

RoeTest - das Computer-Röhren-Messgerät -

professional tube-testing-system (c) Helmut Weigl www.roehrentest.de

Testing Tubes with very high Conductance using a Cathode Resistor with the D3a as Example

Problems when measuring these Tubes:

The D3A is a frame grid tube with a very high conductance. It was used by Deutsche Post.

Due to the pentode's very high conductivity of 35 (30-40) mA/V (even higher when used in triode mode) there are the following problems:

- Tendency to oscillate: The testing device must be capable of handling the high conductivity and be able to suppress tube oscillations (no problem with the RoeTest when built with short wires and socket boxes containing only one socket according to my advice)
- A tiny change of the grid voltage results in a very high change of the plate current. Although the tubes are manufactured with tight tolerances small deviations from the average characteristic curve have significant effects. So standard tube measuring is of little value.

Data sheet of the D3a:

Due to the aforementioned reason the data sheet of the D3a specifies another measuring method, the use of a cathode resistor. An excerpt from the data sheet (Siemens):

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Kenndaten

		min.	nom.	max.	
U_{ba}	=		190		V
U_{g3}	=		0		V
U_{bg2}	=		160		V
$+U_{bg1}$	=		10		V
R_k	=		400		Ω
I_a	=	21	22	23	mA
I_{g2}	=	5,4	6	6,6	mA
S	=	30	35	40	mA/V
μ_{g2g1}	\approx		80		
R_i	=		120		$k\Omega$
$R_{äq}$	=		150		Ω
R_{e1} (100 MHz)	=		1		$k\Omega$ 1)
S/C	=		2,9		mA/VpF
$S/2\pi C_{ges}$	=		230		MHz 2)
F	=		7		dB 3)
$-I_g$	\leq			0,3	μA

Triodenschaltung (g2 an a, g3 an k)

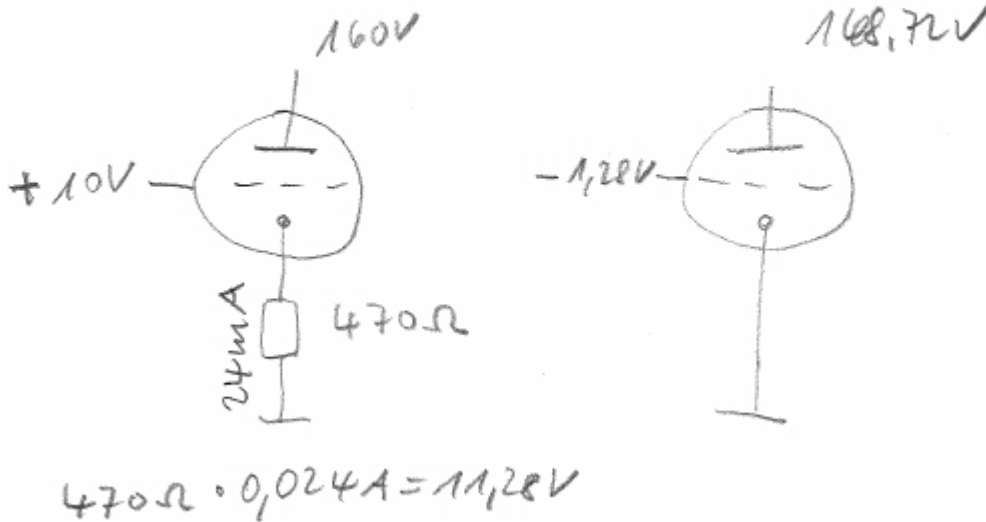
U_{ba}	=		160		V
U_{g3}	=		0		V
$+U_{bg1}$	=		10		V
R_k	=		470		Ω
I_a	=		24		mA
S	=		41		mA/V
μ	\approx		77		
R_i	=		1,9		$k\Omega$
$R_{äq}$	=		65		Ω

