Universität für Musik und darstellende Kunst, Wien
Institut für Elektroakustik
Jürg Jecklin

Tontechnik Workshop

Mikrofon-Verstärker

1. Vorgaben

1.1 Vorgaben, Unterlagen

Technische Daten

Verstärkung regelbar, .	10 dB - 60 dB
Vordämpfung	20 dB
Phantomspeisung, schaltbar	48 V
Geräusch bezogen auf Eingang (unbewertet)	-128 dB
Ausgangspegel, normal	+6 dB
Ausgangspegel, max	+20 dB
Frequenzbereich	20 Hz - 20 kHz
Frequenzgang, Abweichungen	+- 0.5 dB
Eingangswiderstand	2 kOhm
Ausgangswiderstand	max 50 Ohm
Eingänge	symmetrisch
Ausgänge	symmetrisch

Zusätzliche Vorgaben für Versionen mit IC's und diskreter Aufbau mit Halbleitern

Ein- und Ausgänge XLR
Aufbau auf Europakarte (10 x 16 cm)
Netzteil mit Trafo auf Print
Schalter und Potis auf Print
VU-Meter mit Zeigerinstrument

Zusätzliche Vorgaben für Version mit Röhren

Ein- und Ausgänge XLR
Aufbau mit diskreter Verdrahtung
Netzteil im Gerät, Trafo eventuell in getrenntem Gehäuse
VU-Anzeige mit Zeigerinstrument oder "magischem Auge"
Gehäuse mit Wärmeabführung.

technische Unterlagen

Datenblätter der in Frage kommenden IC's und Transistoren
Script Schalttechnik
Katalog Conrad

1.2 Vorgehensweise

- Abklären der technischen Möglichkeiten
- Wahl der Schalttechnik (IC, diskrete Halbleiter, Röhren, Hybridlösung)
- Entwurf und Berechnung der Schaltung
- Auswahl der Bauteile, Erstellen einer Stückliste
- Entwurf der Printplatte oder des Verdrahtungsplans
- Wahl des Gehäuses
- Zeichnung für Bearbeitung des Gehäuses (Löcher, Befestigung der Bauteile, etc.
- Materialbestellung
- Aubau der Schaltung
- Test und Aenderungen
- Fertigstellung des Gerätes
- Erstellen der technischen Unterlagen (Betriebs- und Reparaturanleitung)

2. Technische Unterlagen

ANALOG DEVICES

Self-Contained Audio Preamplifier

SSM-2017

FEATURES

- Excellent Noise Performance: 950 pV/√Hz or 1.5 dB Noise Figure
- Ultralow THD: <0.01% @ G = 100 Over the Full Audio Band
- Wide Bandwidth: 1 MHz @ G = 100
- High Slew Rate: 17 V/µs typ
- Unity Gain Stable
- True Differential Inputs
- Subaudio 1/f Noise Corner
- 8-Pin Mini-DIP with Only One External Component Required
- Very Low Cost
- Extended Temperature Range: −40°C to +85°C

APPLICATIONS

- Audio Mix Consoles
- Intercom/Paging Systems
- Two-Way Radio
- Sonar
- Digital Audio Systems

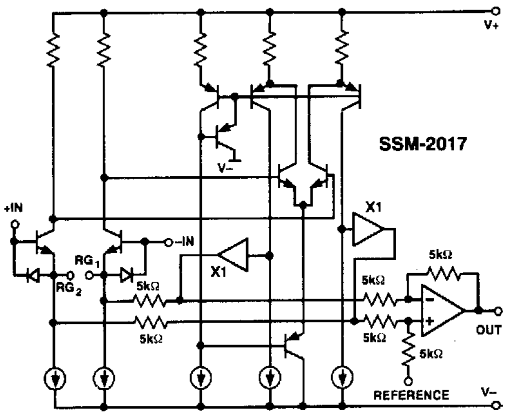
GENERAL DESCRIPTION

The SSM-2017 is a latest generation audio preamplifier combining SSM preamplifier design expertise with advanced processing. The result is excellent audio performance from a self-contained 8-pin mini-DIP device, requiring only one external gain set resistor or potentiometer. The SSM-2017 is further enhanced by its unity gain stability.

