Overview

This document outlines the procedures used to measure a noise generator's output with respect to a 5722 noise diode lab standard. There are two main sections:

> **Procedure to Perform Noise Generator Measurements:** the steps to make measurements and record the data needed for analysis
>
> **Procedure to Analyze Noise Generator Measurements:** the steps to calculate accurate temperatures and spectra from the recorded data.

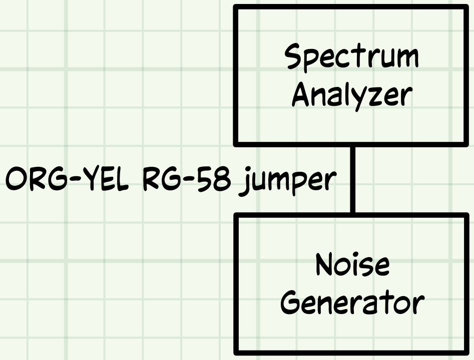
The overall method is to use an R75 receiver as a radiometer and a 5722 diode noise generator lab standard of known absolute noise temperature against which a DUT noise generator is compared. The following equipment and software is used:

- Icom R75 receiver
- 5722 noise generator
- AJ4CO Automatic calibrator
- VNA-2180 vector network analyzer
- DSA815 spectrum analyzer
- Kay 1/432D and 432D step attenuators
- Various RG-58 jumpers
- PC with internal sound card
- RadioSky-Pipe
- Microsoft Excel

Procedure to Perform Noise Generator Measurements

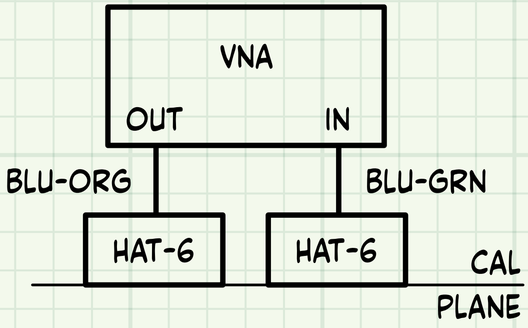
1. Allow all equipment except 5722 to warm up for at least 12 hours to stabilize.

2. Record spectrum of DUT using spectrum analyzer.



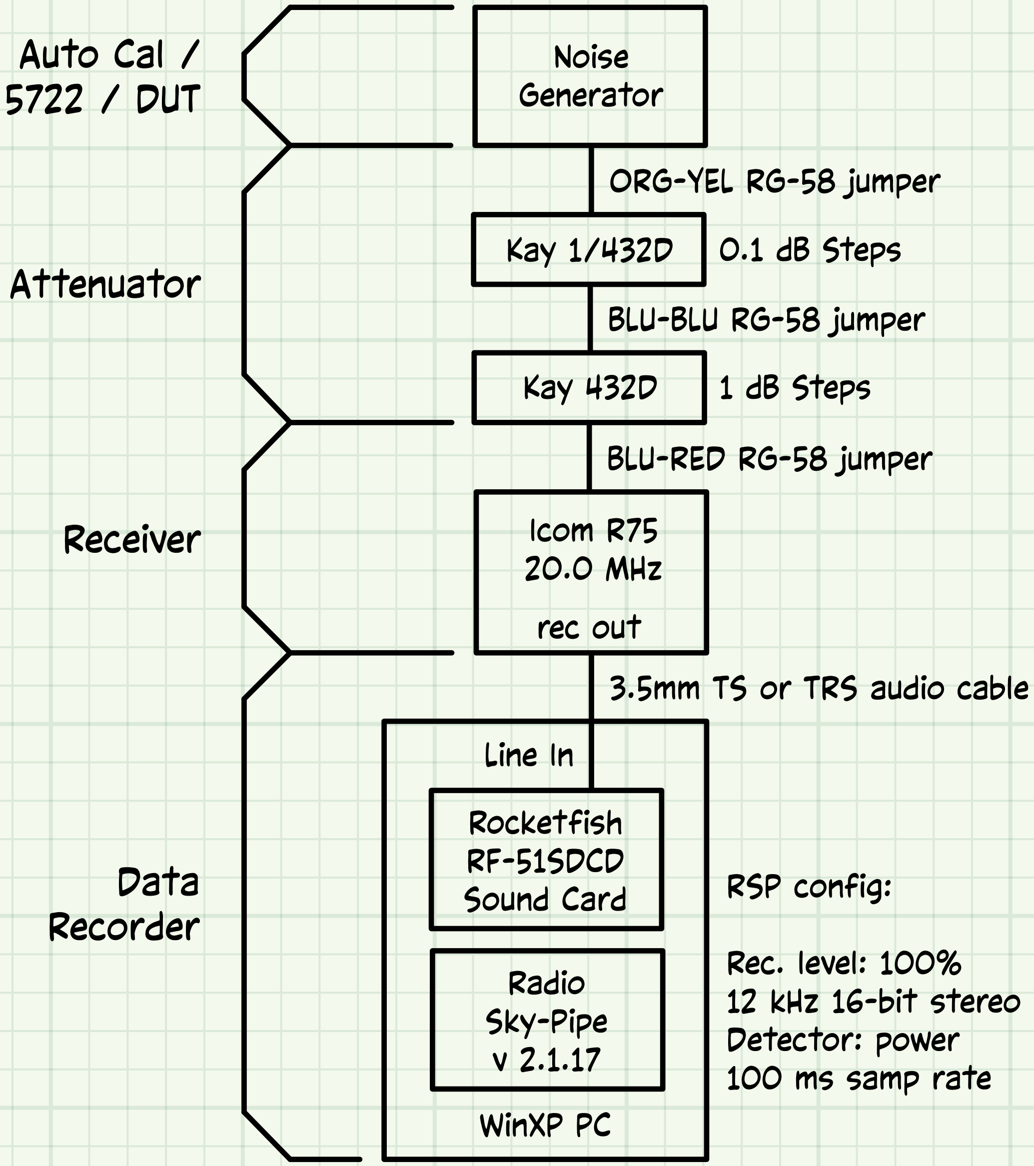
Span: 30 MHz
f_{center}: 25 MHz
RBW: 30 kHz
VBW: 100 Hz
Detector: Volt. Avg.
Trace: Video Avg.
Avgs: 100
Input Attn: 0 dB
Preamp: On

3. Calibrate VNA to ends of HAT-6 pads at ends of BLU-ORG & BLU-GRN RG-58 jumpers.



Procedure to Perform Noise Generator Measurements, continued

4. Tune R75 to desired frequency, usually 20 MHz, USB mode, Wide IF filter, AGC OFF.
5. Connect receiver BLU-RED RG-58 jumper to attenuator.
6. Connect attenuator ORG-YEL RG-58 jumper to AJ4CO Automatic Calibrator output port C or D.
    a. NOTE: ensure all unused ports on the Auto Calibrator are terminated in 50 Ω. Do not use the Auto Cal's port arming switches to control the port outputs during a 5722 measurement series. All four ports on the Auto Cal's noise gen internal splitter must see a 50 Ω load otherwise the noise temperature at all four ports will not be uniform. When the ports are disarmed, the splitter output going to the disarmed Auto Cal port is left in an open connection state. Ref *AJ4CO Automatic Calibrator*.

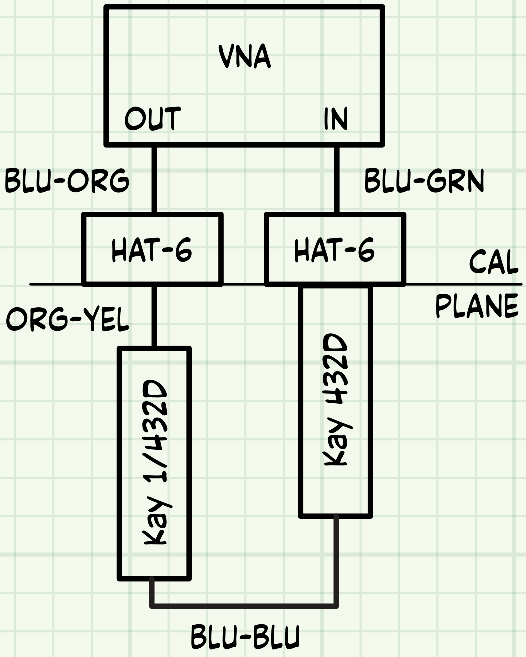


RSP config:

Rec. level: 100%
12 kHz 16-bit stereo
Detector: power
100 ms samp rate

Procedure to Perform Noise Generator Measurements, continued

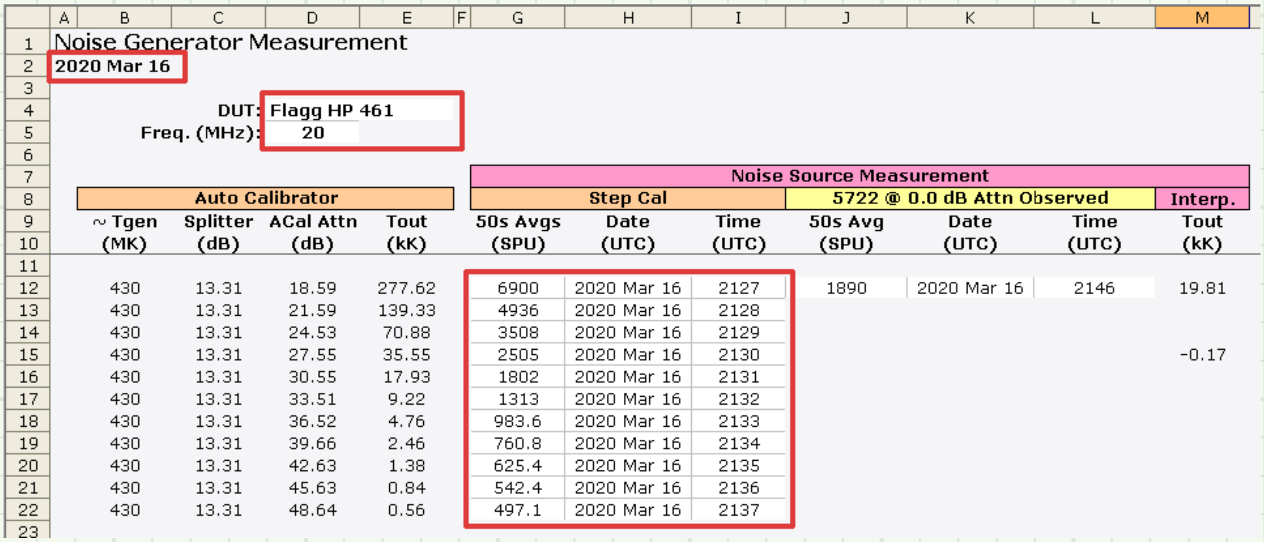
7. Use Auto Cal to run a step cal with 1-minute steps, strip chart reporting in terms of SkyPipe Units (SPU).
8. Connect attenuator ORG-YEL jumper to 5722 reference noise generator output.
9. Record 3 minutes of 5722 output, note position of trace in terms of SPU.
10. Sweep S_{21} on the attenuator ("0.0" dB setting).



11. Connect attenuator ORG-YEL jumper to DUT noise generator output.
12. Adjust attenuator until chart reading is the same (by eye) as the reading noted for the 5722.
13. Record 2 minutes of DUT output.
14. Sweep S_{21} on the attenuator at the final setting used in step 12.
15. In the next section, **Procedure to Analyze Noise Generator Measurements**, enter step cal, 5722, and DUT SPU readings, attenuator S_{21} measurements, and spectrum analyzer sweep data into spreadsheet to calculate and plot DUT output temperature and spectrum.

Procedure to Analyze Noise Generator Measurements

1. Enter date, DUT name, test frequency, and step cal SPU readings.



Noise Generator Measurement
2020 Mar 16

DUT: Flagg HP 461
Freq. (MHz): 20

				Noise Source Measurement						
Auto Calibrator				Step Cal			5722 @ 0.0 dB Attn Observed			Interp.
~ Tgen (MK)	Splitter (dB)	ACal Attn (dB)	Tout (kK)	50s Avgs (SPU)	Date (UTC)	Time (UTC)	50s Avg (SPU)	Date (UTC)	Time (UTC)	Tout (kK)
430	13.31	18.59	277.62	6900	2020 Mar 16	2127	1890	2020 Mar 16	2146	19.81
430	13.31	21.59	139.33	4936	2020 Mar 16	2128				
430	13.31	24.53	70.88	3508	2020 Mar 16	2129				
430	13.31	27.55	35.55	2505	2020 Mar 16	2130				-0.17
430	13.31	30.55	17.93	1802	2020 Mar 16	2131				
430	13.31	33.51	9.22	1313	2020 Mar 16	2132				
430	13.31	36.52	4.76	983.6	2020 Mar 16	2133				
430	13.31	39.66	2.46	760.8	2020 Mar 16	2134				
430	13.31	42.63	1.38	625.4	2020 Mar 16	2135				
430	13.31	45.63	0.84	542.4	2020 Mar 16	2136				
430	13.31	48.64	0.56	497.1	2020 Mar 16	2137				

a. This calibrates the strip chart's output in terms of T_{noise} at the radiometer input.

b. This requires a step calibrator for which the output temperatures at the frequency being used for measurement is known. Here the AJ4CO Automatic Calibrator is used.

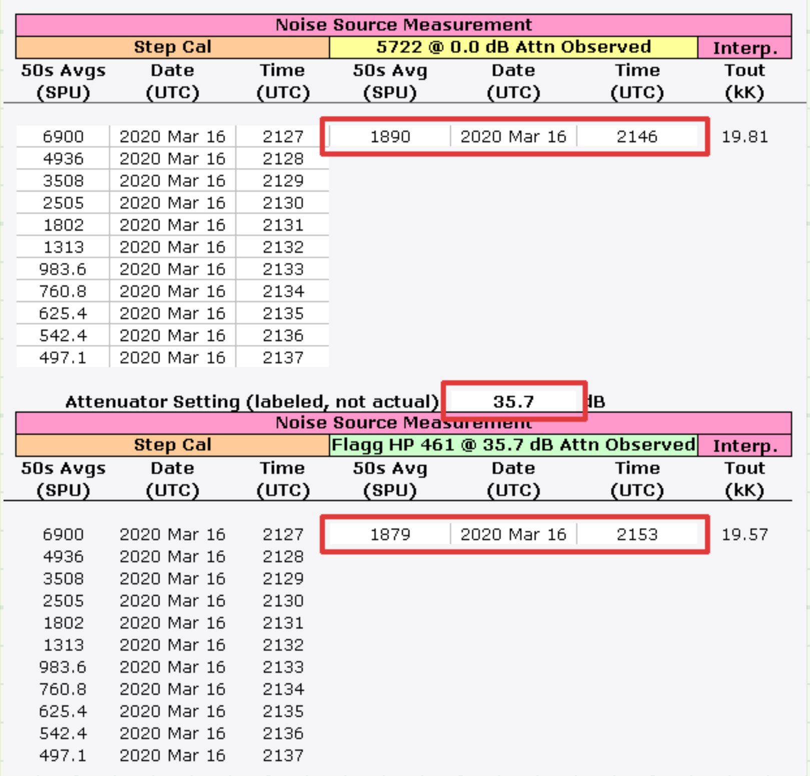
c. NOTE: this step calibration need not be exact. A rough calibration will also suffice because this calibration is NOT used to measure the DUT directly. It is used only to ensure the measurements of the 5722 and the DUT lie within the linear response of the radiometer.

d. Linearity is required because the reading of the DUT (when padded in 0.1 dB steps) will never perfectly match the reading of the 5722, If the radiometer's response is linear, the difference between the two readings can be calculated in terms of dB and accounted for during calculation of the DUT's noise temperature.

e. 50-second averages are used throughout the analysis. The integration time, when used with a radiometer having a ~ 3 kHz bandwidth, provides good enough (≲ ± 0.1 dB) accuracy while not being too burdensome time-wise. This duration also allows 5-second margins within each 1-minute calibration step to ensure that no stray switching spikes (as digital attenuator relays open and close) are measured.

