d	187,5		14,0625
RGN2504	yes	300	75	2,5	d	187,5		14,0625
RGN354	yes	250	25	10	d	250		6,25
RGN4004	yes	300	75	2,5	d	187,5		14,0625

RGN504	yes	250	25	10	d	250		6,25
RGN564	yes	300	30	10	d	300		9
U27	yes	300	25	10	d	250		6,25
U801	yes	200	35	5	i	175		6,125
U81	yes	400	70	5	d	350		24,5
UY1	no	10	90	0	i	0		0
UY11	no	10	90	0	i	0		0
UY2	yes	250	40	5	i	200		8
UY21	no	10	90	0	i	0		0
UY3	yes	250	45	5	i	225		10,125
UY4	yes	250	40	5	i	200		8
UY41	no	10	50	0	i	0		0
UY82	no	16	180	0	i	0		0
UY85	no	10	100	0	i	0		0
UY85	no	10	100	0	i	0		0
VY1	yes	250	40	5	i	200		8
VY2	yes	250	30	10	i	300	x	9
Z2b	yes	300	45	5	i	225		10,125
Z2c	yes	300	45	5	i	225		10,125
Z2e	yes	300	34	5	i	170		5,78

Neuberger used both methods. I do not know the reason why a specific method was used for a specific tube. There seems to be no defined criterion for a method but the method seems to have been chosen arbitrarily.

The table also shows that the resistor power of 25 W is enough even for the most powerful tube.

Something else came to my attention. Some test cards cannot be right:

Tube	**High voltage**	**Vrms**	**mA**	**Rvor (Kohm)**	**indirect/ direct**	**VacrossRvor**
	~					
6Y5	yes	350	50	10	i	500
VY2	yes	250	30	10	i	300

At the specified current through the resistor the voltage drop across the resistor would have to be larger than the supplied voltage what cannot happen anyway. In my opinion a smaller series resistance has to be chosen.

4. Implementation in the RoeTest

The RoeTest uses for measurement of rectifiers solely the first method (low DC voltage). The question is if the second method is also possible and hence a test for voltage flashovers can be done.

In **manual mode with series resistor** a freely selectable resistor may be connected externally to relay boards 9+10. So this mode can be used to operate tubes with series resistor without cutting a connection wire. This works for all tubes that do not use pins 9+10 (or head connection).

There are only DC voltages present in the RoeTest. To simulate both directions of an AC voltage is is necessary to connect the DC voltage to the tube differently poled.

a) Forward (Pass-) operation mode

No problem when using **manual mode with series resistor**. First a consideration about the height of the voltage. Ideally we assume that the AC voltages are exact and constant (in reality the voltages in the Neuberger devices are of course load dependent as they are are not stabilized).

The Neuberger uses AC voltages. Specified are RMS values. Peak or peak to peak values are higher. Due to the rectifying effect of the tube the negative half wave is always cut off. It remains the positive half wave that swings between 0 and the peak value of the voltage but is smoothed by the 2 µF capacitor. From the specified current and the value of the load resistor Urms dropped at the load resistor or the tube respectively can be calculated. These values should be the same for pure DC voltage so we use the same voltage values and series resistor values as given in the test cards. For directly heated tubes the AC heating would also have to be taken into account (see other report). With the high test voltages this factor can be ignored completely. The same applies to the small inner resistance of the measuring meter. In fact this measurement can be omitted as there is already a statement for the emission capability from the low voltage measurement.

Note: There is only a very low voltage drop across the tube (“tube drop”). A test for voltage flashovers can therefore not be performed in pass mode operation.

b) Backward (Blocking-) operation mode

The tube blocks the negative half wave. No current will flow as long as the tube is okay.

Test for voltage flashovers: An AC voltage has a higher peak voltage:

Urms	**Upeak**
150	211
200	282
250	352
300	423
350	493
400	564

We can adjust the voltage in the RoeTest for a **short-period** to test for voltage flashovers. The series resistor limits the current in case of a fault. A resistor of higher value should be used to limit the current to lower values in the case of fault (for example 50 kohm/5W - this would lead to a current flow of 10 mA at 500 V with a short in the tube).

With the RoeTest a polarity reversal of the DC voltage is only possible with **indirectly** heated tubes. The reason is that one pole of the DC voltage has a fixed ground connection and so is connected to the filament voltage. For directly heated tubes this test is not possible with the RoeTest (applies to manual mode with series resistor – see following addendum).

The same measurement circuit is used as with forward mode of operation only the electrodes A and K are reversed (invert the naming of the pins). The voltage may be adjusted up to the peak value for a short-period.

There must not flow any current. In case of a voltage flashover the series resistor will limit the current.

At the same time the insulation between filament and cathode is tested with a high voltage here.

The test for voltage flashovers in blocking mode of operation can of course also be applied for all other indirectly heated tubes as diodes where there are no Neuberger test cards or where Neuberger measures with low voltages. As this is not a measurement but a test a larger series resistor can be used and the voltage may be adjusted up to the maximum peak voltage (see tube data sheet).

Summary:

Measuring the emission in analogy to Neuberger using a high voltage is possible with the RoeTest but there is no advantage compared to the measurement using low voltage.
I will implement the blocking operation mode voltage test into the automatic test modes of the RoeTEst.

Addendum:

My friend Hans-Thomas Schmidt gave me the tip that during blocking voltage test it is possible to switch off the heating voltage for a short while and so the voltage can be reversed even with directly heated tubes. Thank you Hans-Thomas for this tip.

Enhancement of the software

For diodes/rectifiers I will implement a blocking voltage test into the automatic mode "statische Messungen". For that purpose the heating will be switched off for a short time so that directly heated as well as indirectly heated tubes can be tested.

I will do that without use of external resistors but using the built in ones used for tuning eyes. **Thus the additional test will be done fully automatically.** As the G2-voltage source will be used for this reason the maximal test voltage is limited to 300V. For tubes with a lower anode voltage the test voltage will be limited to that value.