Key specifications include ultralow noise (1.5 dB noise figure) and THD (<0.01% at G = 100), complemented by wide bandwidth and high slew rate.

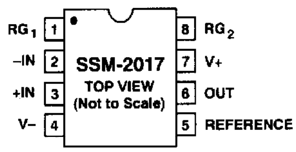
Applications for this low cost device include microphone preamplifiers and bus summing amplifiers in professional and consumer audio equipment, sonar, and other applications requiring a low noise instrumentation amplifier with high gain capability.

FUNCTIONAL BLOCK DIAGRAM

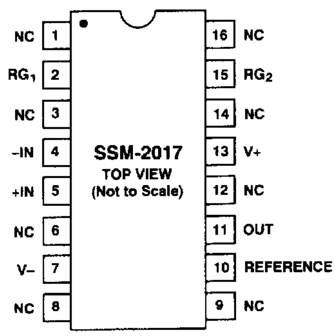


PIN CONNECTIONS

Epoxy Mini-DIP (P Suffix) and Hermetic DIP (Z Suffix)



16-Pin SOIC (S Suffix)



NC = NO CONNECT

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
REFERENCE INPUT						
Input Resistance				10		kΩ
Voltage Range				±8		V
Gain to Output				1		V/V
POWER SUPPLY						
Supply Voltage Range	V_S		±6		±22	V
Supply Current	I_{SY}	V_{CM} = 0 V, R_L = ∞		±10.6	±14.0	mA

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS

Supply Voltage . . . . ±22 V
Input Voltage . . . . Supply Voltage
Output Short Circuit Duration . . . . 10 sec
Storage Temperature Range (P, Z Packages) . −65°C to +150°C
Junction Temperature (T_J) . . . . −65°C to +150°C
Lead Temperature Range (Soldering, 60 sec) . . . . 300°C
Operating Temperature Range . . . . −40°C to +85°C
Thermal Resistance[1]
8-Pin Hermetic DIP (Z): θ_{JA} = 134; θ_{JC} = 12 . . . . . . °C/W
8-Pin Plastic DIP (P): θ_{JA} = 96; θ_{JC} = 37 . . . . °C/W
16-Pin SOIC (S): θ_{JA} = 92; θ_{JC} = 27 . . . . °C/W

NOTE
[1]θ_{JA} is specified for worst case mounting conditions, i.e., θ_{JA} is specified for device in socket for cerdip and plastic DIP; θ_{JA} is specified for device soldered to printed circuit board for SOIC package.

ORDERING GUIDE

Model	Operating Temperature Range*	Package
SSM-2017P	−40°C to +85°C	8-Pin Plastic DIP
SSM-2017Z	−40°C to +85°C	8-Pin Hermetic DIP
SSM-2017S	−40°C to +85°C	16-Lead SOIC

*XIND = −40°C to +85°C.

Typical Performance Characteristics

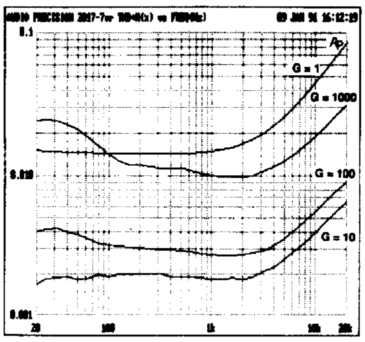


Figure 1. Typical THD+Noise at G = 1, 10, 100, 1000; V_O = 7 V_{RMS}, V_S = ±15 V, R_L = 5 kΩ; T_A = +25°C*

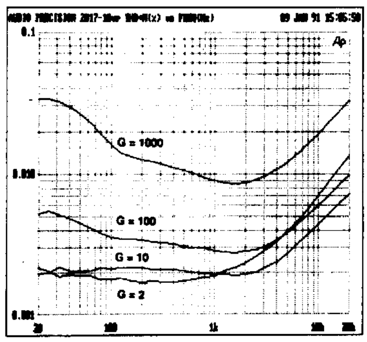


Figure 2. Typical THD+Noise at G = 2, 10, 100, 1000; V_O = 10 V_{RMS}, V_S = ±18 V, R_L = 5 kΩ; T_A = +25°C*