Procedure to Analyze Noise Generator Measurements, continued

2. Enter 5722 and DUT SPU readings and the attenuator setting used with the DUT.

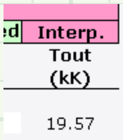


Noise Source Measurement						
Step Cal			5722 @ 0.0 dB Attn Observed			Interp.
50s Avgs (SPU)	Date (UTC)	Time (UTC)	50s Avg (SPU)	Date (UTC)	Time (UTC)	Tout (kK)
6900	2020 Mar 16	2127	1890	2020 Mar 16	2146	19.81
4936	2020 Mar 16	2128				
3508	2020 Mar 16	2129				
2505	2020 Mar 16	2130				
1802	2020 Mar 16	2131				
1313	2020 Mar 16	2132				
983.6	2020 Mar 16	2133				
760.8	2020 Mar 16	2134				
625.4	2020 Mar 16	2135				
542.4	2020 Mar 16	2136				
497.1	2020 Mar 16	2137				

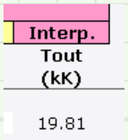
Attenuator Setting (labeled, not actual) 35.7 dB

Noise Source Measurement						
Step Cal			Flagg HP 461 @ 35.7 dB Attn Observed			Interp.
50s Avgs (SPU)	Date (UTC)	Time (UTC)	50s Avg (SPU)	Date (UTC)	Time (UTC)	Tout (kK)
6900	2020 Mar 16	2127	1879	2020 Mar 16	2153	19.57
4936	2020 Mar 16	2128				
3508	2020 Mar 16	2129				
2505	2020 Mar 16	2130				
1802	2020 Mar 16	2131				
1313	2020 Mar 16	2132				
983.6	2020 Mar 16	2133				
760.8	2020 Mar 16	2134				
625.4	2020 Mar 16	2135				
542.4	2020 Mar 16	2136				
497.1	2020 Mar 16	2137				

3. Use interpolation to find the noise temperatures of the 5722 and the DUT+attn.



Interp.
Tout (kK)
19.57



Interp.
Tout (kK)
19.81

a. Once the values are entered in step 2 above, the spreadsheet uses a double parabolic interpolation function within the array of known temperatures entered in step 1 to determine the temperatures of the values entered in step 2.

b. The interpolation function is part of an Excel add-in called XlXtraFun (Excel Extra Functions) available for free from Advanced Systems Design and Development. The download includes a help file that explains in detail the Interpolate() function used in this analysis.

c. Note that the interpolated temperatures shown above are ~ 0.2 dB lower than the 5722's known output of 20.6 kK. This is due to

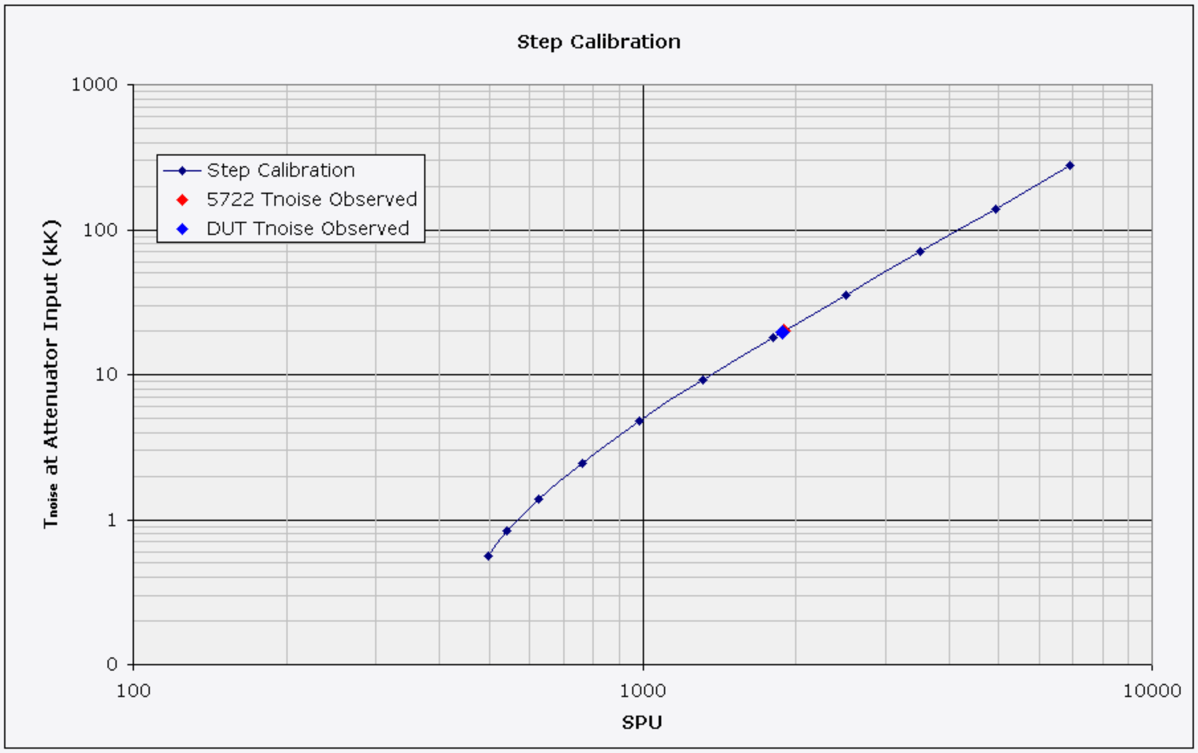
   i. the attenuation present in the cabling and step attenuators (between the 5722 and the radiometer) when the attenuators are set to "0.0" dB labeled attenuation and

   ii. inaccuracy of the step calibration performed in step 1 resulting from imperfect knowledge of the output temperature of the step calibrator.

   iii. This difference is unimportant because the 5722 *defines* the 20.6 kK reference point regardless of what that reading may be in terms of SPU or calibrated radiometer temperature. All that matters here is the *relative* difference in terms of dB between the 5722 and the padded DUT.

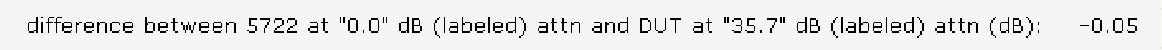
Procedure to Analyze Noise Generator Measurements, continued

4. Ensure that 5722 & DUT readings are in the linear region of the radiometer's response.



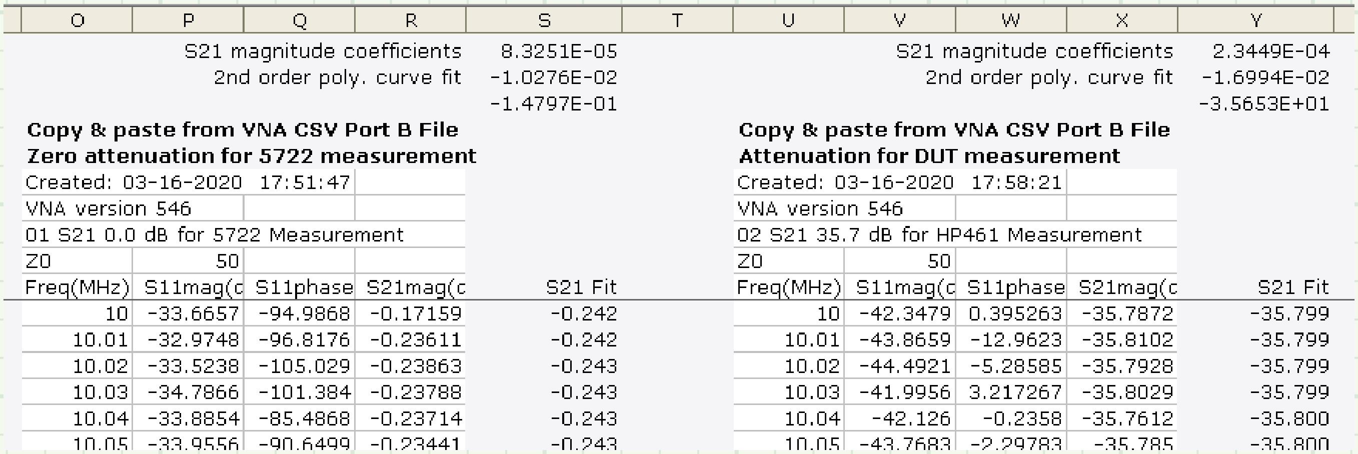
   a. To make the calculation of the difference (in terms of dB) between the 5722 and the padded DUT readings as accurate as possible, the data points should lie in the linear region of the radiometer's response.

5. Calculate observed difference in dB (from step 3 results) between 5722 at "0.0" dB attn and the padded DUT. The Excel spreadsheet does this automatically.


difference between 5722 at "0.0" dB (labeled) attn and DUT at "35.7" dB (labeled) attn (dB): -0.05

Procedure to Analyze Noise Generator Measurements, continued

6. Enter attenuator's VNA S_{21} sweep data for 5722 and DUT attenuator settings.



O	P	Q	R	S	T	U	V	W	X	Y
			S21 magnitude coefficients	8.3251E-05					S21 magnitude coefficients	2.3449E-04
			2nd order poly. curve fit	-1.0276E-02					2nd order poly. curve fit	-1.6994E-02
				-1.4797E-01						-3.5653E+01
Copy & paste from VNA CSV Port B File						**Copy & paste from VNA CSV Port B File**				
Zero attenuation for 5722 measurement						**Attenuation for DUT measurement**				
Created: 03-16-2020 17:51:47						Created: 03-16-2020 17:58:21				
VNA version 546						VNA version 546				
01 S21 0.0 dB for 5722 Measurement						02 S21 35.7 dB for HP461 Measurement				
Z0	50					Z0	50			
Freq(MHz)	S11mag(d	S11phase	S21mag(d	S21 Fit		Freq(MHz)	S11mag(d	S11phase	S21mag(d	S21 Fit
10	-33.6657	-94.9868	-0.17159	-0.242		10	-42.3479	0.395263	-35.7872	-35.799
10.01	-32.9748	-96.8176	-0.23611	-0.242		10.01	-43.8659	-12.9623	-35.8102	-35.799
10.02	-33.5238	-105.029	-0.23863	-0.243		10.02	-44.4921	-5.28585	-35.7928	-35.799
10.03	-34.7866	-101.384	-0.23788	-0.243		10.03	-41.9956	3.217267	-35.8029	-35.799
10.04	-33.8854	-85.4868	-0.23714	-0.243		10.04	-42.126	-0.2358	-35.7612	-35.800
10.05	-33.9556	-90.6499	-0.23441	-0.243		10.05	-43.7683	-2.29783	-35.785	-35.800

a. As noted in step 3.c.i, the step attenuators and cabling used to pad the DUT have a non-zero loss when set to the "0.0" dB setting. Therefore the attenuators and cabling are swept with a VNA to measure S_{21} from 10 to 40 MHz at each attenuator setting used.

b. The spreadsheet accepts a copy-and-paste of the first four columns (unshaded cells in the image above) of the "Port B" CSV data file generated by the software operating the VNA-2180 hardware.

c. Due to the slightly noisy nature of S_{21} measurements, especially at losses > ~ 40 dB, a second-order polynomial is fit to the data. The spreadsheet does this automatically.

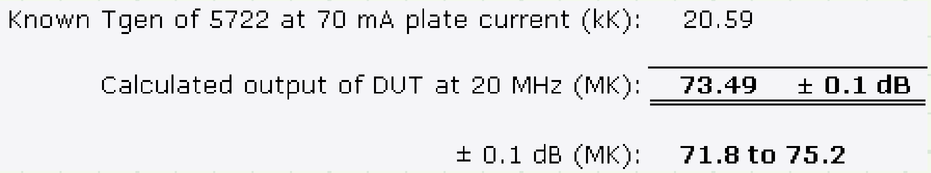
7. Calculate the difference in measured S_{21} between the attenuator's "0.0" dB setting and the setting used to match the DUT output to the 5722. The spreadsheet does this automatically by comparing the polynomial curve fits from step 6.c.

difference between attnuator at "0.0" (labeled) dB and "35.7" (labeled) dB: -35.58

8. Calculate attenuation required to make DUT output equal to the 5722 (step 7 result minus step 5 result). This removes the difference between the padded DUT's output reading and the 5722's output reading described in step 1.d. The spreadsheet does this automatically.

Attenuation required to make DUT output equal to 5722 (dB): -35.53

9. Calculate output of DUT as 20.59 kK * 10^[-(step 8 result) / 10]. The output of two 5722 diodes is 20.59 kK at 70 mA plate current. The spreadsheet does this automatically.



