Chapter 1 - Basic Amplifier stage

Last updated: 2 September 2003

This chapter, we look the basic tube amplifier stage. Also the theory how the amplification done.

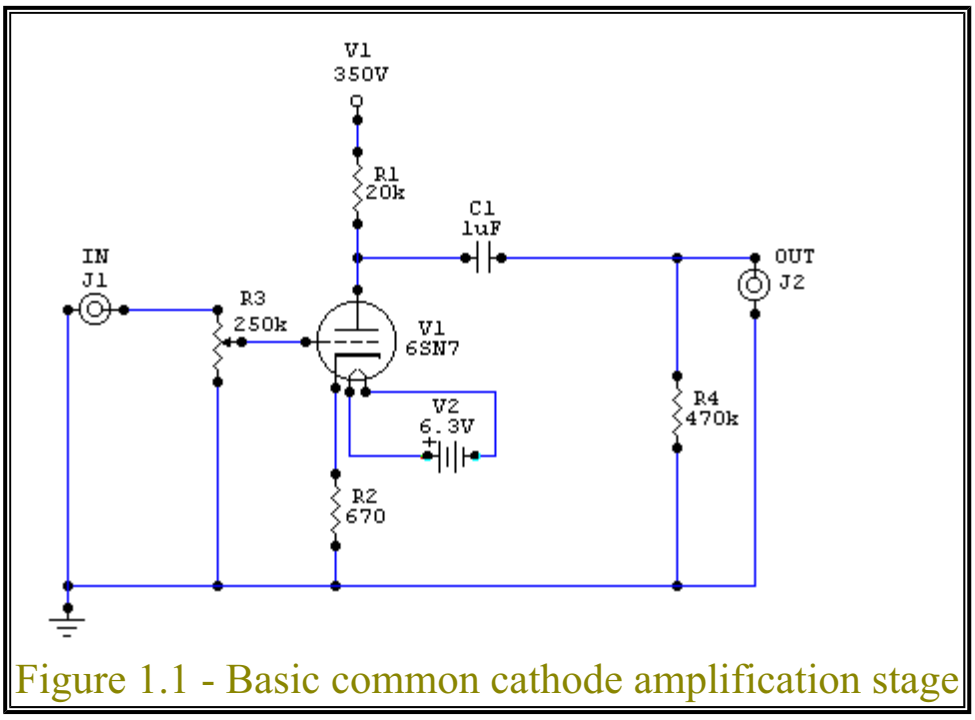

Figure 1.1 - Basic common cathode amplification stage

Basic and simple stage:

Figure 1.1 show a basic Common cathode stage. It is acturally a simple voltage amplifier. Where: -

V2 is 6.3V battery supply for filament. Filament must be within + or - 5% for the tube function in the spec.

V1 is Well know call B+, it is the supply DC voltage for V1 working.

When there is a signal (AC voltage) from J1, passed throught R3 (Volume control) to adjust the sound level. The signal pass the grid of 6SN7 to the cathode and then R2 to ground.

When this circuit as a current in grid to cathode, the characteristic of the tube will allow current flow with voltage change proportional to the signal level, from Anode to cathode. The amplificated signal will flow through C1 to J2.

R1 give a loading to Tube V1 6SN7, for triode It always 2 times or more the tube internal resistance

R2 control the tube working point

R3 is volume control and also the input loading to the source

R4 provide output loading

C1 is coupling capacitor which allow AC but no DC pass through

Read the Tube Menu:

Refer to General Electronic menu: 6SN7WGTA On the Mid-top, Three version 6SN7 GTA, 6SN7 GTB and 12SN7 GTA are all refer to this datasheet. And then, "Description and Rating" show what this tube is and could be used for. Below it "General - Electrical" show the filament voltage, current and AC/DC, also heater	

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TWIN TRIODE

DESCRIPTION AND RATING

The 6SN7-GTB is a medium-mu twin triode suitable for use in a wide variety of general-purpose amplifier and phase-inverter applications. It is also especially useful as a blocking oscillator, multivibrator, or vertical-deflection amplifier in television receivers.