SSM-2017—SPECIFICATIONS

(V_S = ±15 V and −40°C ≤ T_A ≤ +85°C, unless otherwise specified. Typical specifications apply at T_A = +25°C.)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
DISTORTION PERFORMANCE		T_A = +25°C				
		V_O = 7 V_{RMS}				
		R_L = 5 kΩ				
Total Harmonic Distortion Plus Noise	THD+N	G = 1000, f = 1 kHz		0.012		%
		G = 100, f = 1 kHz		0.005		%
		G = 10, f = 1 kHz		0.004		%
		G = 1, f = 1 kHz		0.008		%
NOISE PERFORMANCE						
Input Referred Voltage Noise Density	e_n	f = 1 kHz, G = 1000		0.95		nV/√Hz
		f = 1 kHz; G = 100		1.95		nV/√Hz
		f = 1 kHz; G = 10		11.83		nV/√Hz
		f = 1 kHz; G = 1		107.14		nV/√Hz
Input Current Noise Density	i_n	f = 1 kHz, G = 1000		2		pA/√Hz
DYNAMIC RESPONSE						
Slew Rate	SR	G = 10	10	17		V/μs
		R_L = 4.7 kΩ				
		C_L = 50 pF				
		T_A = +25°C				
Small Signal Bandwidth	$BW_{-3 dB}$	G = 1000		200		kHz
		G = 100		1000		kHz
		G = 10		2000		kHz
		G = 1		4000		kHz
INPUT						
Input Offset Voltage	V_{IOS}			0.1	1.2	mV
Input Bias Current	I_B	V_{CM} = 0 V		6	25	μA
Input Offset Current	I_{OS}	V_{CM} = 0 V		±0.002	±2.5	μA
Common-Mode Rejection	CMR	V_{CM} = ±8 V				
		G = 1000	80	112		dB
		G = 100	60	92		dB
		G = 10	40	74		dB
		G = 1, T_A = +25°C	26	54		dB
		G = 1, T_A = −40°C to +85°C	20	54		dB
Power Supply Rejection	PSR	V_S = ±6 V to ±18 V				
		G = 1000	80	124		dB
		G = 100	60	118		dB
		G = 10	40	101		dB
		G = 1	26	82		dB
Input Voltage Range	IVR		±8			V
Input Resistance	R_{IN}	Differential, G = 1000		1		MΩ
		G = 1		30		MΩ
		Common Mode, G = 1000		5.3		MΩ
		G = 1		7.1		MΩ
OUTPUT						
Output Voltage Swing	V_O	R_L = 2 kΩ; T_A = +25°C	±11.0	±12.3		V
Output Offset Voltage	V_{OOS}			−40	500	mV
Minimum Resistive Load Drive		T_A = +25°C		2		kΩ
		T_A = −40°C to +85°C		4.7		kΩ
Maximum Capacitive Load Drive				50		pF
Short Circuit Current Limit	I_{SC}	Output-to-Ground Short		±50		mA
Output Short Circuit Duration					10	sec
GAIN						
Gain Accuracy	$R_G = \frac{10\,k\Omega}{G-1}$	T_A = +25°C				
		R_G = 10 Ω, G = 1000		0.25	1	dB
		R_G = 101 Ω, G = 100		0.20	1	dB
		R_G = 1.1 kΩ, G = 10		0.20	1	dB
		R_G = ∞, G = 1		0.05	0.5	dB
Maximum Gain	G			70		dB