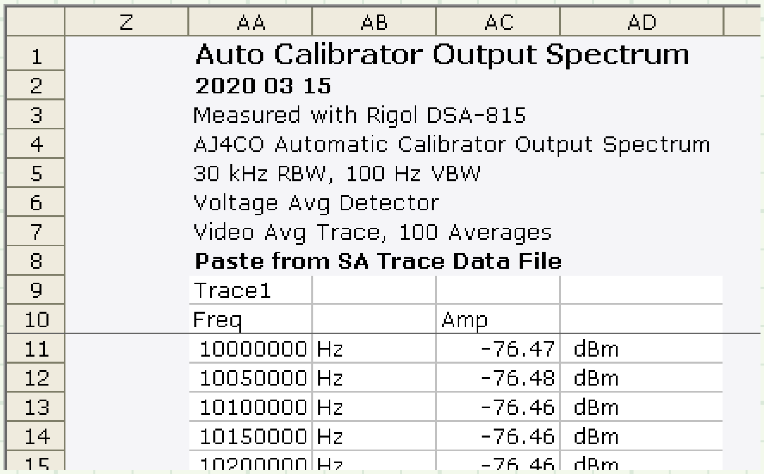
Known Tgen of 5722 at 70 mA plate current (kK): 20.59

Calculated output of DUT at 20 MHz (MK): **73.49 ± 0.1 dB**

± 0.1 dB (MK): **71.8 to 75.2**

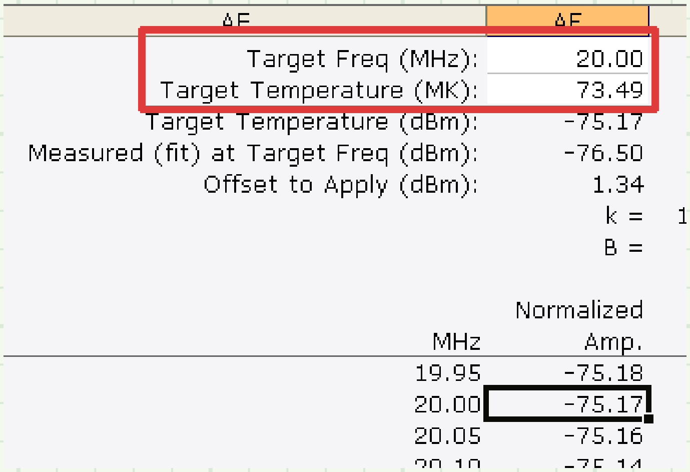
Procedure to Analyze Noise Generator Measurements, continued

10. Enter DUT spectrum analyzer data.



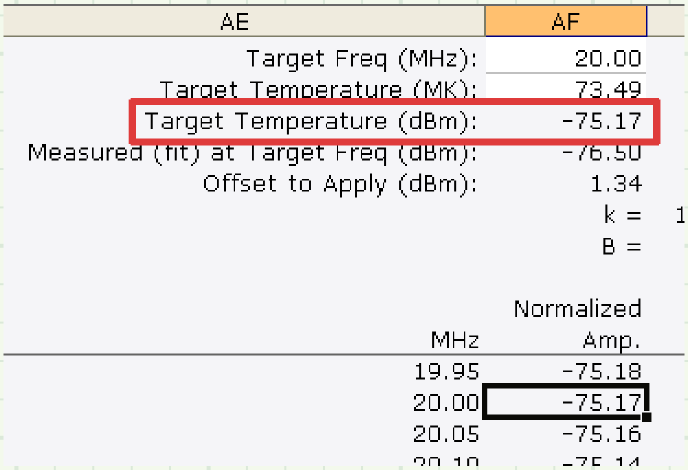
	Z	AA	AB	AC	AD
1		**Auto Calibrator Output Spectrum**			
2		**2020 03 15**			
3		Measured with Rigol DSA-815			
4		AJ4CO Automatic Calibrator Output Spectrum			
5		30 kHz RBW, 100 Hz VBW			
6		Voltage Avg Detector			
7		Video Avg Trace, 100 Averages			
8		**Paste from SA Trace Data File**			
9		Trace1			
10		Freq		Amp	
11		10000000	Hz	-76.47	dBm
12		10050000	Hz	-76.48	dBm
13		10100000	Hz	-76.46	dBm
14		10150000	Hz	-76.46	dBm
15		10200000	Hz	-76.46	dBm

a. Enter the radio frequency used for the test and the known output of the DUT from step 9 above.



AE	AF
Target Freq (MHz):	20.00
Target Temperature (MK):	73.49
Target Temperature (dBm):	-75.17
Measured (fit) at Target Freq (dBm):	-76.50
Offset to Apply (dBm):	1.34
	k =
	B =
MHz	Normalized Amp.
19.95	-75.18
20.00	-75.17
20.05	-75.16
20.10	-75.14

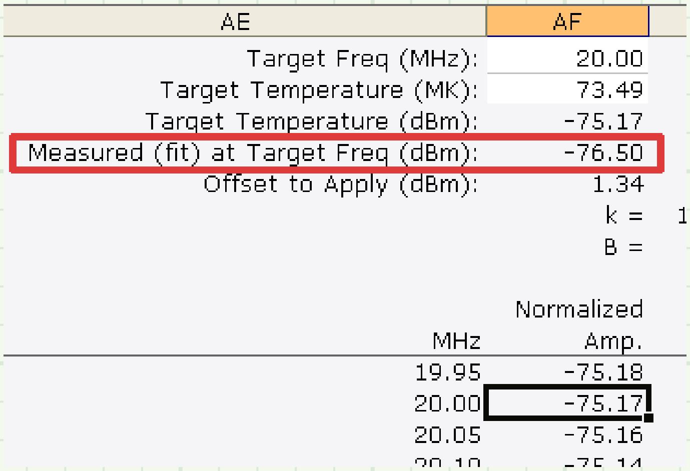
b. The spreadsheet calculates the temperature of the DUT at the frequency of interest in terms of dBm via P=kTB (e.g., -75.2 dBm).



AE	AF
Target Freq (MHz):	20.00
Target Temperature (MK):	73.49
Target Temperature (dBm):	-75.17
Measured (fit) at Target Freq (dBm):	-76.50
Offset to Apply (dBm):	1.34
	k =
	B =
MHz	Normalized Amp.
19.95	-75.18
20.00	-75.17
20.05	-75.16
20.10	-75.14

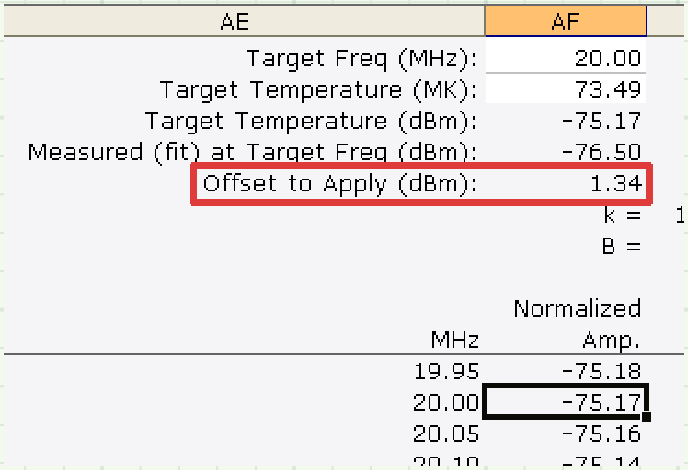
Procedure to Analyze Noise Generator Measurements, continued

c. The spreadsheet performs an on-the-fly 4th order polynomial curve fit to the raw SA data and finds the curve fit value at the frequency of interest. (e.g., -76.5 dBm).



AE	AF	
Target Freq (MHz):	20.00	
Target Temperature (MK):	73.49	
Target Temperature (dBm):	-75.17	
Measured (fit) at Target Freq (dBm):	-76.50	
Offset to Apply (dBm):	1.34	
	k =	1
	B =	
	Normalized	
MHz	Amp.	
19.95	-75.18	
20.00	-75.17	
20.05	-75.16	
20.10	-75.14	

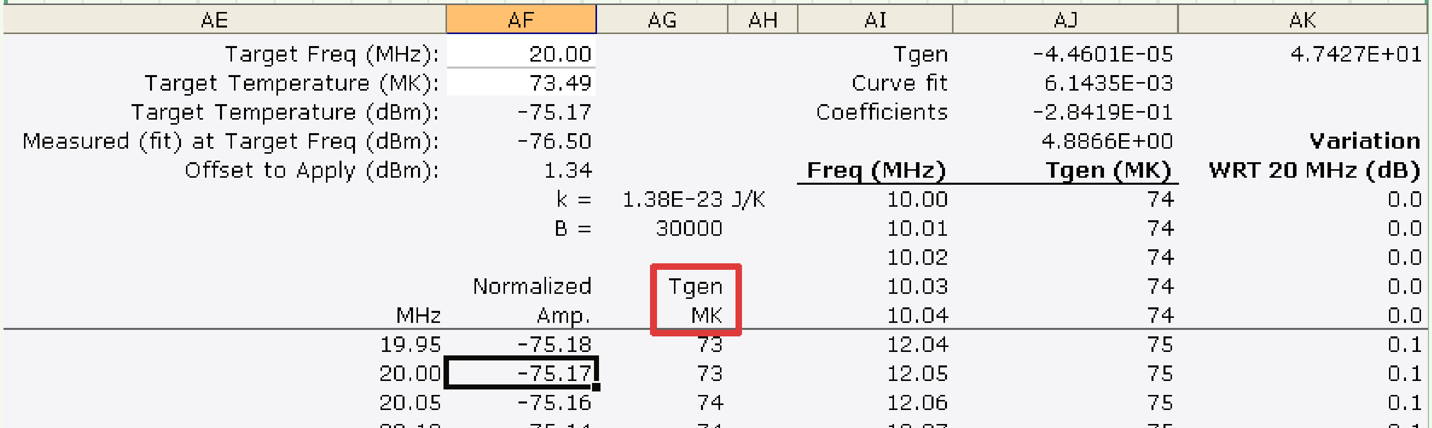
d. The spreadsheet calculates the difference between the known output of the DUT and the fitted curve (e.g., -75.17 dBm - (-76.50 dBm) = +1.34 dB) and fills column AF with the raw spectral amplitude data (from column AC) normalized by this constant offset.



AE	AF	
Target Freq (MHz):	20.00	
Target Temperature (MK):	73.49	
Target Temperature (dBm):	-75.17	
Measured (fit) at Target Freq (dBm):	-76.50	
Offset to Apply (dBm):	1.34	
	k =	1
	B =	
	Normalized	
MHz	Amp.	
19.95	-75.18	
20.00	-75.17	
20.05	-75.16	
20.10	-75.14	

NOTE: Spectrum analyzers do not always report noise amplitudes the way one might imagine. This is due to differences in the detector type, avergaing method, trace type, and noise bandiwdth of the frequency channels. See Keysight App Note 5966-4008E, *Spectrum and Signal Analyzer Measurements and Noise*. Since it may be difficult to know these details of the instrument's characteristics with precision, We find it most practical to reference one channel to the 5722 and adjust the entire spectrum accordingly.

e. The spreadsheet then fills column AG with the normalized amplitudes in terms of MK.

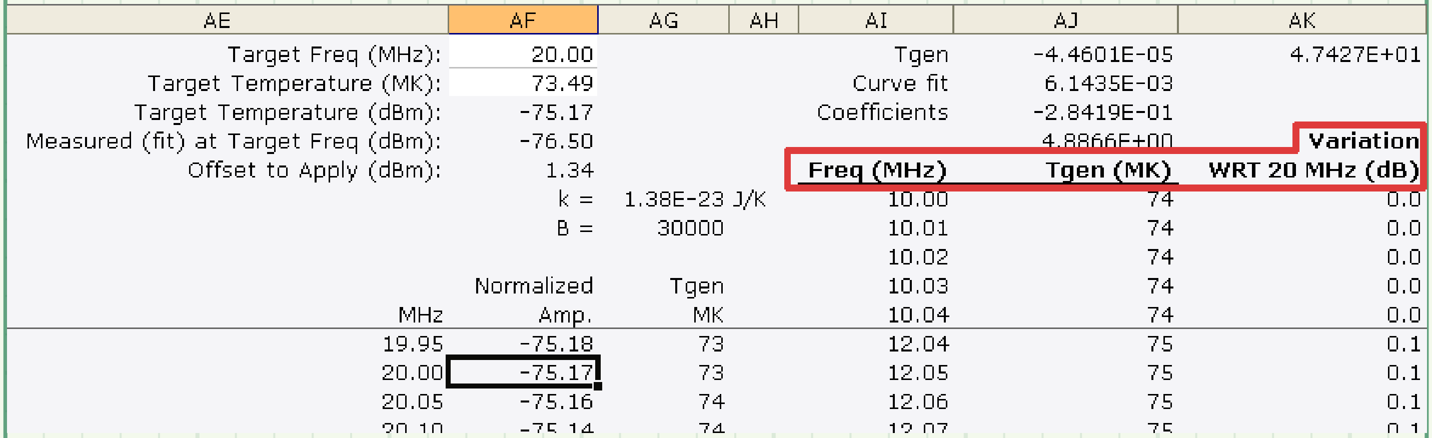


AE	AF	AG	AH	AI	AJ	AK
Target Freq (MHz):	20.00			Tgen	-4.4601E-05	4.7427E+01
Target Temperature (MK):	73.49			Curve fit	6.1435E-03	
Target Temperature (dBm):	-75.17			Coefficients	-2.8419E-01	
Measured (fit) at Target Freq (dBm):	-76.50				4.8866E+00	**Variation**
Offset to Apply (dBm):	1.34			**Freq (MHz)**	**Tgen (MK)**	**WRT 20 MHz (dB)**
	k =	1.38E-23 J/K		10.00	74	0.0
	B =	30000		10.01	74	0.0
				10.02	74	0.0
	Normalized	Tgen		10.03	74	0.0
MHz	Amp.	MK		10.04	74	0.0
19.95	-75.18	73		12.04	75	0.1
20.00	-75.17	73		12.05	75	0.1
20.05	-75.16	74		12.06	75	0.1
20.10	-75.14	74		12.07	75	0.1

Procedure to Analyze Noise Generator Measurements, continued

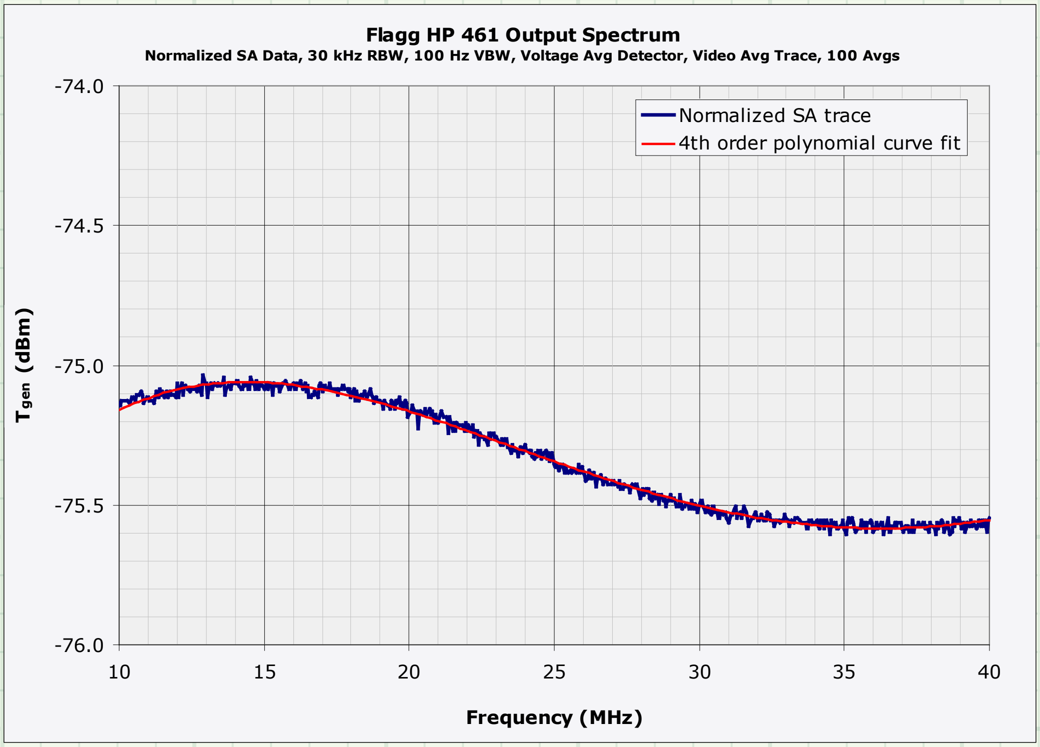
f. The spreadsheet fits a 4th order polynomial curve to the normalized temperature data and populates columns AI and AJ with points on that curve. This curve fitting provides the constants for an equation that can be used as an accurate model of the DUT's output spectrum for calibrating spectrographs in terms of amplitude.

g. The spreadsheet populates column AK with the variation in fitted temperatures with respect to the fitted temperature at 20 MHz.