According to the data sheet a cathode resistor of 400 Ohm has to be used when measuring as a pentode and a resistor of 470 Ohm when measuring as a triode. In the following consideration the circuit as a triode (plate and screen grid connected) is used for easier presentation:

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a) mit Kathodenwiderstand b) ohne



According to the data sheet the average voltage drop at the cathode resistor is 11,28V. Feeding +10V to the grid results in the following effective voltages at the tube:

Plate-Cathode voltage: 148,72V (160-11,28)

Grid-Cathode voltage: -1,28 V (10-11,28)

So also in this case the tube is still driven with negative grid bias. The cathode resistor causes a large negative feedback. The tube self stabilizes its working point. Conductivity is greatly reduced.

The data sheet specifies for this case that the tube is within specifications when the plate current is within +/- 1 mA of the nominal value. The test card of the Grundig 55a is even less restrictive and allows a tolerance of the plate current of +/- 10%.

In the following the test card of the Grundig 55a tube tester (a tube tester custom-made for Deutsche Post) and the Neuberger test card:

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Röhre: D3a		Datenblatt Nr.:	
Vergleichstyp:			
Schalter	Einstellwerte	System I	
		a	b
1 Ug1/Rg1	V~/MOhm	0,5 V	0,5 MA
2 Meßfeld	-	-	-
3 Jg2	mV	6 mA	0
4 Ug2	V-	150	107 %
5 Rk/Up	Ohm/V	400	0
6 Ug1	V-	+ 10	0
7 Ua~	V~	30..100	6,5(657)
8 Ja	mA	20 mA	2(22mA)
9 Ua	V	150	127 %
10 Uh	V	6,3	-
11 Ra	kOhm	4	1(5)

Sockelschaltung: Noval		Kenndaten		Bemerkungen ILT = 10 000 Std. Pentode für Breitband-Verstärker
Stift: 1	6	Ja	22-10 mA	
2	7	Jg2	mA	
3	8	S	35-10 mA/V	
4	9	Ua	V	
5	10	Ug2	V	

Ende der Lebensdauer		Isolation	
Abfall auf		Rk	≤ 20 MOhm
Ja	%	Ra	≤ 500 MOhm
Jg2	%	Rg1	≤ 500 MOhm
S	%	Rg2	≤ 500 MOhm

gez.: 26.10.66 H. Weigl FA 1 Mohn 23 Fbl 437 A5

Both tube testers require the use of a cathode resistor (due to the reasons mentioned above).

Note: Static measuring the conductivity or characteristic curve recording with a cathode resistor is not meaningful (with the D3a the cathode resistor reduces conductivity to about 2 mA/V). Due to this reason **two measurement cycles** are done with the RoeTest, first the plate current with the cathode resistor and second further static measurements (e.g. conductivity) without cathode resistor.

RoeTest Measurement with Cathode Resistor:

The test with a cathode resistor with the RoeTest requires the following conditions:

- Hardware Version >= V9
- Software Version >= V 10.3.1.0

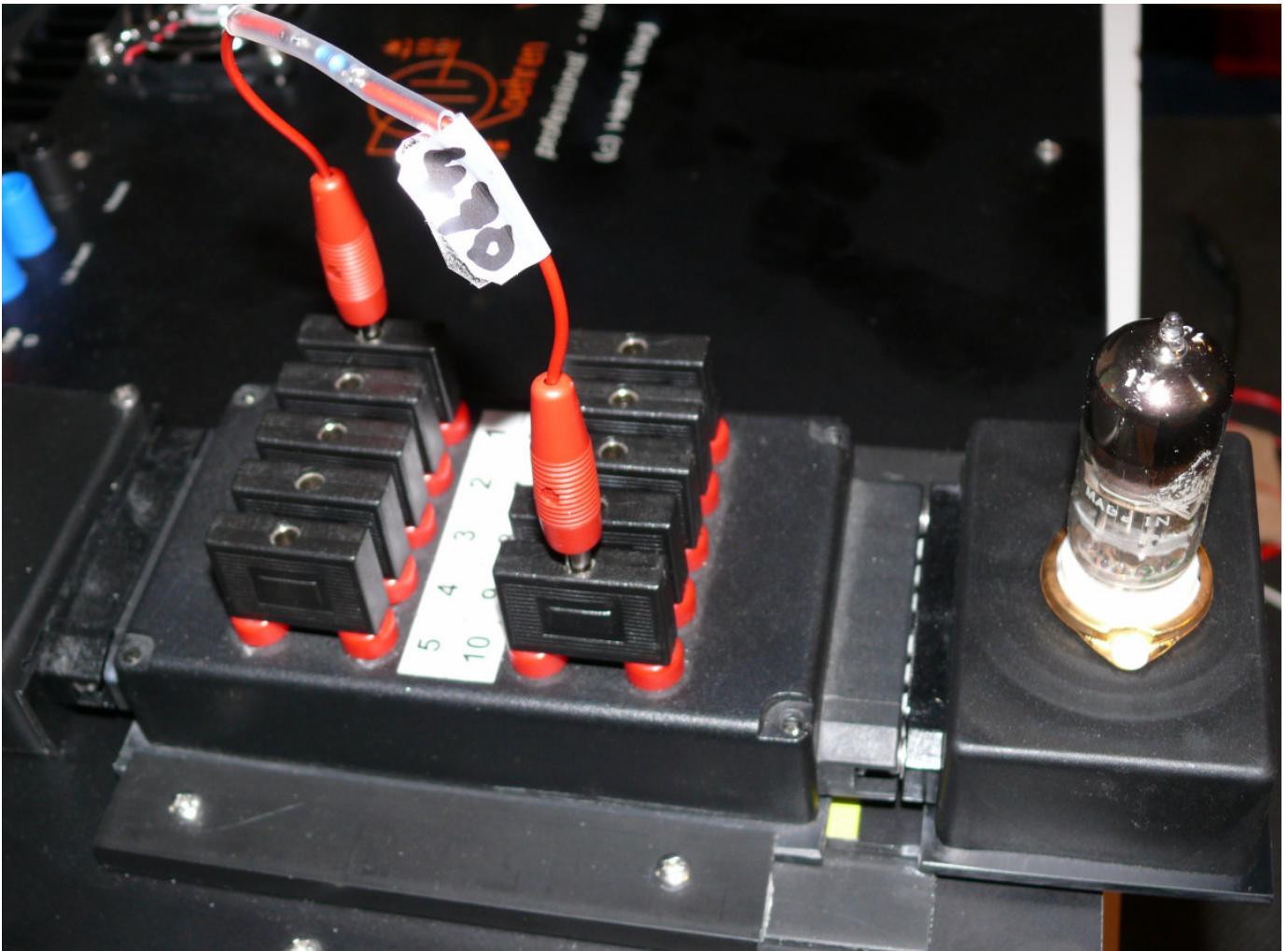
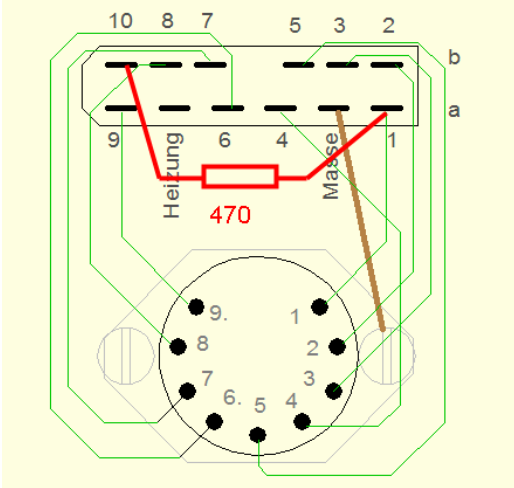
Measurement shall be done conveniently. When all required data have been specified all measurements are done automatically, started with the button <stat.Messung> (static measurement).