SSM-2017

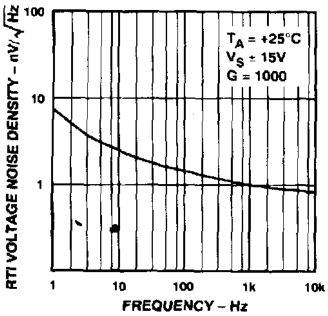


Figure 3. Voltage Noise Density vs. Frequency

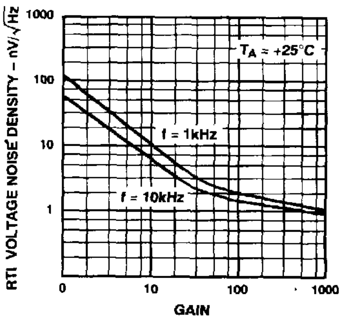


Figure 4. RTI Voltage Noise Density vs. Gain

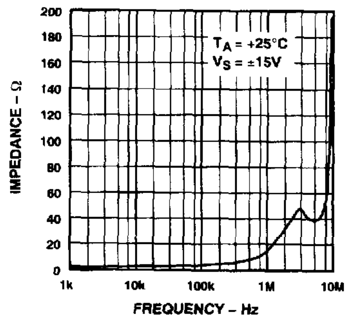


Figure 5. Output Impedance vs. Frequency

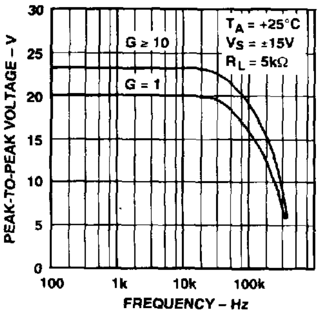


Figure 6. Maximum Output Swing vs. Frequency

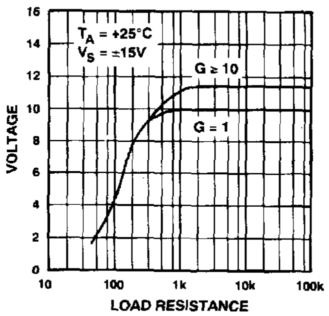


Figure 7. Maximum Output Voltage vs. Load Resistance

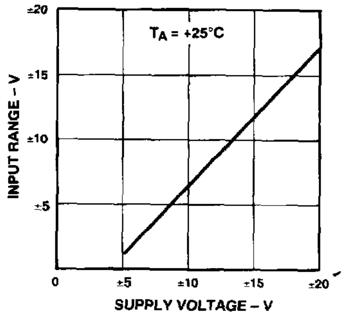


Figure 8. Input Voltage Range vs. Supply Voltage

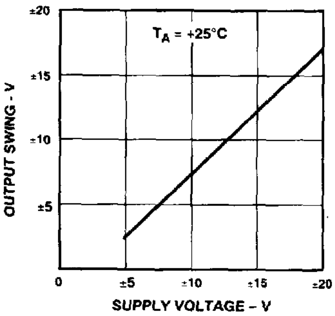


Figure 9. Output Voltage Range vs. Supply Voltage

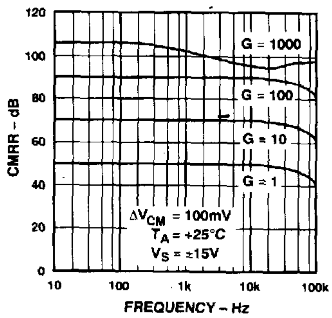


Figure 10. CMRR vs. Frequency

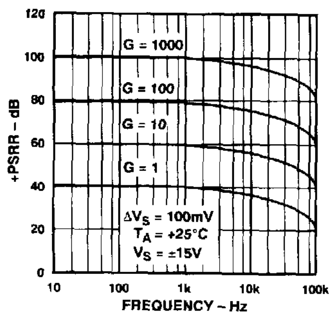


Figure 11. +PSRR vs. Frequency

Typical Performance Characteristics—SSM-2017

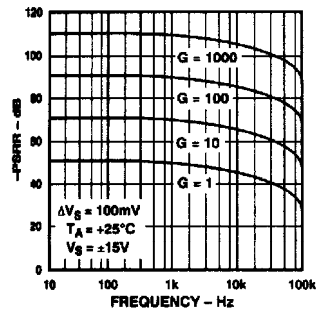


Figure 12. −PSRR vs. Frequency

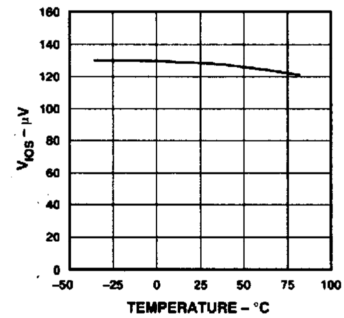


Figure 13. V_{IOS} vs. Temperature

