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. Ref circuit diagram Rev C.

In April, 2020, the 4700 pF output coupling cap was moved to the filament center tap of one of the tubes and the RF output was straight from the plates. Ref circuit diagram Rev D. A 0.1 μF coupling cap was added between the plate and RF output. Ref circuit diagram Rev E. The noise temperature output of circuit revisions C, D, and E were measured; no appreciable difference was observed. The noise generator was left in the Rev E state.

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 kΩ
to 50Ω

5722 X 2

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)
5722 Noise Generator

Plate supply
TTi PLH250
150 VDC
70 mA

Filament supply
TTi PL155
5.15 VDC
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19" rack panel
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3.078 A

19" rack panel
Large filter box

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

Noise output
20.6 kΩ into 50Ω

0.1μF

*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

\[ T_0 = 290 \text{ K} \]

\[ e = 1.602E-19 \text{ C} \]

\[ I = 70.0 \text{ mA} \]

\[ R = 50.0 \text{ } \Omega \]

\[ k = 1.381E-23 \text{ J/K} \]

\[ eR/2k = 290007.2411 \]

\[ T_{gen} = 20,591 \text{ K} \]

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

\[ T_{gen} = 290 + 290I = 290(1 + I) \text{ where } I \text{ is in mA} \]
In order to determine the absolute power received by a radio telescope it is necessary to have a source that provides 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

$$W = kT\Delta\nu$$

(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

$$i_n^2 = 2eI\Delta\nu$$

(2)

Where $e$ is the charge of the electron ($1.6 \times 10^{-19}$ 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

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

(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

\[ T = \frac{eIR}{2k} \]

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

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

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

\[ T = 434.78 I + 290 \]  

(in K)

(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

FR
07/19/2012
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 mF

* 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 R where R is the
total generator resistance and I is the diode plate current in amperes. To convert
to decibels NFdb = 10 log10 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,

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.
RECOMMENDED CIRCUIT

PARTS LIST

C1, C2, C3, C4, C5 
500 \mu F

RFC1, RFC2 
6 Turns #16 Enamel Wire on 3/16\textquoteright\ Air Core

RFC3, RFC4 
30 Turns #16 Enamel Wire on 3/8\textquoteright\ O.D., 1/4\textquoteright\ I.D. Bakelite Coil Form With Powdered Iron Core

R1 
50 to 300 Ohms as Required to Match Load

R2 
Filament Voltage Control
SYLVANIA TYPE 5722
LIFE EXPECTANCY VS FILAMENT VOLTS
$E_b = 100$ VOLTS

LIFE END POINT DETERMINED BY
40% REDUCTION IN FILAMENT DIAMETER
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-3½
Base ............... E7-1 Miniature Button 7-Pin
Outline ............. 5-2
Standing ........... 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 ....... 35 Ma Max.
Intermittent Service .... 3.5 Watts Max.
Maximum on Period in 50% Duty Cycle 5.0 Watts Max.
5 Minutes

CHARACTERISTICS:

Filament Voltage¹ ........ 4.9 Volts
Filament Current .......... 1.6 Amps
Plate Voltage ............ 150 Volts
Plate Current ............ 30 Ma

NOTE:

1. In application, adjust B1 to obtain desired Plate Current or Noise Output.
APPLICATION DATA

The Sylvania Type 3722 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 \( NF = 20 \log_{10} \frac{R}{I} \) 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
SATURATION CURVE
FILAMENT EMISSION CURVE

$E_b = 100 \text{ VOLTS}$

CURRENT IN MA

FILAMENT VOLTAGE
LIFE EXPECTANCY vs. FILAMENT VOLTS

$E_b = 100$ VOLTS

LIFE END POINT DETERMINED BY
40% REDUCTION IN FILAMENT DIAMETER

Life Expectancy in Hours
Sylvania Type 5722

NOISE GENERATING DIODE

PHYSICAL SPECIFICATIONS

Base .......................................................... Miniature Button 7 Pin
Bulb .......................................................... T-53/4
Maximum Overall Length .......................... 2 1/4"
Maximum Seated Height ............................ 1 3/4"
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 µfd.