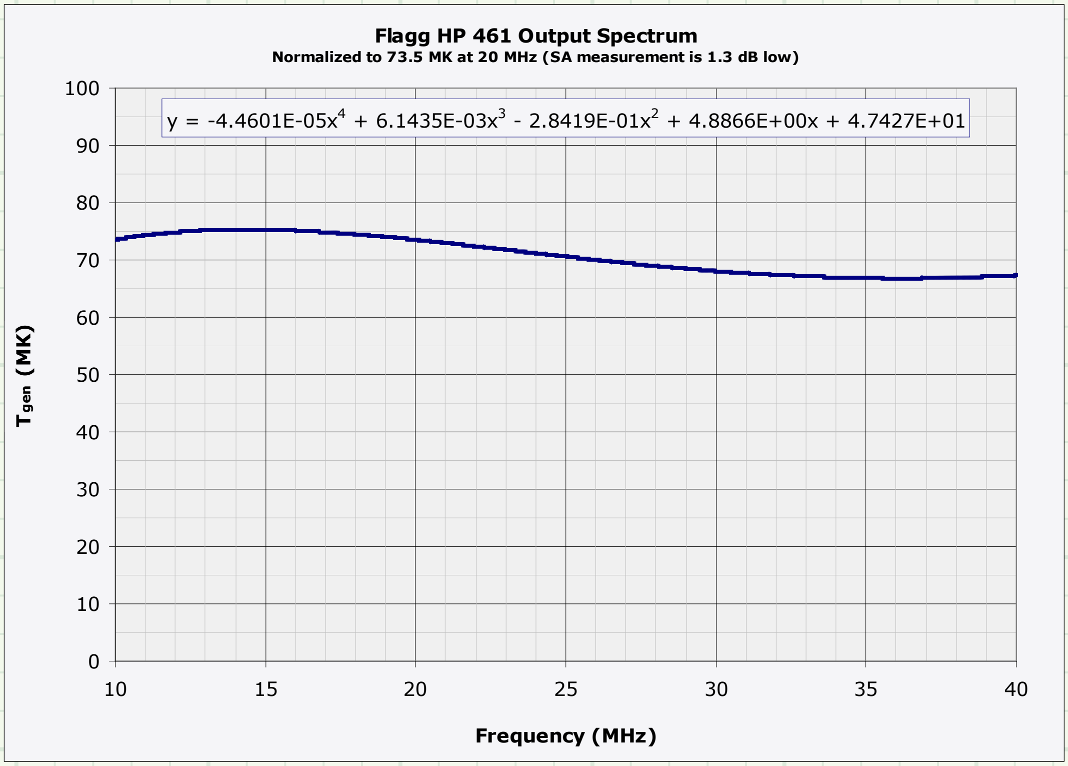
AE	AF	AG	AH	AI	AJ	AK
Target Freq (MHz):	20.00			Tgen	-4.4601E-05	4.7427E+01
Target Temperature (MK):	73.49			Curve fit	6.1435E-03	
Target Temperature (dBm):	-75.17			Coefficients	-2.8419E-01	
Measured (fit) at Target Freq (dBm):	-76.50				4.8866E+00	**Variation**
Offset to Apply (dBm):	1.34			**Freq (MHz)**	**Tgen (MK)**	**WRT 20 MHz (dB)**
	k =	1.38E-23 J/K		10.00	74	0.0
	B =	30000		10.01	74	0.0
				10.02	74	0.0
	Normalized	Tgen		10.03	74	0.0
MHz	Amp.	MK		10.04	74	0.0
19.95	-75.18	73		12.04	75	0.1
20.00	-75.17	73		12.05	75	0.1
20.05	-75.16	74		12.06	75	0.1
20.10	-75.14	74		12.07	75	0.1

h. The normalized spectrum analyzer values in terms of dBm (column AF) are plotted against frequency in terms of MHz (column AE).

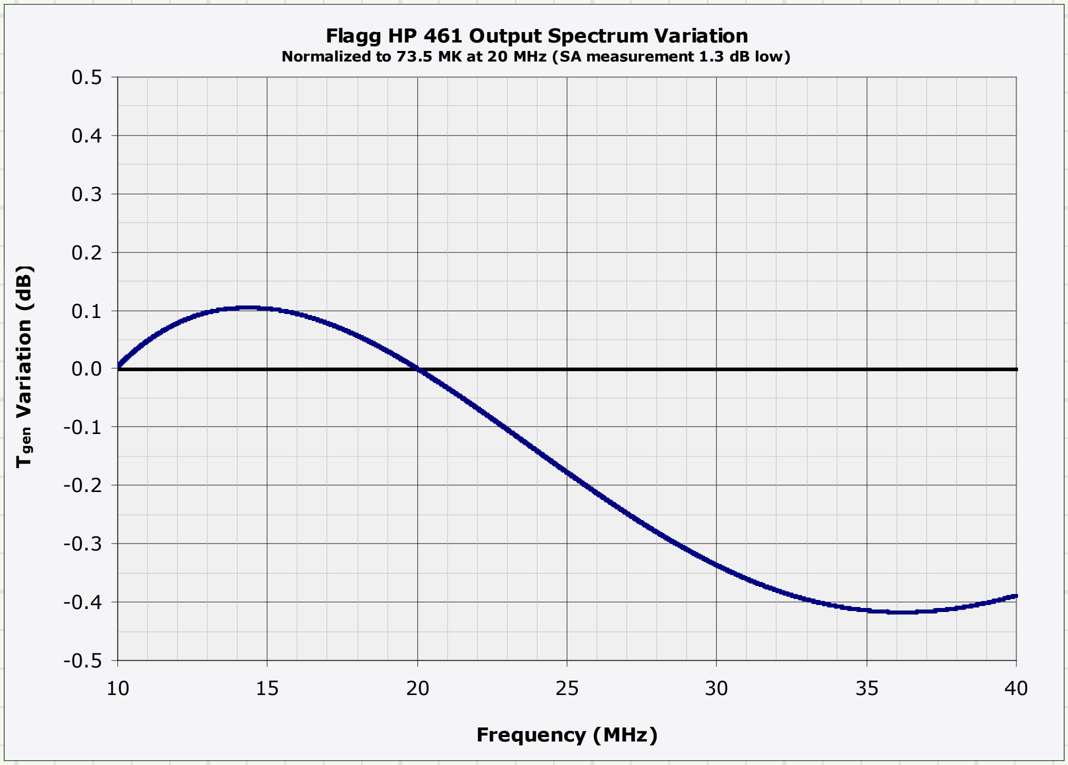


Procedure to Analyze Noise Generator Measurements, continued

i. The fitted curve values in term of MK (column AJ) are plotted against frequency in terms of MHz (column AI) along with the equation modeling the DUT's output with frequency.



j. The variation in the fitted curve values in terms of dB with respect to the 20 MHz value (column AK) are plotted against frequency in terms of MHz (column AI).



UFRO 5722 NOISE SOURCE
USER'S MANUAL

Dave Typinski, May, 2018

Description

The UFRO 5722 Noise Source is based on two Sylvania 5722 vacuum tube noise diodes operating in parallel. The unit has been modified by AJ4CO to eliminate the plate current sensing resistor and remote power supply controls as the original power supplies have been replaced with supplies that include accurate voltage and current meters. The circuit is much like that recommended by Sylvania. A schematic and tube tech data are included in this manual.

The assembly is built on one 3U (5¼" tall) 19" rack panel and requires two power sources:

Filament supply: 5.2 VDC at 3.1 A
Plate supply: 150 VDC at 70 mA

As installed at AJ4CO Observatory, the filament supply is a TTi PL155 power supply and the plate voltage is provided by a TTi PLH250 power supply.

In the Summer of 2012, the noise generator was salvaged from the Dixie Radio Observatory. In the Spring of 2013, it was found that the 5 VDC supply being used for the filament circuit could no longer deliver the required current—about 5 volts at 3.1 amps. In lieu of another 5 VDC supply, the noise generator panel was modified to include a 6.3 volt filament transformer driven by a small variac. That is, the filaments were then fed with ~ 5 VAC.

In June 2017, it was noticed that line voltage variations were causing a +/- 2 mA random oscillation in plate current. This is equivalent to +/- 0.12 dB in terms of noise power output. It was decided that a 0.25 dB uncertainty range was too large.

In May, 2018, the AC filament power circuit elements were removed and replace by the TTi low voltage DC supply in May, 2018. The plate current sensing resistor was also removed, as the plate current reading on the new TTi plate supply was observed to be within 0.01 mA of that shown on a freshly-calibrated HP 34401A DVM connected in series.

With 70 mA of plate current, the noise output is 20,600 K into a 50 ohm load.

Operation

Start up:

1) Connect power supplies, **note proper polarity: plate supply positive goes to ground**.
2) Feed 3.5 VDC to the filament circuit to put the tubes in standby mode. Best practice for tube type equipment is to always turn on the filaments before applying plate voltage.
3) Feed 150 VDC to the plate circuit.
4) Increase the filament voltage until the plate current reads about 67 mA. Use the fine voltage control to increase the filament voltage until the plate current reads 70 mA.
5) Allow a 10-minute stabilization period during which time the plate current will slowly drop a few mA as the tubes reach thermal equilibrium. Use the fine voltage control on the filament supply to keep the plate current near 70 mA.
6) After the 10-minute stabilization period, measurements of the RF noise output may be made. Continue using the fine voltage control on the filament supply to keep the plate current between 69.9 and 70.1 mA. This is not difficult after that stabilization period. Typical stable values are:

   Filament: 5.15 VDC @ 3.078 A ± 10 mA

   Plate: 150 VDC @ 70.0 ± 0.1 mA

NOTE: While the Sylvania manual recommends keeping the maximum on period in a 50% duty cycle to no more than 5 minutes, the unit has been operated for up to an hour at a time with no apparent detrimental effects. However, it is possible that this may shorten tube life, so extended periods of operation should be avoided when possible. The Sylvania manual indicates a tube life of about 100 hours when the filaments are operated at 5.15 volts.

Shut down:

1) Turn off the DC plate supply.
2) Turn the filament supply voltage down to zero and then turn it off.

Figure 1 – 5722 diode noise generator, two tubes in parallel.

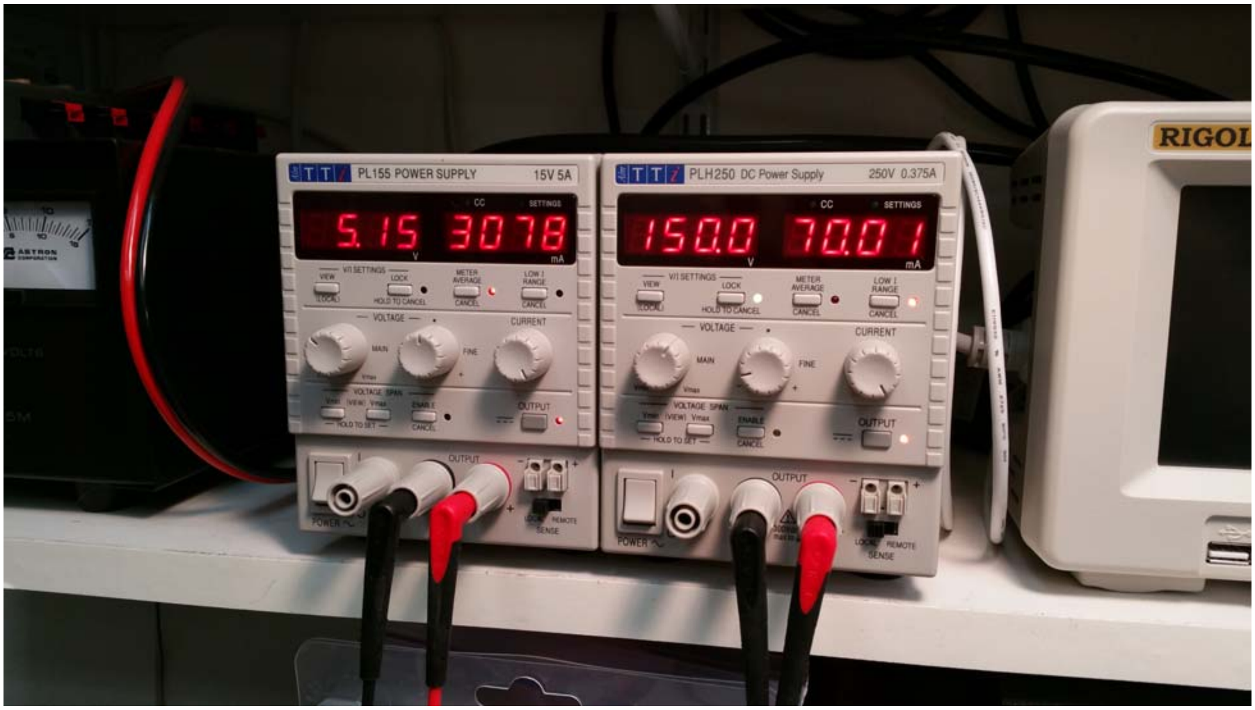
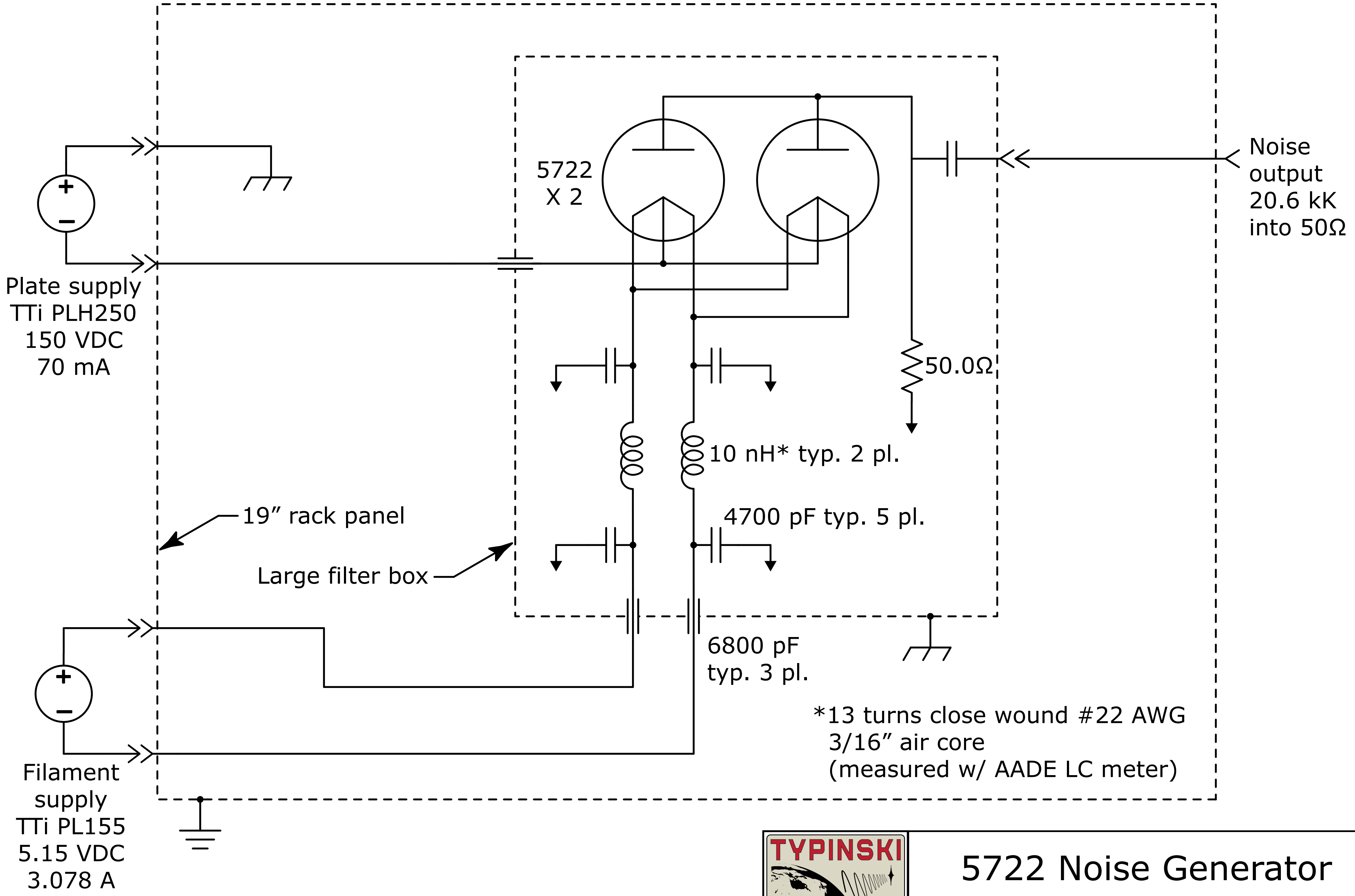