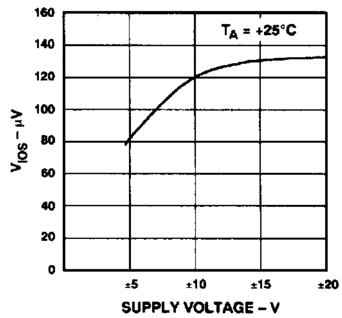


Figure 14. V_{IOS} vs. Supply Voltage

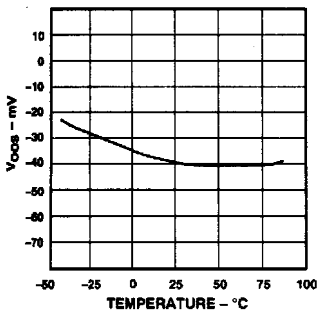


Figure 15. V_{OOS} vs. Temperature

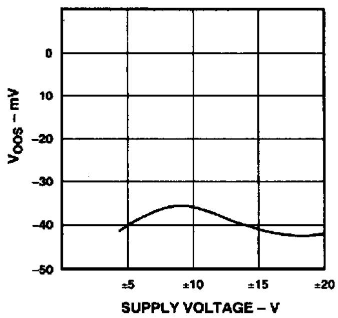


Figure 16. V_{OOS} vs. Supply Voltage

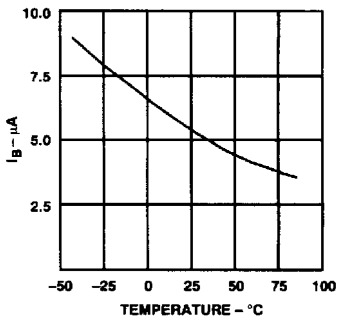


Figure 17. I_B vs. Temperature

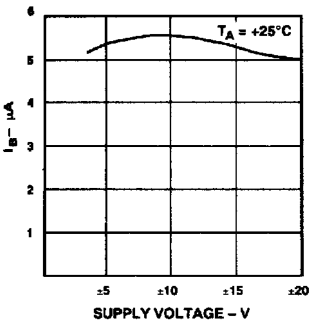


Figure 18. I_B vs. Supply Voltage

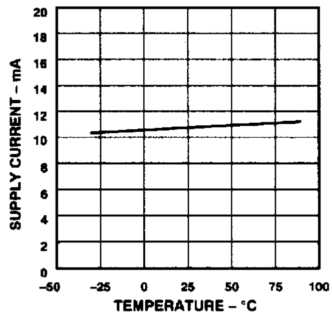


Figure 19. I_{SY} vs. Temperature

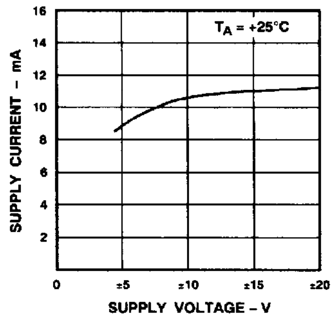
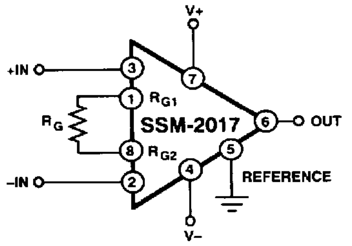


Figure 20. I_{SY} vs.Supply Voltage

SSM-2017—Applications Information



$$G = \frac{V_{OUT}}{(+IN) - (-IN)} = \left(\frac{10k\Omega}{R_G}\right) + 1$$

Basic Circuit Connections

GAIN

The SSM-2017 only requires a single external resistor to set the voltage gain. The voltage gain, G, is:

$$G = \frac{10\ k\Omega}{R_G} + 1$$

and

$$R_G = \frac{10\ k\Omega}{G - 1}$$

For convenience, Table I lists various values of R_G for common gain levels.