Electrically and physically the 6SN7-GTB is a replacement for the 6SN7-GTA. In addition, however, the 6SN7-GTB exhibits a controlled heater warm-up characteristic which makes the tube especially suited for use in television receivers which employ series-connected heaters. When the 6SN7-GTB is used in conjunction with other 600-milliampere types which have essentially the same heater warm-up characteristic, heater voltage surges across the individual tubes are minimized during the warm-up.

Except for heater and heater warm-up time ratings, the 12SN7-GTA is identical to the 6SN7-GTB.

BASING DIAGRAM

KEY

TERMINAL CONNECTIONS

Pin 1—Grid (Section 2)
Pin 2—Plate (Section 2)
Pin 3—Cathode (Section 2)
Pin 4—Grid (Section 1)
Pin 5—Plate (Section 1)
Pin 6—Cathode (Section 1)
Pin 7—Heater
Pin 8—Heater

PHYSICAL DIMENSIONS

GENERAL

Electrical
Cathode—Coated Unipotential

	6SN7-GTA	6SN7-GTB	12SN7-GTA	
Heater Voltage, AC or DC	6.3	6.3	12.6	Volts
Heater Current	0.6	0.6	0.3	Amperes
Heater Warm-up Time*		10.5		Seconds

Direct Interelectrode Capacitances†

	Section 1	Section 2	
Grid to Plate	4.0	3.8	μμf
Input	2.2	2.6	μμf
Output	0.7	0.7	μμf

Mechanical
Mounting Position—Any
Envelope—T-9, Glass
Base—B8-6, Intermediate Shell Octal 8-Pin
or B8-58, Short Intermediate Shell Octal 8-Pin

warm-up time on the 6SN7 GTB version. Follow is the direct inter-electrode capacitance. This figure is small but very important on high frequency application. We will talk it on later chapter.

And then "General - Machanical" show the Mounting poistion, tube socket and Envelope shape and material.

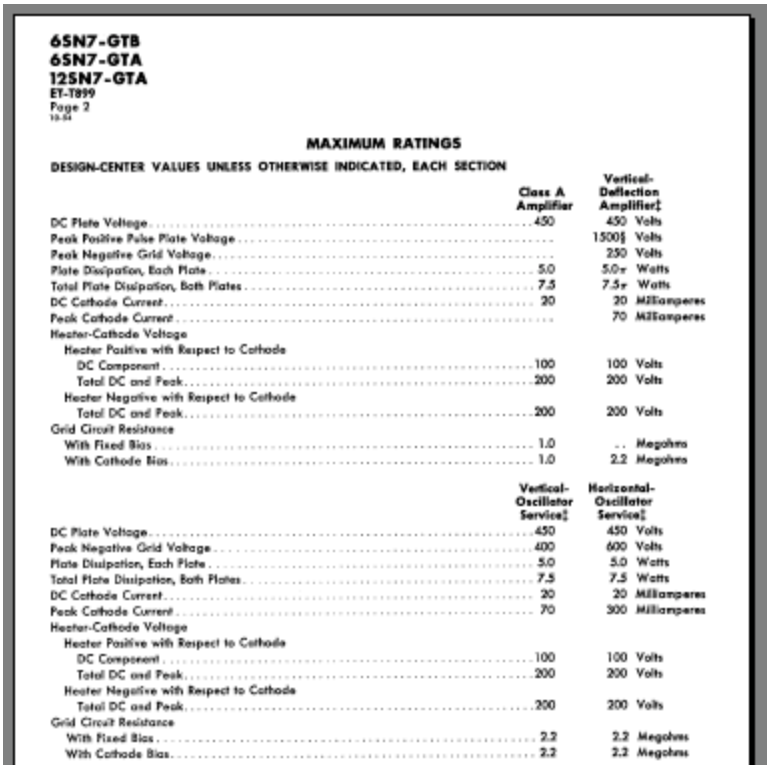
Refer to the right column, the bottom view of tube base shown the pin-out. Below is the name and tube size shown below.

On page 2: -

There is a "Maximum Rating"

We use 6SN7 as a Class A amp. The "Plate dissipation" 5.0W either plate and total 7.5W for both plate. We don't want the tube die fast. So, always use it with 70% the Maximum. On power tube, we sometime use up to 100%.

Another important figure is the Max plate voltage.