Figure 2 – Power supplies showing typical voltages and currents.



TYPINSKI
RADIO ASTRONOMY

5722 Noise Generator

SIZE	DATE	DRAWN BY	REV
A	12 MAY 2018	DAVE TYPINSKI	C

SCALE			SHEET
1:1	5722-01		1 OF 1

UFRO 5722 Noise Diode Ouput Temperature Calculation

ref Francisco Reyes's notes

T0	290	K
e	1.602E-19	C
I	**70.0**	**mA**
R	50.0	Ω
k	1.381E-23	J/K
eR/2K	290007.2411	
T_gen	**20,591**	**K**

$$T_{gen} = T_0 + \frac{e I R}{2k}$$

$$T_{gen} = 290 + 290 I = 290(1 + I)$$ where I is in mA

Noise diodes 5722 calibrator

(Translation of Appendix A of F. Reyes Univ. of Chile thesis "Radiotelescopio en 45 MHz para Fuentes Extragalacticas,1977)

In order to determine the absolute power received by a radio telescope it is necessary to have of a source that provide a signal of a known power, so it can be used as a calibrator. Since the signal received by the antenna has the characteristic of noise, it is required that the calibrator has the same characteristics.

A resistor at the absolute temperature T generates a noise power W that can be calculated by

$$W = kT\Delta\nu \qquad (1)$$

Where k is the Boltzmann constant
and $\Delta\nu$ is the bandwidth

In radio astronomy and in particular at low frequencies the antenna temperatures are of the order of several thousand K. This makes impossible to obtain a source of noise of the required power from the noise produced by a resistor.

For the frequency range of 1 to 1000 MHz, it is accepted as a standard noise source, the saturated diodes limited by temperature.

The quadratic mean value of the noise current i_n^2 for these diodes is given by the relationship

$$i_n^2 = 2eI\Delta\nu \qquad (2)$$

Where e is the charge of the electron (1,6 10^{-19} coulombs)
and I is the plate DC current of the diode

These diodes are essentially a source of noise current. It is necessary to define the noise power delivered by the diodes by defining the impedance over which the noise current circulate. Figure 1 is a simplified schematic of the circuit of a noise diode.

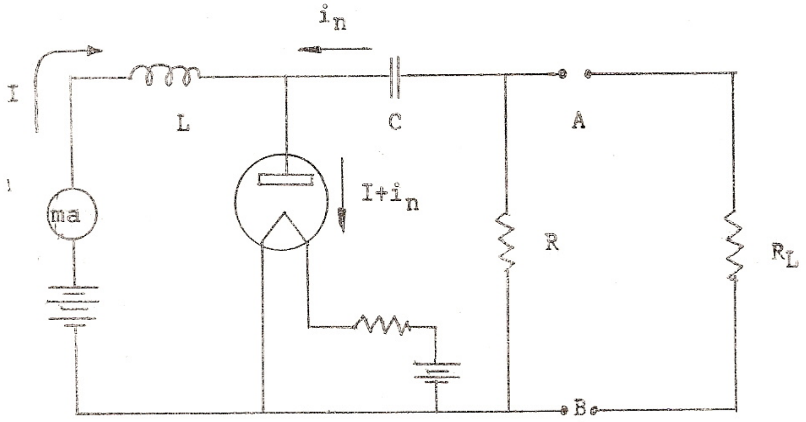


Figure 1. Simplified schematic of the circuit of a noise diode

R_L is the load resistor (of value equal to R), R is the resistor that define the power delivered by the diode, C a capacitor to isolate R from the DC plate voltage and L is an inductance to keep the noise power from reaching the DC plate voltage source.

The noise power available at the terminals AB is

$$W = (\tfrac{1}{2} i_n)^2 R \qquad (3)$$

The power can be expressed as function of temperature by combining equations (1) and (3)

$$kT\Delta\nu = (\tfrac{1}{2} i_n)^2 R$$

Rearranging this equation and substituting by equation (2) we get

$$T = eIR/2k$$

To this noise temperature T one has to add the contribution of noise due to the ambient temperature T_o of the resistor R.
The equation becomes

$$T_g = T_o + eIR/2k \qquad (4)$$

This equation shows that it is possible to determine the noise temperature of the diodes by measuring I, the DC plate current.

Substituting in equation (4) the values for $e = 1.6\ 10^{-19}$ Coulombs, $k = 1.38\ 10^{-23}$ Joule/K, $T_o = 290$ K, R = 75 ohms and expressing the current I in milliamps,

$$T = 434.78\ I + 290 \ \ \text{(in K)} \qquad (5)$$

One of the diodes commonly used is the 5722. Some of the parameters of this diode are:

Maximum plate current = 35 ma
Plate voltage = 200 v
Output capacitance = 2.2 pf
Filament voltage = 6.3 v
Filament current = 1.5 amps

Most calibrator used at radio observatories in the past make use of two 5722 diodes. Two diodes provides up to 70 ma DC current, which correspond to a noise temperature of 30,000 K. This standard calibrator can be used to calibrate other source noise such as the noisy amplifier HP 461 which can provide up to 60 million K of noise temperature which makes them useful for calibrating low frequency emission from Jupiter and the Sun.

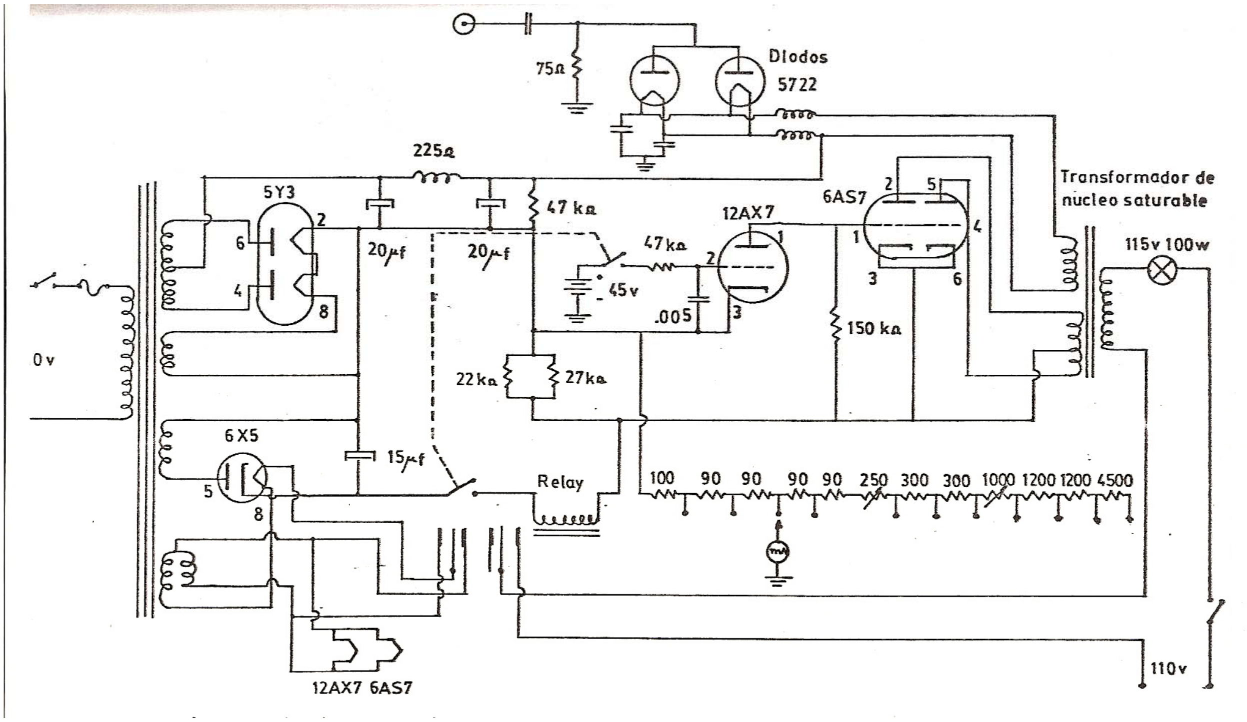


Figure 2. Schematic of 5722 noise diodes and power supply

References

R.N. Bracewell, Radio Astronomy Techniques. In Handbuch Der Physik, Volume LIV, pages 53-55
J.D. Kraus, Radio Astronomy, chapter 7 (by Martti E. Tiuri) pages 284-286

FR
07/19/2012

TECHNICAL DATA

5722

Sylvania

TYPE 5722

NOISE GENERATING DIODE

RATINGS AND CHARACTERISTICS

Maximum Filament Voltage	5.5	Volts
Minimum Filament Voltage	2.0	Volts
Filament Current at 4.9 Volts	1.6	Amperes
Maximum DC Plate Voltage	200	Volts
Maximum Plate Current	35	Ma.
Maximum Plate Dissipation		
Continuous Service	3.5	Watts
Intermittent Service	5.0	Watts
Maximum On Period in 50% Duty Cycle	5	Min.
Direct Interelectrode Capacitances:**		
Plate to Filament	1.5	μμf

* *Horizontal operation permitted if Pins 1 and 2 are in vertical plane.*

** *With no external shield.*

PHYSICAL SPECIFICATIONS

Style	Miniature
Bulb	T 5 1/2
Diameter	3/4" Max.
Seated Height	1 7/8" Max.
Overall Length	2 1/8" Max.
Mounting	Vertical*

BASE PIN CONNECTIONS

Pin 1 - Plate
Pin 2 - No Connection
Pin 3 - Filament
Pin 4 - Filament
Pin 5 - No Connection
Pin 6 - Plate
Pin 7 - Filament Center

RMA Basing 5 CB

TYPICAL OPERATING CONDITIONS

Plate Voltage	150 Volts
Filament Voltage	Adjust to give desired Plate Current or Noise Output

CIRCUIT APPLICATION

Sylvania Type 5722 is a tungsten filament diode designed for use as a noise generator at frequencies up to 400 or 500 mc. The filament center tap allows better RF grounding of the filament when used in the recommended circuit shown on a following page.

Since the tube has a tungsten filament the "shot effect" may be used as a standard noise source if sufficient plate voltage is applied to obtain saturation. The noise factor (NF) may be obtained from the equation $NF = 20\ IR$ where R is the total generator resistance and I is the diode plate current in amperes. To convert to decibels $NF_{db} = 10 \text{ Log}_{10}\ 20\ IR$.

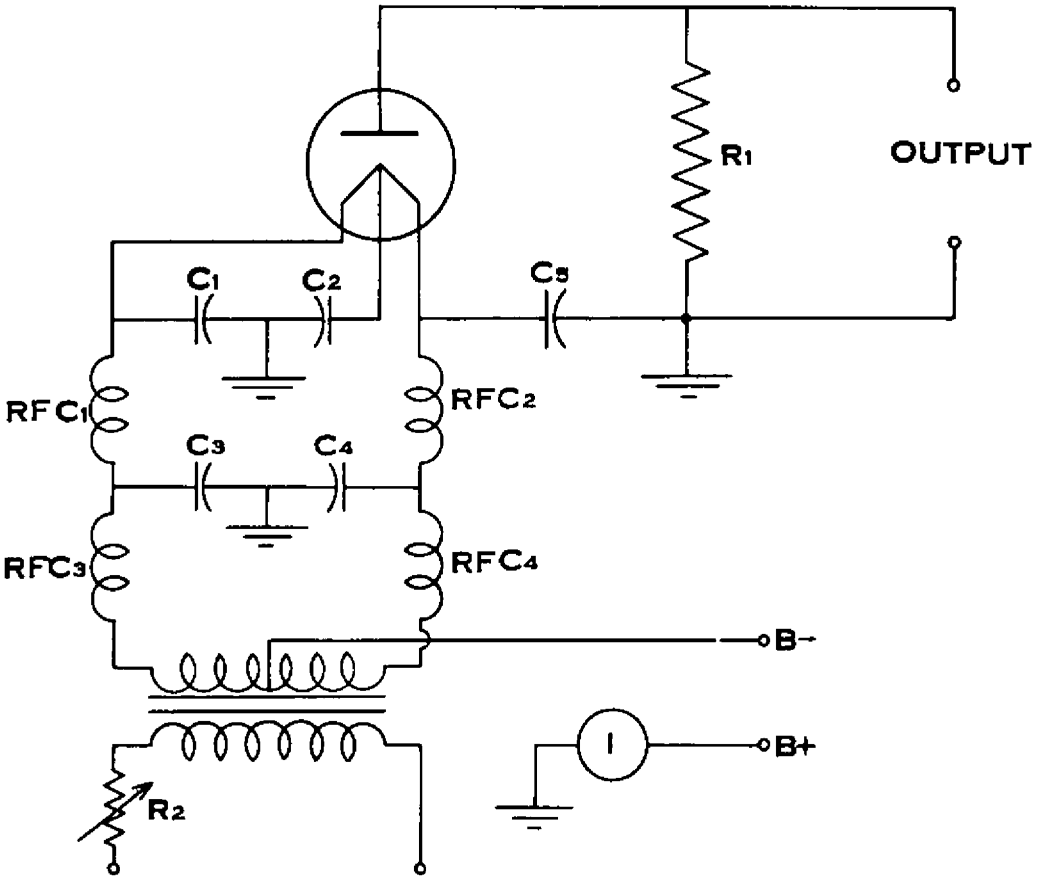
In use, the diode is coupled to the input of the amplifier under test and the filament voltage is increased until the noise output power is double that read without the diode. From the plate current reading and the generator resistance the noise factor can be calculated. Additional construction details may be obtained from the article "How Sensitive Is Your Receiver", by Byron Goodman in the September 1947 issue of Q.S.T. and also "Coaxial Noise Diode" by H. Johnson, RCA Review, March, 1947, Volume VIII, No. 1.