Table I. Values of R_G for Various Gain Levels

A_V	dB	R_G
1	0	NC
3.2	10	4.7k
10	20	1.1k
31.3	30	330
100	40	100
314	50	32
1000	60	10

The voltage gain can range from 1 to 3500. A gain set resistor is not required for unity gain applications. Metal-film or wire-wound resistors are recommended for best results.

The total gain accuracy of the SSM-2017 is determined by the tolerance of the external gain set resistor, R_G, combined with the gain equation accuracy of the SSM-2017. Total gain drift combines the mismatch of the external gain set resistor drift with that of the internal resistors (20 ppm/°C typ).

Bandwidth of the SSM-2017 is relatively independent of gain as shown in Figure 21. For a voltage gain of 1000, the SSM-2017 has a small-signal bandwidth of 200 kHz. At unity gain, the bandwidth of the SSM-2017 exceeds 4 MHz.

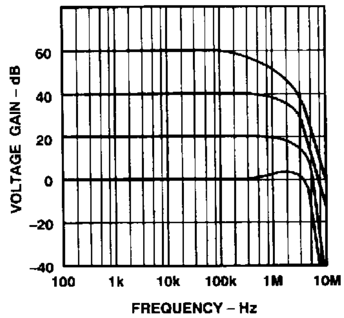


Figure 21. Bandwidth of the SSM-2017 for Various Values of Gain

NOISE PERFORMANCE

The SSM-2017 is a very low noise audio preamplifier exhibiting a typical voltage noise density of only 1 nV/√Hz at 1 kHz. The exceptionally low noise characteristics of the SSM-2017 are in part achieved by operating the input transistors at high collector currents since the voltage noise is inversely proportional to the square root of the collector current. Current noise, however, is directly proportional to the square root of the collector current. As a result, the outstanding voltage noise performance of the SSM-2017 is obtained at the expense of current noise performance. At low preamplifier gains, the effect of the SSM-2017's voltage and current noise is insignificant.

The total noise of an audio preamplifier channel can be calculated by:

$$E_n = \sqrt{e_n^2 + (i_n R_s)^2 + e_t^2}$$

where:

E_n = total input referred noise

e_n = amplifier voltage noise

i_n = amplifier current noise

R_s = source resistance

e_t = source resistance thermal noise.

For a microphone preamplifier, using a typical microphone impedance of 150 Ω the total input referred noise is:

$e_n = 1\ nV/\sqrt{Hz}$ @ 1 kHz, SSM-2017 e_n

$i_n = 2\ pA/\sqrt{Hz}$ @ 1 kHz, SSM-2017 i_n

$R_S = 150\ \Omega$, *microphone source impedance*

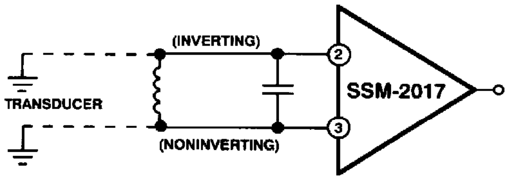
$e_t = 1.6\ nV/\sqrt{Hz}$ @ 1 kHz, *microphone thermal noise*

$E_n = \sqrt{(1\ nV/\sqrt{Hz})^2 + (2\ pA/\sqrt{Hz} \times 150\ \Omega)^2 + (1.6\ nV/\sqrt{Hz})^2} = 1.93\ nV/\sqrt{Hz}$ @ 1 kHz.

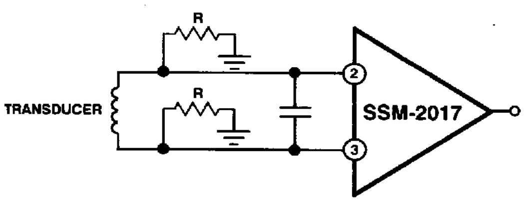
This total noise is extremely low and makes the SSM-2017 virtually transparent to the user.