1. The RoeTest provides, besides the heater voltage, two positive voltage sources: The A-Card and the G2-Card. The G2-Card is used for the positive grid voltage of +10V. The A-Card remains for the other positive voltages. The tube's plate and screen grid are connected for the measurement. Measurement is done in triode mode as described in the data sheet.

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2. A 470 Ohm/0,6W cathode resistor has to be connected manually. This resistor should be as accurate as possible (either measure from 1% type resistors or better use a 0,1% type resistor). The resistor has to be placed between Pin 1 and Pin 10 of the socket box (or mounted in the socket box). If you have an Insert-box you can attach the resistor to the Insert-box.



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3. Data set for the D3a: For testing this type of tube a specific data set was defined:

Röhrenname: D3a **Rk=470Ohm, +Ug1** K

Hersteller: ---

s. Vergleichsröhre: _____

Philips code: NR

Herstelljahr: _____

Heizung: _____

Heizspannung [V]: 6,30 **Regelung:**

Heizstrom [A]: 0,315

Heizart: indirekt

Kaltwiderstand Heizfaden [Ohm]: 0,00

Allgem. Daten

Daten getestet/verifiziert:

Datenherkunft: datasheet

Daten erfaßt durch: H. Weigl

Daten geändert (oder neu): (hier markieren, falls Daten zur Zusammenführung übersandt werden)

Daten geändert durch: H. Weigl

Bemerkungen zu Änderungen: getestet

Röhren-(System)art: System 1: Triode +G1 Rk; System 2: Triodemode; System 3: -

Stift 1: K; **Stift 2:** G1; **Stift 3:** K; **Stift 4:** F1; **Stift 5:** F2; **Stift 6:** _____; **Stift 7:** A; **Stift 8:** G3; **Stift 9:** G2; **Stift 10:** RK

Socket/Fassung: 8 x 36° 1.02 φ PC φ: 11.9 mm B9A

Novol B9A

Bemerkungen zur Röhre: Hilfe zu Röhrenart: Messvorschrift als Triode gemäß Datenblatt. **Rk=470 Ohm in Fassungsbbox von Pin 1 nach Pin 10 manuell anschließen.** System 2 = zweite Messung erstes System. mind. 2 Minuten heizen!

Navigation Datensatz:

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	System 1	System 2	System 3
Röhren-(System)art:	Triode +G1 Rk	Triodemode	-
typische Werte: S2 +1 UA/L [V] *)	160,0	150,0	0,0
S3 -1 UG1 [V] *)	0,00	-1,25	-1,25
S4 +2 UG2/An/Stn [V] *)	10,0	0,0	0,0
S5 -2 UG3/G4Okt. [V] *)	0,0	0,0	0,0
UG4/G5 [V] *)		= Stiftzuordnung gemäß Röhrenart	
IA/L Soll [mA]:	24,000	24,000	0,000
IG2/An Soll [mA]:	0,000	0,000	0,000
S [mAV]:	0,00	41,00	0,00
μ:	0,0	77,0	0,0
D:	0,0	0,0	0,0
Ri [KOhm]:	0,0	1,9	470,0

*) bei Hexoden, Heptoden, Oktoden, Nonoden können die Spannungsquellen auch mit anderen Elektroden verbunden sein (z.B. G3,G4,G5) - siehe Zuordnung in der Datenbank "Röhrenart"

First Measurement Cycle:

In the data set's column **System 1** the test parameters with cathode resistor are defined (typical values according to the data sheet). Here the plate current is measured with cathode resistor. The defined tube type „Triode +G1 Rk“ ensures that the cathode resistor „RK“ connected to Pin 10 will be switched to ground instead of the „K“ connections. **The value of the cathode resistor has to be entered in the column for System 3 in the field Ri in Ohm (not kOhm).**

Second Measurement Cycle:

The column **System 2** is used for the second measurements (principally the data fields for a second tube system can also be used for the same tube system but for different measurement tasks). Here the tube measurements are done without cathode resistor. The tube's „K“ connections are switched to GND. Connector „RK“ is not switched.