The useful life is dependent on the operating voltages since the usual causes of failure are burnout or vaporization of the tungsten filament. A curve is given on a following page which shows this relationship.

NOV. 29, 1948
COMMERCIAL ENGINEERING DEPARTMENT
Sylvania Electric Products Inc., Emporium, Pennsylvania
PRINTED IN U.S.A.

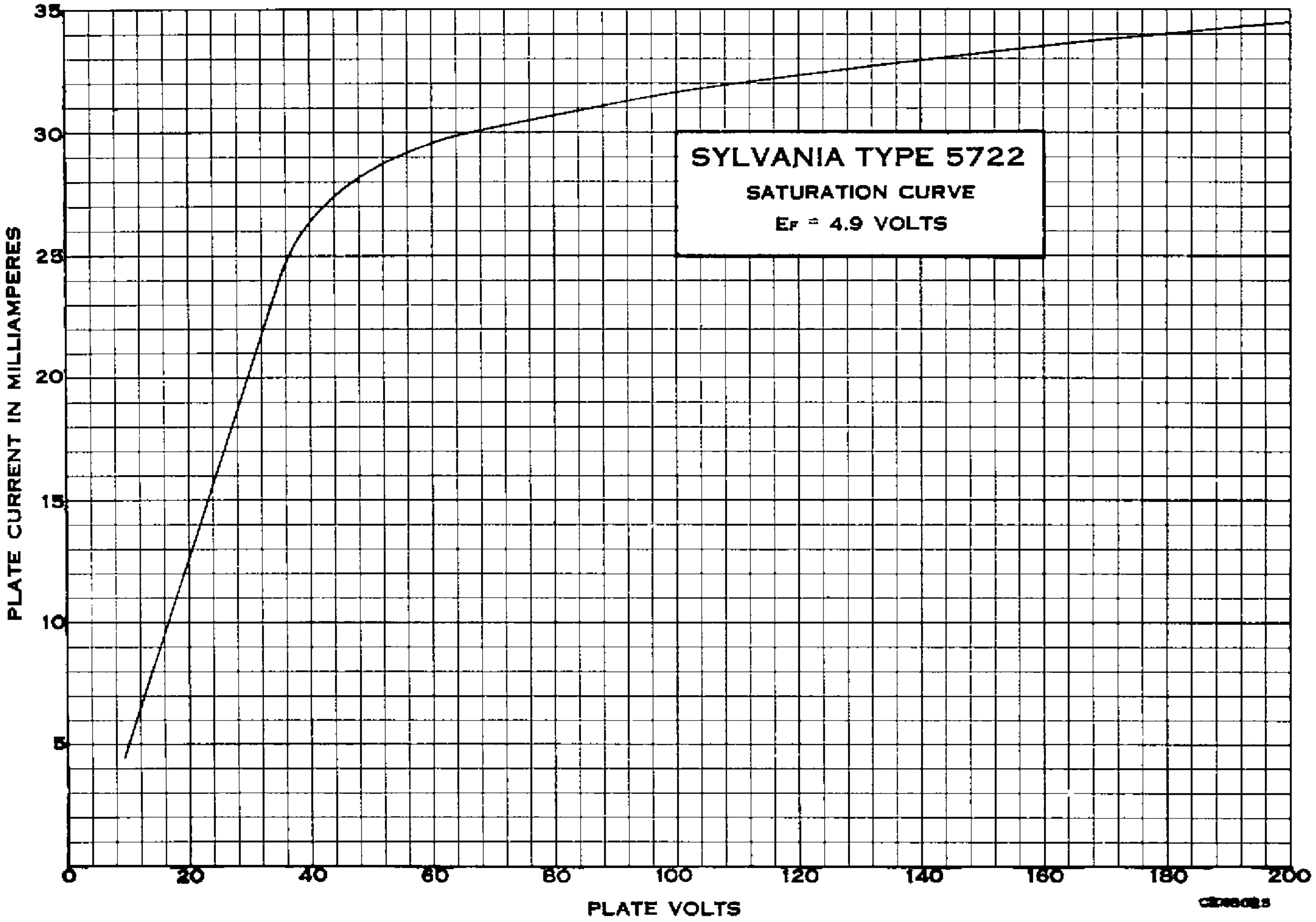
from RMA release # 668B, March 3, 1949

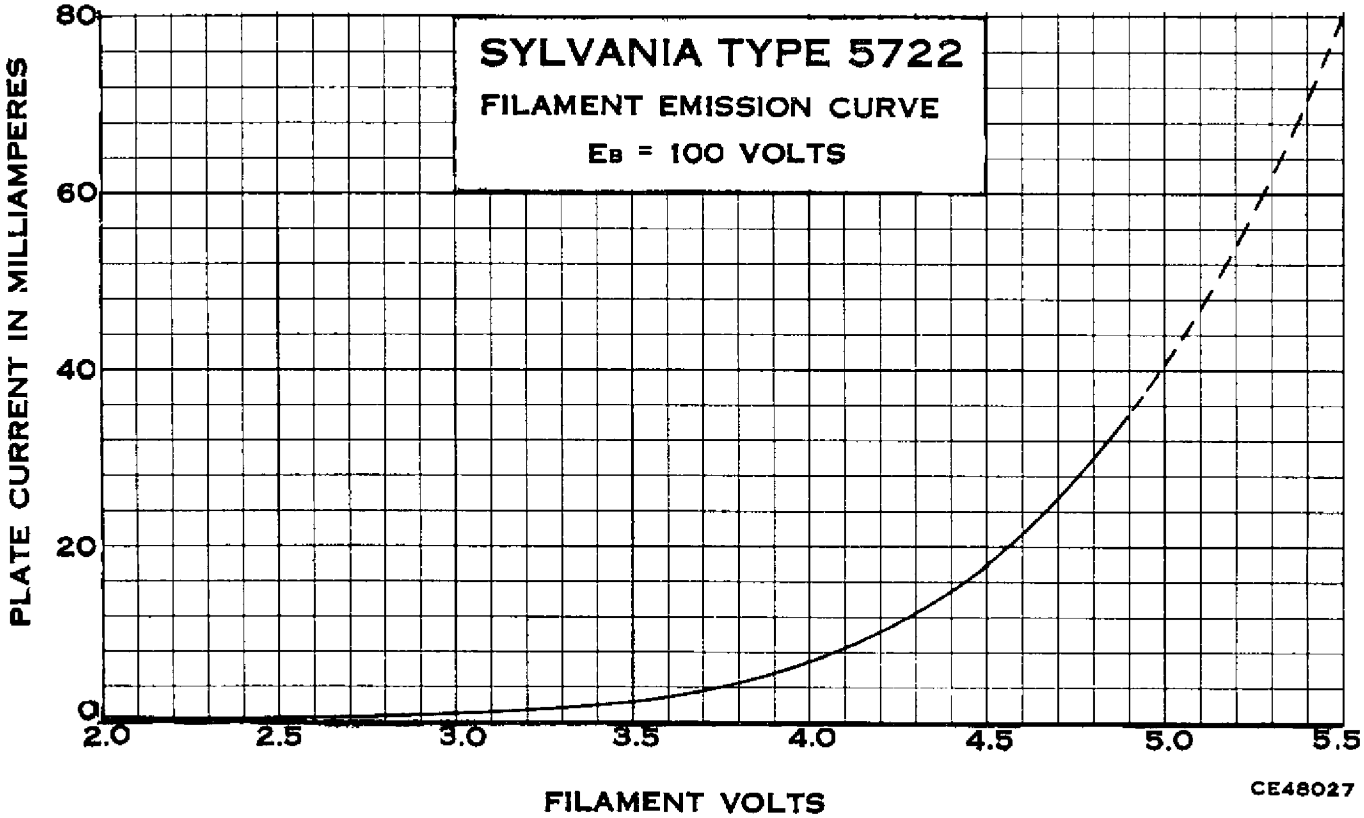
RECOMMENDED CIRCUIT

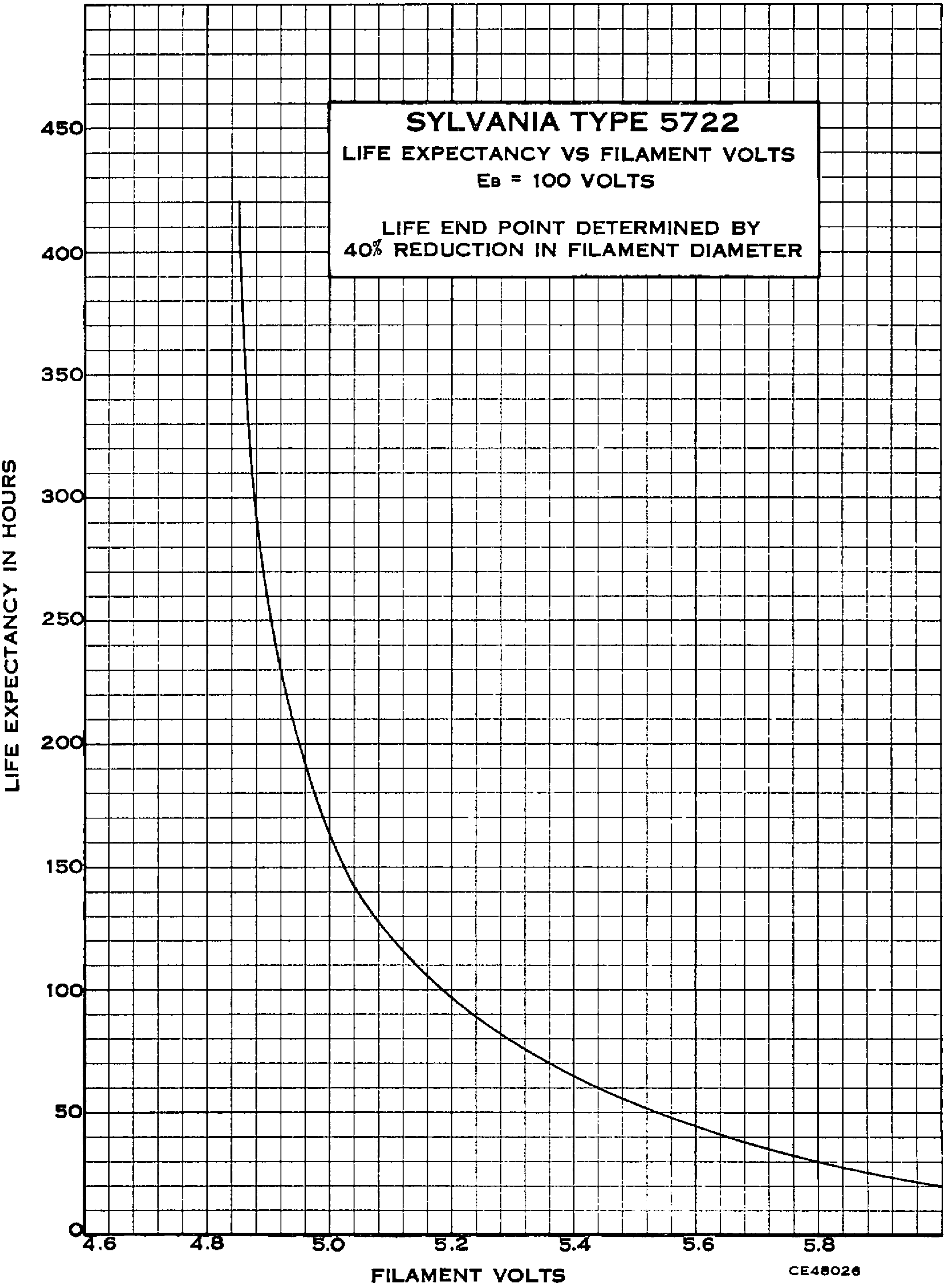


PARTS LIST

C_1 C_2 C_3 C_4 C_5	500 µµf
RFC_1 RFC_2	6 Turns #16 Enamel Wire on 3/16" Air Core
RFC_3 RFC_4	30 Turns #16 Enamel Wire on 3/8" O.D., 1/4" I.D. Bakelite Coil Form With Powdered Iron Core
R_1	50 to 300 Ohms as Required to Match Load
R_2	Filament Voltage Control


SYLVANIA TYPE 5722
SATURATION CURVE
EF = 4.9 VOLTS
PLATE CURRENT IN MILLIAMPERES
35
30
25
20
15
10
5
0
20
40
60
80
100
120
140
160
180
200
PLATE VOLTS


SYLVANIA TYPE 5722
FILAMENT EMISSION CURVE
EB = 100 VOLTS
PLATE CURRENT IN MILLIAMPERES
80
60
40
20
0
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
FILAMENT VOLTS
CE48027


SYLVANIA TYPE 5722
LIFE EXPECTANCY VS FILAMENT VOLTS
EB = 100 VOLTS
LIFE END POINT DETERMINED BY
40% REDUCTION IN FILAMENT DIAMETER
LIFE EXPECTANCY IN HOURS
450
400
350
300
250
200
150
100
50
0
4.6
4.8
5.0
5.2
5.4
5.6
5.8
FILAMENT VOLTS

CE48026

SYLVANIA engineering data service

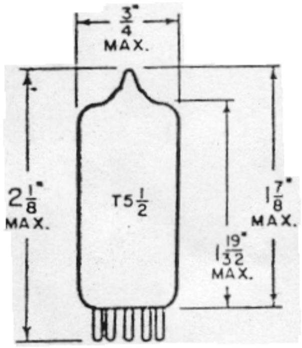
SYLVANIA 5722

QUICK REFERENCE DATA

The Sylvania Type 5722 is a miniature tungsten filament diode intended for use as a noise generator. It is designed for operation at frequencies up to 400 or 500 mc.