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MAXIMUM RATINGS

DESIGN-CENTER VALUES UNLESS OTHERWISE INDICATED, EACH SECTION

	Class A Amplifier	Vertical-Deflection Amplifier‡	
DC Plate Voltage	450	450	Volts
Peak Positive Pulse Plate Voltage		1500§	Volts
Peak Negative Grid Voltage		250	Volts
Plate Dissipation, Each Plate	5.0	5.0#	Watts
Total Plate Dissipation, Both Plates	7.5	7.5#	Watts
DC Cathode Current	20	20	Milliamperes
Peak Cathode Current		70	Milliamperes
Heater-Cathode Voltage			
Heater Positive with Respect to Cathode			
DC Component	100	100	Volts
Total DC and Peak	200	200	Volts
Heater Negative with Respect to Cathode			
Total DC and Peak	200	200	Volts
Grid Circuit Resistance			
With Fixed Bias	1.0	..	Megohms
With Cathode Bias	1.0	2.2	Megohms

	Vertical-Oscillator Service‡	Horizontal-Oscillator Service‡	
DC Plate Voltage	450	450	Volts
Peak Negative Grid Voltage	400	600	Volts
Plate Dissipation, Each Plate	5.0	5.0	Watts
Total Plate Dissipation, Both Plates	7.5	7.5	Watts
DC Cathode Current	20	20	Milliamperes
Peak Cathode Current	70	300	Milliamperes
Heater-Cathode Voltage			
Heater Positive with Respect to Cathode			
DC Component	100	100	Volts
Total DC and Peak	200	200	Volts
Heater Negative with Respect to Cathode			
Total DC and Peak	200	200	Volts
Grid Circuit Resistance			
With Fixed Bias	2.2	2.2	Megohms
With Cathode Bias	2.2	2.2	Megohms

6SN7 has a high value, but some tube could be very low. The other figure are rare to exceed, e.g. max current, heater to cathode, but we should take care.

We don't use it as Oscillator, so we look on next page.

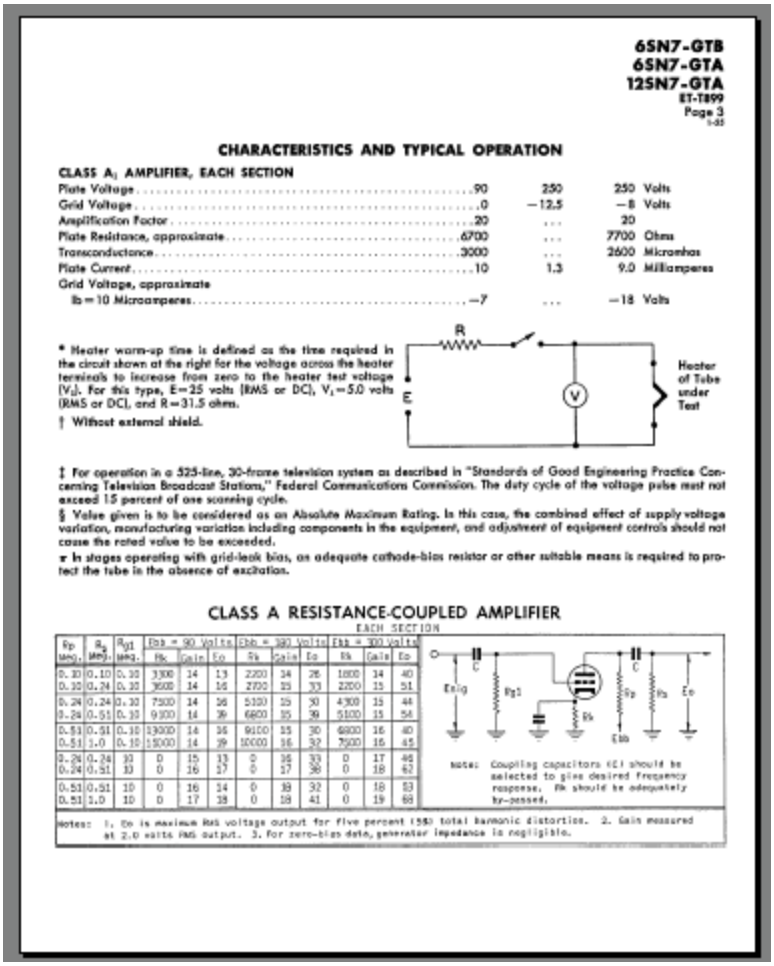
On Page 3: -

"Characteristices and typical application" - There is 2 recommendation for Class A1 amplificer. If you are lazy to design, you can simply use that figures.