Ug1 for Vacuum Measurement

When performing Vacuum measurements Ug1 must be constant to ensure comparability of the measured values. On the one hand Ug1 shall be small so that with weaker tubes grid current can still be measured. On the other hand measurement shall be done outside the tube's region where current begins to flow. Further on Ug1 must be sufficiently negative so that with good tubes there will not be a too large plate current. For the D3a I determined an optimum Ug1 of -1,25V. This value shall be specified in the column for "System 3". If no value is given there a standard value of -1,5V will be used for grid current measurement.

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When pressing the button <**statische Messung**> (static measurement) the following happens: In a **first measurement cycle** the plate current with cathode resistor is measured. Additionally the estimated effective plate voltage and grid voltage are calculated and written to the green fields of the second system.

Important: Before starting the first measurement cycle you **should at least wait 2 minutes** (longer is better) until the tube is properly heated up and the automatic working point regulation with the cathode resistor has stabilized. You can specify the RoeTest Autostart for fixed time as follows:

bitte bestätigen:

Bitte warten bis Röhren aufgeheizt und Messwerte konstant sind! Bestätigen mit 'starten'.

Warte seit **17** Sekunden

Nach 300 900 3600
Sekunden wird automatisch abgebrochen!

Autostart

kein Autostart

Autostart erfolgt, wenn der Anodenstrom mindestens 20% des Sollwertes erreicht hat, und der Strom eine Zeit lang konstant ist.

max. Hysterese [mA] : Zeit [s]:
(x1) -> 0,05mA (3-99)

Autostart nach fester Zeit von [s]:

erste Messung: Folgemessungen:
(>=5s)

After the first measurement a **second measurement cycle** is automatically started from the RoeTest.

Now the grid voltage is searched that will approximately yield the same plate current as found in the first measurement with cathode resistor. With that working point further static measurements are done (conductivity, inverse amplification factor, grid current etc.). After the static measurements have been done (and hence the working point has been found) characteristic curve recordings can be done. By the way, for the second measurements I defined another additional tube type „Triodemode“. With this type the pentode is measured in triode mode (plate and screen grid will both be connected to the A-Card).

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The measured values look like that:

The screenshot shows the RoeTest software interface. At the top, there are eight analog-style gauges for different measurements: UH, UA, U, UG1, IH, IA, I, and U. Below these are control buttons for 'nachregeln' and 'Drehmoment'. The main control area includes buttons for 'Durchgangsprüfer', 'Stromüberwachung', 'COM 19', 'Data In', and 'Data Out'. A 'Kühlkörpertemperatur' field shows 21.0 °C. The 'Röhrendaten' section displays 'D3a Rk=470Ohm, +Ug' and 'Noval B9A' socket. A pin diagram is shown. The 'Meldungen' table is the central focus, with columns for System, 1, 2, and 3. The table contains various parameters like 'Röhrenart', 'Sollwert IA', 'Messwert IA', 'Ug1(la)', 'Ig', 'Rk', 'S', 'bei Delta UG1', 'Messwert IA bei +1/2 dUG1', 'Messwert IA bei -1/2 dUG1', 'μ', 'D Anode', 'Messwert IA bei UA', 'URk', 'Ug1-URk', 'Ua-URk', 'Ri', and 'Ig'. The table is color-coded: red for the first cycle, green for the second, and blue for the working point approximation. A blue arrow points from the 'Messwert IA' row in the table to the 'IA' gauge. The right sidebar contains buttons for 'laden Röhrendaten', 'Daten akt. Röhre', 'Datenbanken', 'Eadentest', 'Kurzschlussstest', 'statische Messung', 'Kennlinien', 'Schnelltest', 'drucken', 'Kennlinien auswerten', 'Stapelverarbeitung', 'manuell', 'Info', and 'Ende'.