MECHANICAL DATA

Bulb	T-5½
Base	E7-1 Miniature Button 7-Pin
Outline	5-2
Basing	5CB
Cathode	Tungsten Filament
Mounting Position	Vertical, Base up or down Horizontal, Leads 3 and 4 in a vertical plane



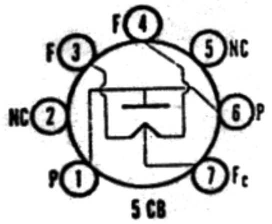
ELECTRICAL DATA

DIRECT INTERELECTRODE CAPACITANCES (Unshielded)

Plate to Filament	1.5 $\mu\mu$f

RATINGS (Absolute Values)

Filament Voltage	5.5	Volts	Max.
	2.0	Volts	Min.
Plate Voltage (dc)	200	Volts	Max.
Plate Current	35	Ma	Max.
Plate Dissipation			
Continuous Service	3.5	Watts	Max.
Intermittent Service	5.0	Watts	Max.
Maximum on Period in 50% Duty Cycle	5	Minutes	



CHARACTERISTICS

Filament Voltage[1]	4.9	Volts
Filament Current	1.6	Amps
Plate Voltage	150	Volts
Plate Current	30	Ma

NOTE:

1. *In application, adjust E_f to obtain desired Plate Current or Noise Output.*

SYLVANIA ELECTRONIC TUBES
A Division of
SYLVANIA ELECTRIC PRODUCTS, Inc.
RECEIVING TUBE
OPERATIONS
EMPORIUM, PENNSYLVANIA

Prepared and Released By The
TECHNICAL PUBLICATIONS SECTION
EMPORIUM, PENNSYLVANIA

DECEMBER 1958

APPLICATION DATA

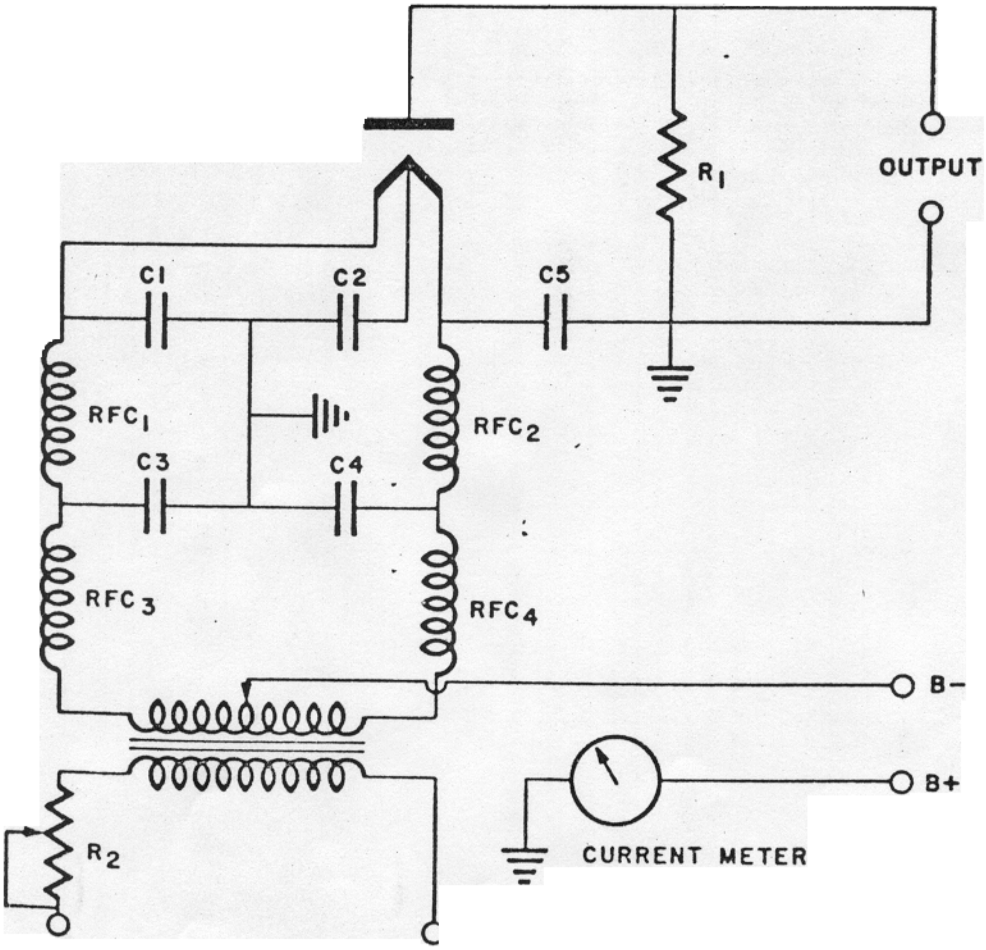
The Sylvania Type 5722 has a filament center tap which allows better RF grounding of the filament when used in the Recommended Circuit.

Since the tube has a tungsten filament the "shot effect" may be used as a standard noise source if sufficient plate voltage is applied to obtain saturation. The noise factor (NF) may be obtained from the equation $NF = 20\ IR$ *where R is the total generator resistance and I is the diode plate current in amperes. To convert to decibels* $NF_{db} = 10\ Log_{10}\ 20\ IR$.

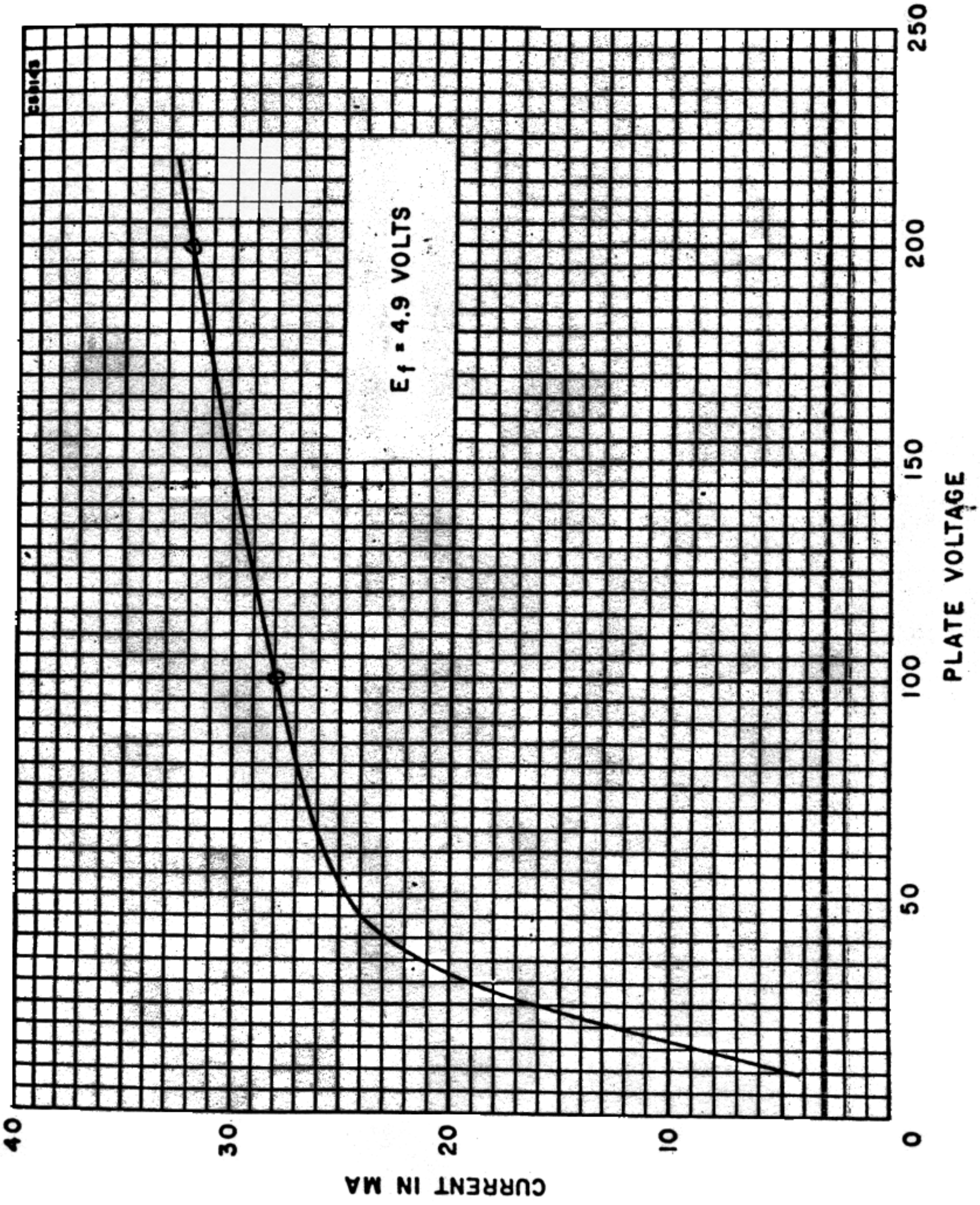
In use, the diode is coupled to the input of the amplifier under test and the filament voltage is increased until the noise output power is double that read without the diode. From the plate current reading and the generator resistance the noise factor can be calculated. Additional construction details may be obtained from the article. "Noise Generators and Measuring Techniques," by I. J. Melman in the May, June and July 1950 issues of Tele-Tech and also "Temperature-Limited Noise Diode Design," by R. W. Slinkman, in the October 1949 issue of The Sylvania Technologist.

The useful life is dependent on the operating voltages since the usual causes of failure are burnout or vaporization of the tungsten filament. A life expectancy curve is shown on a following page which illustrates this relationship.

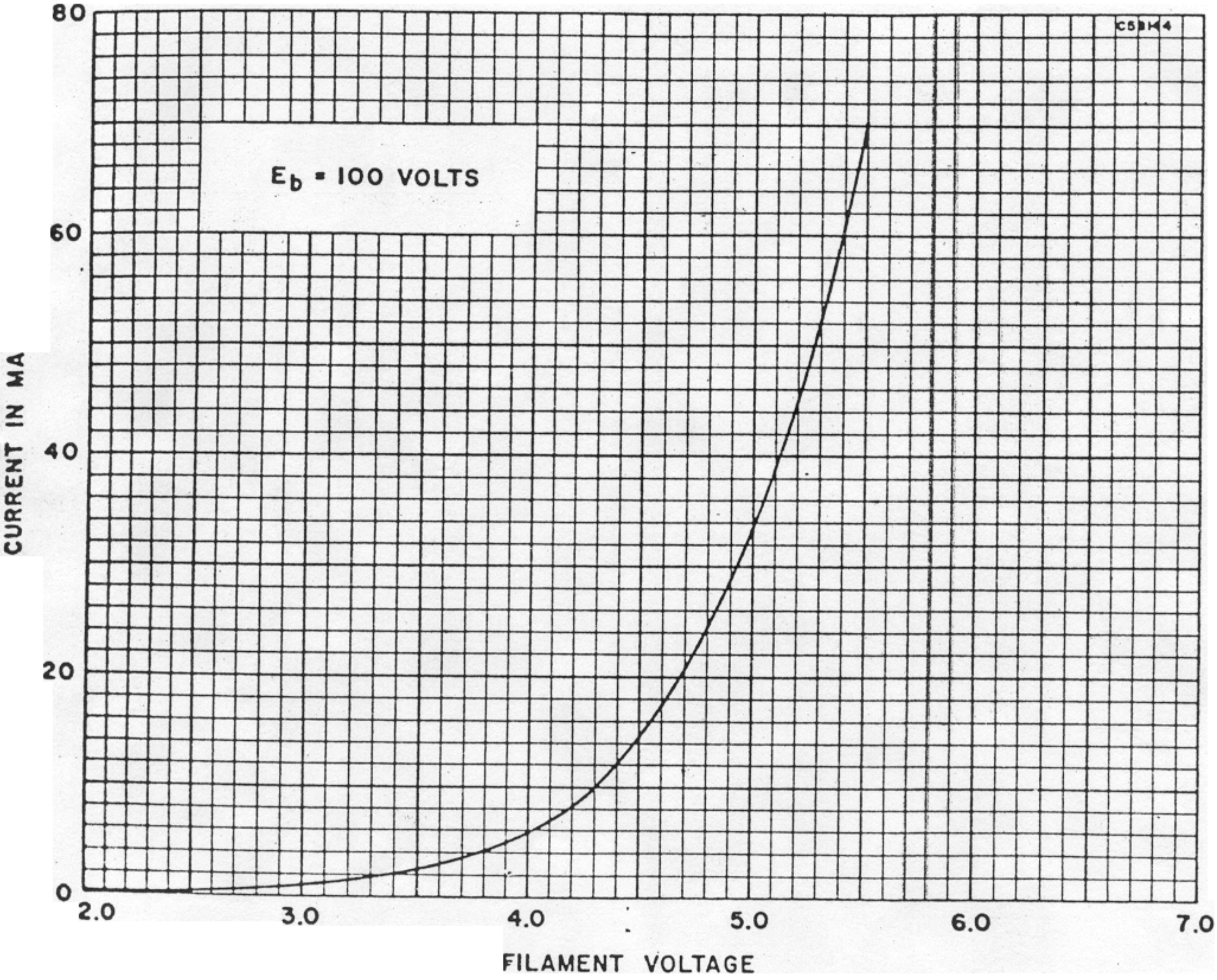
CIRCUIT I



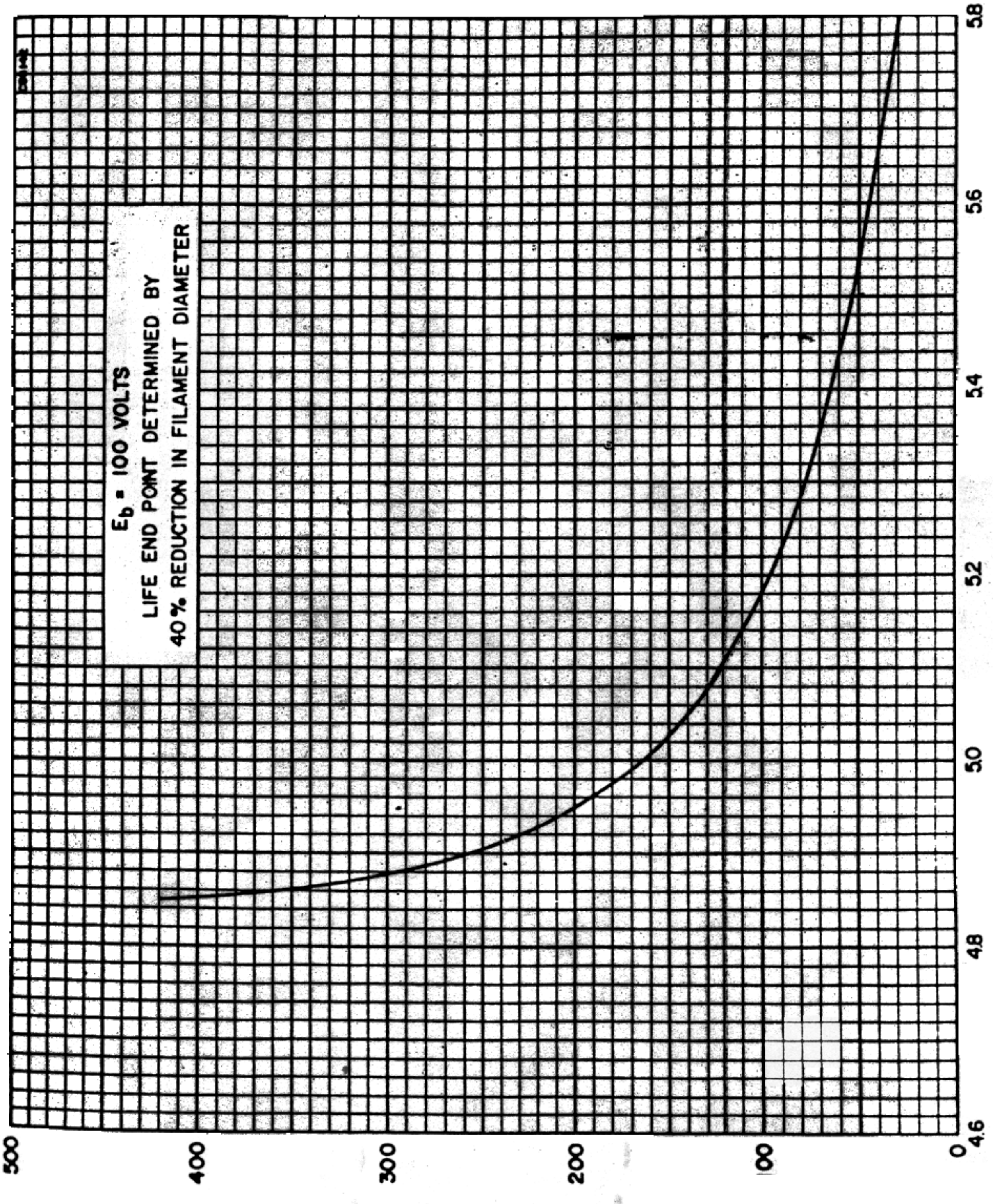
SATURATION CURVE

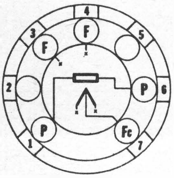


FILAMENT EMISSION CURVE

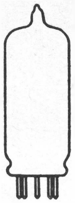


LIFE EXPECTANCY vs. FILAMENT VOLTS





5CB-0-0



Sylvania Type 5722

NOISE GENERATING DIODE

PHYSICAL SPECIFICATIONS

Base	Miniature Button 7 Pin
Bulb	T-5½
Maximum Overall Length	2⅛″
Maximum Seated Height	1⅞″
Mounting Position	Vertical*

*Horizontal operation permitted if Pins 1 and 2 are in a vertical plane.

RATINGS

Maximum Filament Voltage	5.5 Volts
Minimum Filament Voltage	2.0 Volts
Filament Current at 4.9 Volts	1.6 Amperes
Maximum DC Plate Voltage	200 Volts
Maximum Plate Current	35 Ma.
Maximum Plate Dissipation	
Continuous Service	3.5 Watts
Intermittent Service	5.0 Watts
Maximum On Period in 50% Duty Cycle	5 Minutes

Direct Interelectrode Capacitances:*

Plate to Filament	1.5 $\mu\mu$f.

*With no external shield.

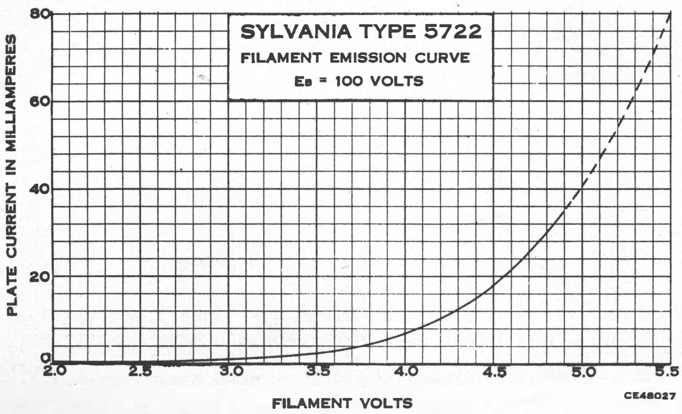
TYPICAL OPERATION

Sylvania Type 5722 is a tungsten filament diode designed for use as a noise generator at frequencies up to 400 or 500 mc. The filament center tap allows better RF grounding of the filament when used in the recommended circuit shown on a following page.

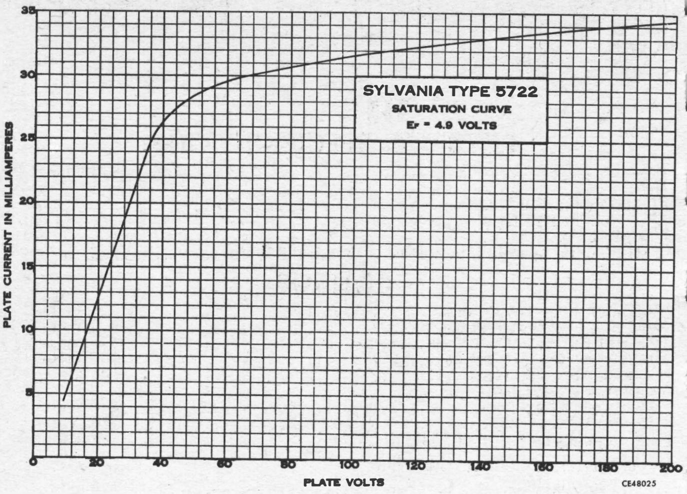
Since the tube has a tungsten filament the "shot effect" may be used as a standard noise source if sufficient plate voltage is applied to obtain saturation. The noise factor (NF) may be obtained from the equation $NF = 20\,IR$ where R is the total generator resistance and I is the diode plate current in amperes. To convert to decibels $NF_{db} = 10 \, \text{Log}_{10} \, 20\,IR$.

In use, the diode is coupled to the input of the amplifier under test and the filament voltage is increased until the noise output power is double that read without the diode. From the plate current reading and the generator resistance the noise factor can be calculated. Additional construction details may be obtained from the article "How Sensitive is Your Receiver," by Byron Goodman in the September 1947 issue of Q.S.T. and also "Coaxial Noise Diode" by H. Johnson, RCA Review, March 1947, Volume VIII, No. 1.

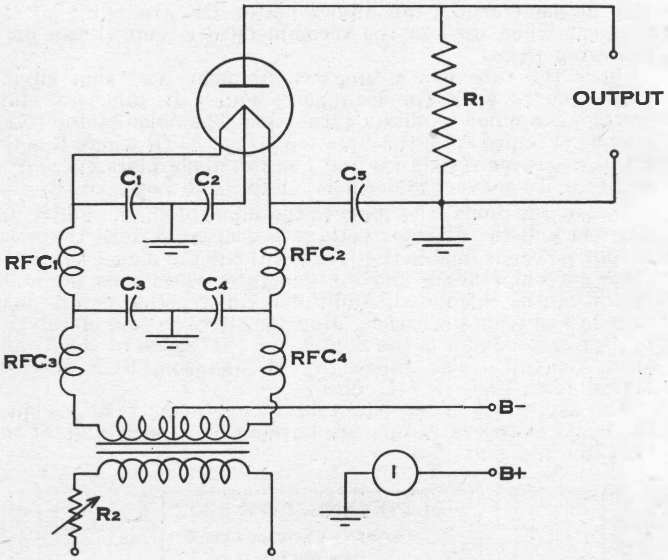
The useful life is dependent on the operating voltages since the usual causes of failure are burnout or vaporization of the tungsten filament.



5722 (Cont'd)



RECOMMENDED CIRCUIT



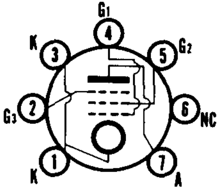
PARTS LIST

C_1 C_2 C_3 C_4 C_5	500 µµf
RFC_1 RFC_2	6 Turns #16 Enamel Wire on 3/16" Air Core
RFC_3 RFC_4	30 Turns #16 Enamel Wire on 3/8" O.D., 1/4" I.D. Bakelite Coil Form With Powdered Iron Core
R_1	50 to 300 Ohms as Required to Match Load
R_2	Filament Voltage Control

SPECIAL PURPOSE TUBES—RECEIVING AND MISCELLANEOUS TYPES Cont'd

TYPE	CONSTRUCTION			EMITTER			NOTES (1) (2) CAPACITIES IN µµf			USE	PLATE VOLTS	SCREEN VOLTS	NEG. VOLTS GRID	PLATE CURRENT MA	SCREEN CURRENT MA	PLATE RESISTANCE OHMS	AMP.■ FACTOR OR Gm µMHOS	OHMS LOAD FOR STATED POWER OUTPUT	POWER OUTPUT MW
	CLASS	STYLE	BASE	TYPE	VOLTS	AMPS	Cgp	Cin	Cout										
7AK7	Pentode	Lock-In	8V	Cathode	6.3	0.8	0.7	12.0	9.5	Computer Tube	150 150 150	90 90 90	0 11 0	40 2.5m 2.0m	21 0.45 60m	11,500 . . . E_{c3}=9.5 V	6,500 . . .	E_{c3}=OV E_{c3}=OV	. . . . . .
12AY7	Special low noise audio amp. See complete data section.																		
25A7GT	Diode Pentode	T-9	8F	Cathode	25.0	0.30	. . .	. . .	. . .	H.W. Rectifier Power Amplifier	117 Volts per plate RMS, 75 Ma Output Current. 100	100	15.0	20.5	4.0	50,000	1,800	4,500	770
26D6	Heptode	T-5½	7CH	Cathode	26.5	0.07	0.3	7.5	14.0	Converter	100 250 26.5	100 100 26.5	1.5 1.5 0.5	2.8 3.0 0.45	8.0 7.8 1.6	500,000♦ 1.0 Meg.♦ . . .	455♥ 475♥ 270♥	R_{g1}=20,000 I_{c1}=0.5 Ma R_{g1}=20,000 I_{c1}=0.5 Ma R_{g1}=20,000 I_{c1}=0.1 Ma	
28D7	Duo-Beam Amplifier	Lock-In	8BS	Cathode	28.0	0.40	. . .	. . .	. . .	Class A2 Amplifier	28 28 28	28 28 28	390▲✱ 3.5 0	9.0✱ 25.0 64.0	0.7✱ 2.0 4.0	R-C Coupled P-P, R-C Coupled P-P Transformer Coupled		4,000✱ 6,000♠ 1,500♠	80✱ 225 600
28D7W (3)	Ruggedized version of Type 28D7. Data same as Type 28D7.																		
1222	Beam Pwr. Amp.	ST-14	1222	Cathode	6.3	0.9	. . .	. . .	. . .	Characteristics similar to Type 6L6GA.									
1229	Tetrode	ST-12	4K	Filament	2.0	0.06	. . .	. . .	. . .	Similar to Type 32. Electrometer tube (Low grid current).									
1273	Pentode	Lock-In	8V	Cathode	6.3	0.30	.004m	6.0	6.5	Amplifier	Characteristics same as Type 14C7 (Special Non-Microphonic Tube)								
1280	Pentode	Lock-In	8V	Cathode	12.6	0.15	.004m	6.0	6.5	Amplifier	Characteristics same as Type 14C7 (Special Non-Microphonic Tube)								
5654/ 6AK5W (3)	Pentode	T-5½	7BD	Cathode	6.3	0.175	0.02m	4.0	2.9	R F Amplifier	120	120	200▼	7.5	2.5	340,000	5,000	. . .	. . .
5679	Duodiode	Lock-In	7CX	Cathode	6.3	0.15	. . .	. . .	. . .		Characteristics same as Type 7A6. For V.T.V.M. use.								
5722	Diode	T-5½	5CB	Filament	4.9	1.6	. . .	. . .	1.5	Noise Diode	150	. . . .	For noise generator service I_b= 35 Ma Max.						
5726/ 6AL5W (3)	Duodiode	T-5½	6BT	Cathode	6.3	0.3	. . .	. . .	. . .	Rectifier	117 A C volts per plate RMS, 9 Ma D C output current per plate.								

BASE DIAGRAMS FOR SPECIAL PURPOSE CHART



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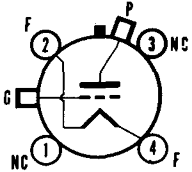

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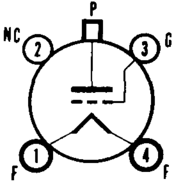

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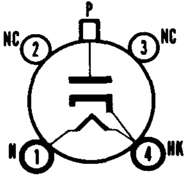

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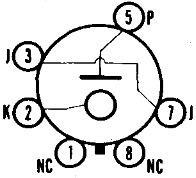

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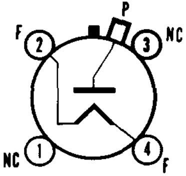

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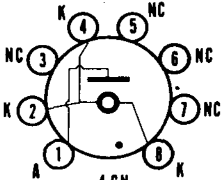

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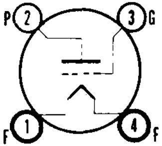

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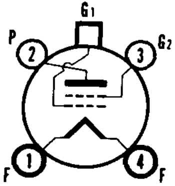

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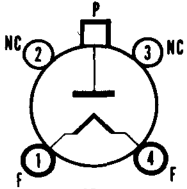

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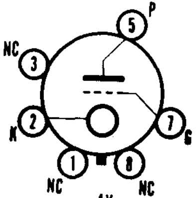

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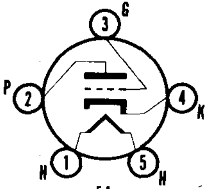

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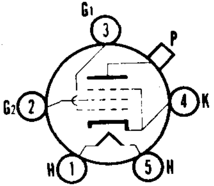

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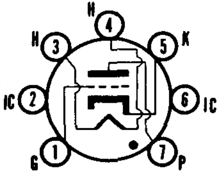

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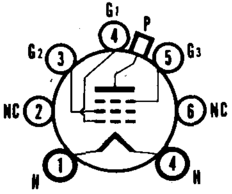

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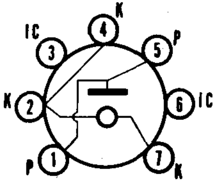

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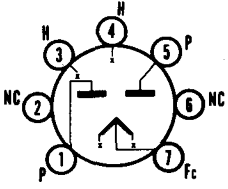

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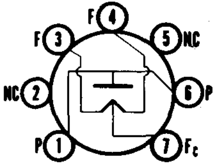

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