Now, just don't ask what is it. And just follow!

I will teach you how to use them on later chapter.

The the lower table: "Class A resistance-coupled amplifier" There are many different working point for different working condition. You may choose one suitable!



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CHARACTERISTICS AND TYPICAL OPERATION

CLASS A_1 AMPLIFIER, EACH SECTION

Plate Voltage	90	250	250 Volts
Grid Voltage	0	−12.5	−8 Volts
Amplification Factor	20	...	20
Plate Resistance, approximate	6700	...	7700 Ohms
Transconductance	3000	...	2600 Micromhos
Plate Current	10	1.3	9.0 Milliamperes
Grid Voltage, approximate I_b = 10 Microamperes	−7	...	−18 Volts

* Heater warm-up time is defined as the time required in the circuit shown at the right for the voltage across the heater terminals to increase from zero to the heater test voltage (V_h). For this type, E = 25 volts (RMS or DC), V_1 = 5.0 volts (RMS or DC), and R = 31.5 ohms.

† Without external shield.

‡ For operation in a 525-line, 30-frame television system as described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations," Federal Communications Commission. The duty cycle of the voltage pulse must not exceed 15 percent of one scanning cycle.

§ Value given is to be considered as an Absolute Maximum Rating. In this case, the combined effect of supply voltage variation, manufacturing variation including components in the equipment, and adjustment of equipment controls should not cause the rated value to be exceeded.

ж In stages operating with grid-leak bias, an adequate cathode-bias resistor or other suitable means is required to protect the tube in the absence of excitation.

CLASS A RESISTANCE-COUPLED AMPLIFIER

EACH SECTION

R_p (meg.)	R_g (meg.)	R_{g1} (meg.)	E_{bb} = 90 Volts R_k	Gain	Eo	E_{bb} = 180 Volts R_k	Gain	Eo	E_{bb} = 300 Volts R_k	Gain	Eo
0.10	0.10	0.10	3300	14	13	2200	14	26	1800	14	40
0.10	0.24	0.10	3600	14	16	2700	15	33	2200	15	51
0.24	0.24	0.10	7500	14	16	5100	15	30	4300	15	44
0.24	0.51	0.10	9300	14	19	6800	15	39	5100	15	54
0.51	0.51	0.10	13000	14	16	9100	15	30	6800	16	40
0.51	1.0	0.10	15000	14	19	10000	16	32	7500	16	45
0.24	0.24	10	0	15	13	0	16	33	0	17	46
0.24	0.51	10	0	16	17	0	17	38	0	18	61
0.51	0.51	10	0	16	14	0	18	32	0	18	53
0.51	1.0	10	0	17	18	0	18	41	0	19	68