Meldungen	1	2	3
System	1	2	3
Röhrenart	Triode +G1	Triodemod	
Sollwert IA [mA]	24		
Messwert IA [mA]	23,118	23,09	
= % vom Sollwert	96		
Ug1(la)[V]			-1
Ig [mA]	0,214		
Rk [Ohm]	470		
S [mA/V]			38,49
bei Delta UG1 [V]			0,6
Messwert IA[mA] bei +1/2 dUG1			35,81
Messwert IA[mA] bei -1/2 dUG1			12,718
μ			85
D Anode [%]			1,2
Messwert IA [mA]			5,984
bei UA [V]			104,55
URk [V]		10,876	
Ug1-URk [V]		-1,026	
Ua-URk [V]		149,1	
Ri [kOhm]			2,7
Ig [μA]		0,0131	Ug1=-1,25

red: First measurement cycle, plate current with cathode resistor 470 Ohm

green: Second measurement cycle, measuring of conductivity, inverse amplification factor, etc.

Blue: Approximation to the working point 23,008 mA (as the maximum resolution of the G1-Card is 0,025V, approximation to 23 mA can only be roughly done. Due to the large conductivity the current at a grid voltage of -1,000V would already be further away from the nominal value).

Grid current measurement at specified measuring condition (Ug1 = -1,25V).

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Characteristic curves can be recorded in the usual manner after the static measurements have been done (with the data measured from the second measurement cycle):

The screenshot displays the RoeTest software interface. At the top, there are eight analog-style gauges for various measurements: UH (0-120V), UA (0-300V), U (0-300V), UG1 (0-100V), IH (0-600mA), IA (0-300mA), I (0-60mA), and U (0-100V). Below these are digital readouts and control buttons. The right side features the 'roehrentest.de' logo, version '10.3.1.0', and an image of a vacuum tube. The bottom section contains a 'Röhrendaten' (Tube Data) panel with fields for tube name, heater voltage, and a table of typical values. The central area shows two graphs: 'UG1/IA (System 2)' and 'UA/IA (System 2)', plotting current (IA) against grid voltage (UG1) and anode voltage (UA) respectively. The right sidebar contains a menu of functions like 'laden Röhrendaten', 'Daten akt. Röhre', 'Eadentest', 'Kurzschlussstest', 'statische Messung', 'Kennlinien', 'Schnelltest', 'drucken', 'Kennlinien auswerten', 'Stapelverarbeitung', and 'manuell'.

Note: With the above given measuring method one complete data set is required for one tube system. For tubes with more systems additional full data sets per system are required.

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Manual Mode

With the same data set the tube can also be tested in manual mode. The data from System 1 may be used for measurements with cathode resistor, the data from System 2 for measurements without cathode resistor.

The screenshot displays the 'RoeTest - professional tube-testing-system - manueller Modus' window. It features several vertical sliders for setting parameters: H (6.30), A (160.0), G1-positiv (10.0), and two others at 0.000. Below the sliders are radio button options for voltage ranges. A 'Spannungen aus' section includes checkboxes for 'Soundtest', 'G1-Vakuumfest', and 'suche G1', along with input fields for 'IaKonst= [mA]' (24) and 'Hyst. [mA]' (0,07). A 'Messvorschrift als Triode gemäß Datenblatt' section contains a table with pin numbers and their corresponding measurements. At the bottom, there are buttons for 'Start', 'Stop <esc>', and 'beenden', and a 'Daten übernehmen von' section with 'System 1' highlighted.

PinNr	=	Röhrenart	Triode +G1 Rk
1	K	Ua [V]	160,0
2	G1	Ug1 [V]	0,00
3	K	Ug2 [V]	10,0
4	F1	Ug3 [V]	0,0
5	F2	Ia [mA]	24,000
6	A	Ig2 [mA]	0,000
8	G3	Uh [V]	6,3
9	G2	Ih [A]	0,315
10	RK		

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Effects affecting the Measurement Results caused by the RoeTest's inaccuracy

a) First measurement cycle with cathode resistor and positive grid voltage:

The measurement with cathode resistor requires a positive grid voltage that is supplied from the G2-Card. The G2-Card has a voltage resolution of 0,1 V. There is no alignment possible at the lower alignment point but only an approximation. Worst case the voltage can be off by ½ Bit of the desired voltage of +10V. The actual voltage might be between 9,95V and 10,05V.