*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

\[ NF = 20 \cdot \frac{R}{I} \]

where \( R \) is the total generator resistance and \( I \) is the diode plate current in amperes. To convert to decibels

\[ NF_{db} = 10 \cdot \log_{10} \left( \frac{20 \cdot R}{I} \right) \]

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.

![Graph of Sylvania Type 5722 Filament Emission Curve](image-url)
SYLVANIA TYPE 5722
SATURATION CURVE
E = 4.9 VOLTS

RECOMMENDED CIRCUIT

PARTS LIST

C1, C2, C3, C4, C5
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., 1/4" I.D. Bakelite Coil Form With Powdered Iron Core

R1, R2
50 to 300 Ohms as Required to Match Load
Filament Voltage Control

SYLVANIA RADIO TUBES
## SPECIAL PURPOSE TUBES—RECEIVING AND MISCELLANEOUS TYPES Cont’d

| TYPE | CONSTRUCTION | Emitter | NOTES (1) (2) | CAPACITIES IN μF | USE | PLATE VOLTS | SCREEN VOLTS | NEG.-VOLTS GRID | PLATE CURRENT | SCREEN CURRENT | PLATE RESISTANCE | AMP. FACTOR Gm | OHMS LOAD FOR STATED POWER OUTPUT | POWER OUTPUT M.W. |
|------|--------------|---------|---------------|-----------------|-----|-------------|--------------|----------------|---------------|---------------|----------------|----------------|------------------|----------------|----------------------------------|------------------|
| 7AK7 | Pentode      | Lock-In 8V | Cathode       | 6.3             | 0.8 | 0.7         | 12.0         | 9.5            | 150           | 90            | 0              | 4.0            | 21              | 11,500          | 6,500              | E₁ₑ = 9V, E₂ₑ = OV |
| 12A7 | Y 7          | Special low noise audio amp. See complete data section. | | | | | | | | | | | | | |
| 25AG7T | Diode       | T-9     | Cathode       | 25.0            | 0.30 | ...         | ...           | ...            | 117 Volts per plate RMS, 75 Ma Output Current | 50,000           | 1,800          | 4,500           | 770            | ...                      | ...              |
| 256D6 | Heptode      | T-5/2   | Cathode       | 26.5            | 0.07 | 0.3         | 7.5          | 14.0           | 100           | 100           | 20.5           | 2.8            | 8.0              | 500,000         | 455*               | ...                      |
| 26D7 | Duo-Beam Amplifier | Lock-In 8BS | Cathode | 28.0            | 0.40 | ...         | ...           | ...            | 28            | 28            | 2.0            | 9.0            | 2.0              | 64.0            | 4.0              | ...                      |
| 26D7W (3) | Ruggedized version of Type 26D7. Data same as Type 26D7. | | | | | | | | | | | | | | |
| 1222 | Beam Pwr. Amp. | ST-14   | Cathode       | 6.3             | 0.9  | ...         | ...           | ...            | Similar characteristics to Type 6L5GA. | ... | ... | ... | ... | ... | ... | ... | ...
| 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 | 5.0 | 2.0 | 0.45 | 1.6 | 1.0 Mega | 475 | ... | ... | ...
| 1280 | Pentode      | Lock-In 8V | Cathode | 12.6 | 0.15 | .004m | 6.0 | 6.5 | 5.0 | 2.0 | 0.45 | 1.6 | 1.0 Mega | 475 | ... | ... | ...
| 5854 | 6AK5W (3) | Pentode | T-5/2 | 7BD | Cathode | 6.3 | 0.175 | 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-5/2   | 5CB Filament | 4.9 | 1.6 | ... | ... | ... | Noise Diode | 150 | ... | ... | ... | ... | ... | ... | ...
| 5726/ 6AL5W (3) | Duodiode | T-5/2 | 6BT | Cathode | 6.3 | 0.3 | ... | ... | ... | Rectifier | 117 A C volts per plate RMS, 9 Ma D C output current per plate. | ... | ... | ... | ... | ... | ... | ... | ...

*Notes:
1. Characters [A], [B], [C], etc., are used for further data on each type.
2. Specific characteristics depend on application.

Components and specifications listed are subject to change. Please consult the manufacturer's latest catalog for the most current information.