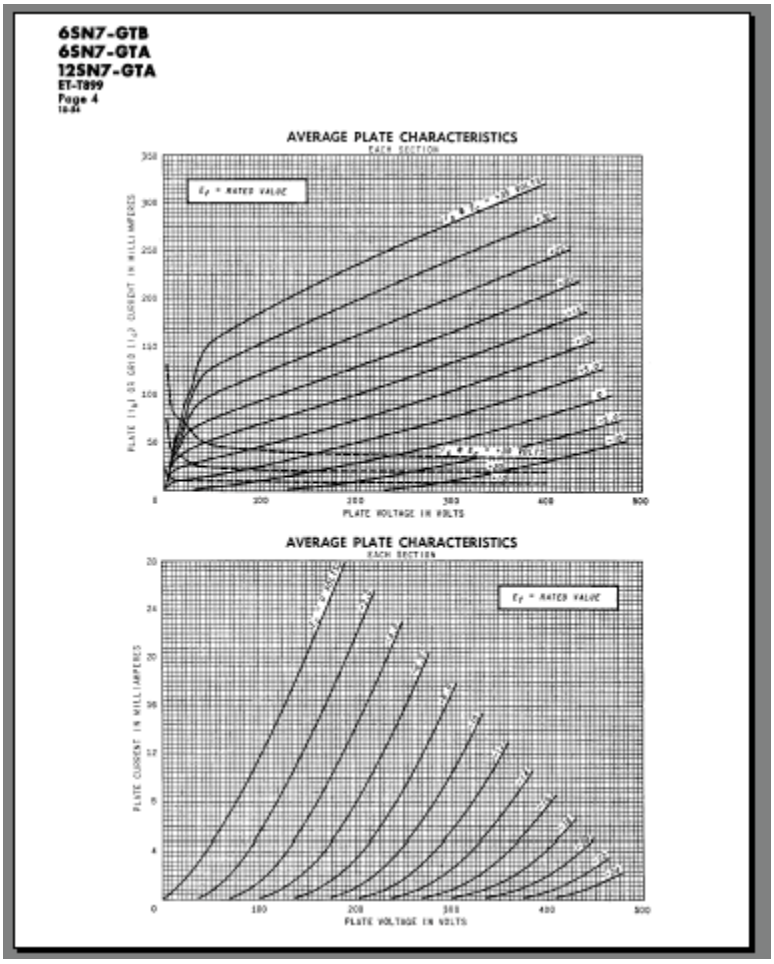
Note: Coupling capacitors (C) should be selected to give desired frequency response. Rk should be adequately by-passed.

Notes: 1. Eo is maximum RMS voltage output for five percent (5%) total harmonic distortion. 2. Gain measured at 2.0 volts RMS output. 3. For zero-bias data, generator impedance is negligible.

Page 4: -

There is a very important chart. Forgot the upper one.

The lower chart is a Class A1 amplifier chart



Design a simple "Class A resistance-coupled amplifier"

If we choose (refer to page 3 chart):-

B+ (Ebb) = 300V

Rk = 1800

Gain = 14 times

as an example.

6SN7		
Max Power	2.5	W
Proposed power	0.1928	W =8%
Max Plate Voltage	300	V
Plate voltage	96.4	V
Max Current	20	mA
Supply Voltage	300	V
Current	2	mA
Dropping resistor		ohm
Power		W
	300	V
Plate resistor	100000	ohm
Power	0.4	W
Plate read voltage	100	V
Proposed -BAIS	3.7	V
C. Resistor	620	ohm
Power	0.0074	W
Proposed C. resistor	1800	ohm
Voltage	3.6	V
Power	0.0072	W
Min. swing	30	V
Max. swing	160	V
AF	18.0556	times

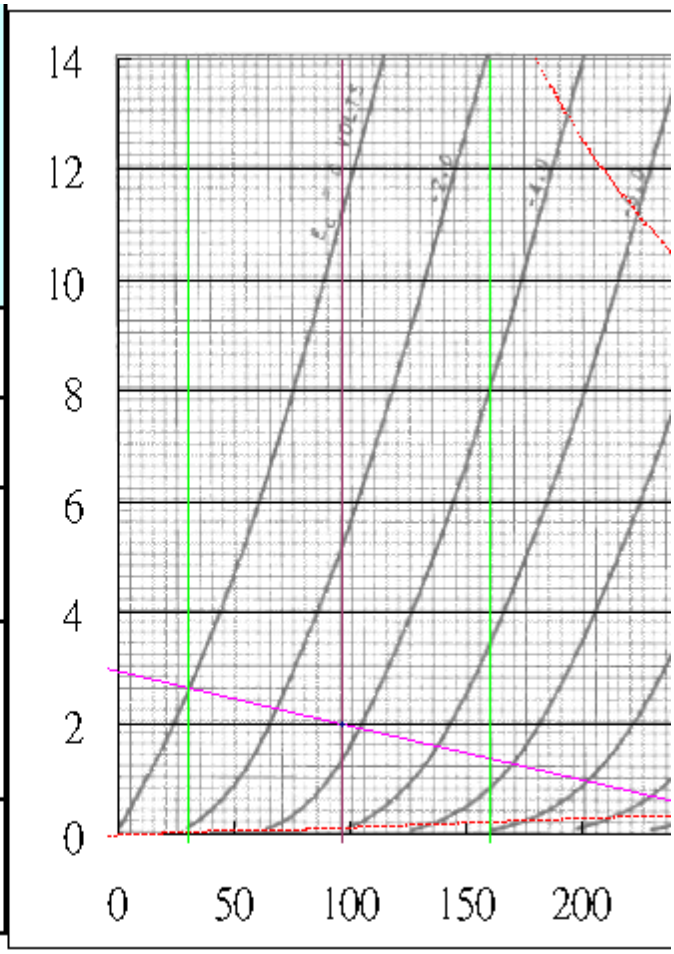


Figure 1.2 - Loading line of 6SN7

On the working point: -

if current = 0;

V = IR

V = 0 * 100000 = 0

So, the voltage is: -

Ebb - 0 = 300V

We draw a point on (0, 300);

if current = 2mA (0.002A),

V = 0.002 * 100000 = 200V

So, the voltage is: -

Ebb - 200V = 100V

We draw a point on (2, 100)

Since the V=IR is a linear function, so we can join the two point (0,300) and (2,100) to get a "LOADING Line" (Purple line in Figure 1.2)

On the loading line, we choose a point which is more lower distortion. Example, the point intercept 2mA.

The voltage across Rk: -

V = IR = 0.002 * 1800 = 3.6V

On the grid line between 2 and 4, we can approx draw the point on loading line of grid = 3.6V. At there, we found the plate voltage is 96.4V

The gain is: -

(Deta Vp) / (Deta Vg)

66 / 3.6 = 18.3 times

Checking: -

On Class A1, we don't allow the swing exceed zero grid.

Now we have a working point on 96.4V and 2mA: -

Maximium input swing allow = 2 * 3.6V = 7.2V P-P = 2.68V RMS, large enough for most sound source input

Maximium signal output/swing 130V P-P

Plate current = 2mA

Plate dissipation = 96.4V * 2mA = 0.1928 W (8% of the Maximium 2.5W, safe)

So, this working point work fine

Output capactor: -

Calculate F3: = 1,000/(2*pi)/(uF * R))

Where: -

F3 is the frequency where -3dB roll-off

pi = 3.1415

uF = Capacitance in uF

R = resistance in k ohm

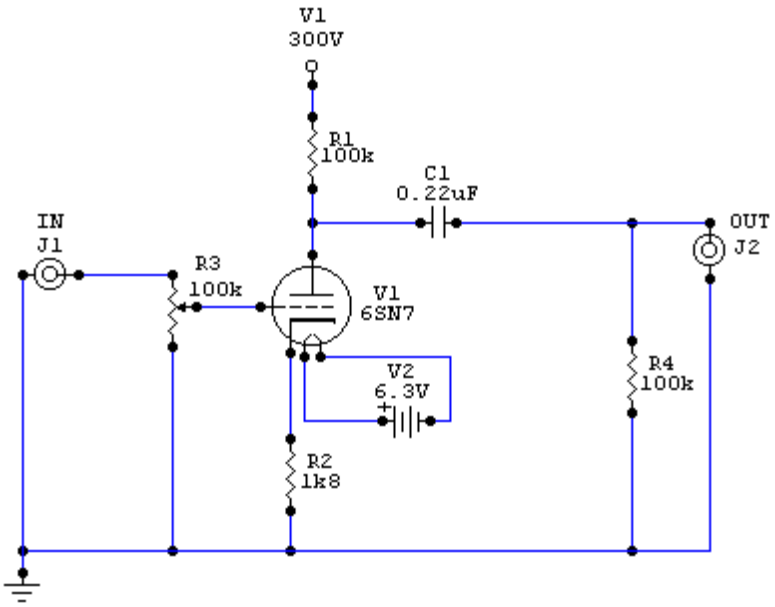
In our case, say: -

0.22 uF on 100k loading

F3 = 7.23Hz, low enough!

Can F3 lower? Yes, just increase Rs (100k) or C1 (0.22uF). But Rs has to be match with next stage, and larger capacitor is more expansive. So, that is good enough.

Now we have a circuit: -



That is a simple pre-amp.