Experimental measurement of a tube with cathode resistor, change of plate current depending on change of grid voltage (at working point):

Ug [V]	9,9	10	10,1
Ia [mA]	22,948	23,143	23,338

Therefore the current change resulting from one half bit inaccuracy is:

$$(23,338 - 22,948) (10,1-9,9) \times 0,5 = 0,0975 \text{ mA max.}$$

This is equivalent to a maximum deviation of 0,416 % from the nominal value of 24 mA. The small G1-Deviation is the same with all tubes and can thus be neglected.

b) Second measurement cycle without cathode resistor and negative grid voltage:

The negative voltage is supplied from the G1-Card. This card has a voltage resolution of 0,025V and is adjustable both at the lower and the upper range end. Tracking is very precise.

Measurement is done without cathode resistor, thus with a very high tube conductance of about 40 mA/V. This conductance leads to a change of plate current per DAC step of $40 \times 0,025 = 1 \text{ mA}$. At start of the second measurement cycle an approximation of the working point found from the first measurement cycle is tried. To achieve this the grid voltage is varied accordingly to give best possible approximation of the plate current from the first measurement. The G1-Card has an intrinsic inaccuracy of ½ Bit what corresponds to an approximation error of +/- 0,5mA of the plate current. Conductance, etc. is measured very close to the optimum working point. This should not lead to a significant deviation of the measurement results.

Conclusion: The measurement accuracy of the RoeTest is good for both the first and the second measurement cycle.

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RoeTest - Datenbank

Röhrenart

Triodemode

A K G1 G2 G3 G4 G5 F1 F2 FM IV S L A1 A2 ST1 ST2

m/k (muß/kann) m k m k k m m k k k k

an Schiene Nr. 2 0 3 2 0 0 1 0

Bezeichnung der Schienen:

Schiene 0:	Masse	0V
Schiene 1:	+ (ext) Heizung	H
Schiene 2:	+ 306V/ 250 mA	A
Schiene 3:	-51V (-5,1V)	G1
Schiene 4:	+306V/ 50 mA	
Schiene 5:	-51 V (ext.Heiz.)	

Bemerkungen:

Pentode als Triode

erlaubte Tests:

Fadentest:	<input checked="" type="checkbox"/>	manueller Modus	<input checked="" type="checkbox"/>
statische Tests:	<input checked="" type="checkbox"/>	manueller Modus mit Vorwiderstand	<input type="checkbox"/>
Steilheit:	<input checked="" type="checkbox"/>	Nixie	<input type="checkbox"/>
Steilheit positive G1:	<input type="checkbox"/>	Stabi/Glimmlampe	<input type="checkbox"/>
Durchgriff Anode:	<input checked="" type="checkbox"/>	Zenerdiode	<input type="checkbox"/>
Durchgriff Schirmgitter:	<input type="checkbox"/>	Dekatron / E1T	<input type="checkbox"/>
Innenwiderstand:	<input checked="" type="checkbox"/>	Thyratron	<input type="checkbox"/>
Vakuumtest:	<input checked="" type="checkbox"/>	Kennlinien G1:	<input checked="" type="checkbox"/>
Kathodenschlußprüfung	<input checked="" type="checkbox"/>	Kennlinien Anode:	<input checked="" type="checkbox"/>
Überschlag in Sperrrichtung (Dioden)	<input type="checkbox"/>	Kennlinie G2:	<input type="checkbox"/>

Elektrodenbezeichnungen:

A = Anode
G1-5 = Gitter
K = Kathode
F1,F2,FM = Heizfaden
S = Schirmung
IV = nicht verbinden
L = Leuchtschirm
A1,A2 = Anode Mag.Auge
St1,St2 = Steuergitter

Navigation Datensatz: