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.
5722 Noise Generator

Plate supply
TTi PLH250
150 VDC
70 mA

19" rack panel
Large filter box

Filament supply
TTi PL155
5.15 VDC
3.078 A

Noise output
20.6 kK into 50Ω

10 nH* typ. 2 pl.
4700 pF typ. 5 pl.
6800 pF typ. 3 pl.

*13 turns close wound #22 AWG
3/16" air core
(measured w/ AADE LC meter)
UFRO 5722 Noise Diode Output Temperature Calculation
ref Francisco Reyes’s notes

\[ T_0 = 290 \text{ K} \]
\[ e = 1.602 \times 10^{-19} \text{ C} \]
\[ I = 70.0 \text{ mA} \]
\[ R = 50.0 \Omega \]
\[ k = 1.381 \times 10^{-23} \text{ J/K} \]
\[ eR/2k = 290007.2411 \]
\[ T_{\text{gen}} = 20,591 \text{ K} \]

\[ T_{\text{gen}} = T_0 + \frac{eIR}{2k} \]

\[ T_{\text{gen}} = 290 + 290I = 290(1+I) \text{ where } I \text{ is in mA} \]
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

$$W = kT \Delta \nu$$  \hspace{1cm} (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

$$i_n^2 = 2eI \Delta \nu$$  \hspace{1cm} (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.
The noise power available at the terminals AB is

\[ W = \left(\frac{1}{2}i_n\right)^2 R \tag{3} \]

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

\[ kT\Delta v = \left(\frac{1}{2}i_n\right)^2 R \]

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

\[ T_g = T_o + \frac{eIR}{2k} \tag{4} \]

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

\[ T = 434.78 I + 290 \text{ (in K)} \tag{5} \]

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
J.D. Kraus, Radio Astronomy, chapter 7 (by Martti E. Tiuri) pages 284-286
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 Interelectode Capacitances:**
  Plate to Filament 1.5 μF

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

** With no external shield.

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 \( NF = 20 \log_{10} R \) where \( R \) is the total generator resistance and \( I \) is the diode plate current in amperes. To convert to decibels \( NF_{db} = 10 \log_{10} 20 I R \).

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

$C_1, C_2, C_3, C_4, C_5 \quad 500 \mu F$

$RFC_1, RFC_2 \quad 6$ Turns #16 Enamel Wire on 3/16" Air Core

$RFC_3, RFC_4 \quad 30$ Turns #16 Enamel Wire on 3/8" O.D., 1/4" I.D.
Bakelite Coil Form With Powdered Iron Core

$R_1 \quad 50$ to 300 Ohms as Required to Match Load

$R_2 \quad$ Filament Voltage Control
SYLVANIA TYPE 5722
LIFE EXPECTANCY VS FILAMENT VOLTS
Es = 100 VOLTS
LIFE END POINT DETERMINED BY
40% REDUCTION IN FILAMENT DIAMETER

LIFE EXPECTANCY IN HOURS

FILAMENT VOLTS
MECHANICAL DATA

Bulb .......... T-3½
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 μF

RATINGS (Absolute Values)

- Filament Voltage .......... 5.5 Volts Max.
- Plate Voltage (dc) .......... 2.0 Volts Min.
- Plate Current .......... 200 Volts 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 E2 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

PAGE 1 OF 5
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 \( NF = 20 \log_{10} R \) where \( R \) is the total generator resistance and \( I \) is the diode plate current in amperes. To convert to decibels \( NF_d = 10 \log_{10} 20 IR \).

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

---

![Circuit Diagram](CircuitDiagram.png)
SATURATION CURVE

E = 4.9 VOLTS

Current in mA

Plate Voltage
FILAMENT EMISSION CURVE

$E_b = 100$ VOLTS

CURRENT IN MA

FILAMENT VOLTAGE

0 2.0 3.0 4.0 5.0 6.0 7.0
LIFE EXPECTANCY vs. FILAMENT VOLTS

E_b = 100 VOLTS
LIFE END POINT DETERMINED BY
40% REDUCTION IN FILAMENT DIAMETER

LIFE EXPECTANCY IN HOURS

FILAMENT VOLTAGE
### PHYSICAL SPECIFICATIONS

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<th>Specification</th>
<th>Value</th>
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<td>Bulb</td>
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<td>Maximum Overall Length</td>
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<td>Maximum Seated Height</td>
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<td>Mounting Position</td>
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*Horizontal operation permitted if Pins 1 and 2 are in a vertical plane.

### RATINGS

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<td>Minimum Filament Voltage</td>
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<td>Filament Current at 4.9 Volts</td>
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<td>Maximum DC Plate Voltage</td>
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<td>Maximum Plate Current</td>
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<td>Continuous Service</td>
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<td>Maximum On Period in 50% Duty Cycle</td>
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### Direct Interelectrode Capacitances:

- Plate to Filament: 1.5 μf.

*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.

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

![Sylvania Type 5722 Filament Emission Curve](image)
RECOMMENDED CIRCUIT

PARTS LIST

- $C_1$, $C_2$, $C_3$, $C_4$, $C_5$: 500 μF
- RFC₁, RFC₂: 6 Turns #16 Enamel Wire on 3/16" Air Core
- RFC₃, RFC₄: 30 Turns #16 Enamel Wire on 3/8" O.D., 1/16" I.D. Bakelite Coil Form With Powdered Iron Core
- $R_1$, $R_2$: 50 to 300 Ohms as Required to Match Load

Filament Voltage Control

SYLVANIA TYPE 5722
SATURATION CURVE
$D^* = 4.9$ VOLTS

SYLVANIA RADIO TUBES
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<tr>
<th>TYPE</th>
<th>CONSTRUCTION</th>
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<th>PLATE VOLTS</th>
<th>SCREEN VOLTS</th>
<th>NEG. VOLTS GRID</th>
<th>PLATE CURRENT MA</th>
<th>SCREEN CURRENT MA</th>
<th>PLATE RESISTANCE OHMS</th>
<th>AMP. FACTOR OR GM</th>
<th>MHOS</th>
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