INPUTS

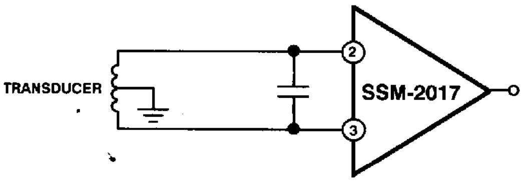
The SSM-2017 has protection diodes across the base emitter junctions of the input transistors. These prevent accidental avalanche breakdown which could seriously degrade noise performance. Additional clamp diodes are also provided to prevent the inputs from being forced too far beyond the supplies.



a. Single Ended



b. Pseudo Differential



c. True Differential

Figure 22. Three Ways of Interfacing Transducers for High Noise Immunity

Although the SSM-2017's inputs are fully floating, care must be exercised to ensure that both inputs have a dc bias connection capable of maintaining them within the input common-mode range. The usual method of achieving this is to ground one side of the transducer as in Figure 22a, but an alternative way is to float the transducer and use two resistors to set the bias point as in Figure 22b. The value of these resistors can be up to 10 kΩ, but they should be kept as small as possible to limit common-mode pickup. Noise contribution by resistors themselves is negligible since it is attenuated by the transducer's impedance. Balanced transducers give the best noise immunity and interface directly as in Figure 22c.

REFERENCE TERMINAL

The output signal is specified with respect to the reference terminal, which is normally connected to analog ground. The reference may also be used for offset correction or level shifting. A reference source resistance will reduce the common-mode rejection by the ratio of 5 kΩ/R_{REF}. If the reference source resistance is 1 Ω, then the CMR will be reduced to 74 dB (5 kΩ/1 Ω = 74 dB).

COMMON-MODE REJECTION

Ideally, a microphone preamplifier responds only to the difference between the two input signals and rejects common-mode voltages and noise. In practice, there is a small change in output voltage when both inputs experience the same common-mode voltage change; the ratio of these voltages is called the common-mode gain. Common-mode rejection (CMR) is the logarithm of the ratio of differential-mode gain to common-mode gain, expressed in dB.

PHANTOM POWERING

A typical phantom microphone powering circuit is shown in Figure 23. Z_1 through Z_4 provide transient overvoltage protection for the SSM-2017 whenever microphones are plugged in or unplugged.

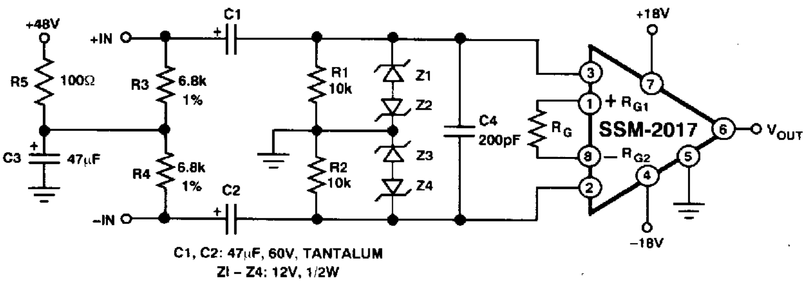


Figure 23. SSM-2017 in Phantom Powered Microphone Circuit

ANALOG DEVICES

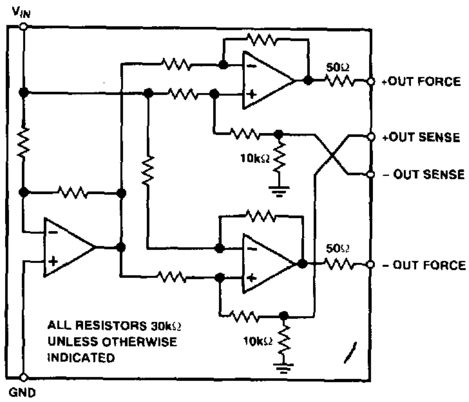
Balanced Line Driver

SSM-2142

FEATURES
Transformer-Like Balanced Output
Drives 10 V RMS Into a 600 Ω Load
Stable When Driving Large Capacitive Loads and Long Cables
Low Distortion
0.006% typ 20 Hz-20 kHz, 10 V RMS into 600 Ω
High Slew Rate
15 V/μs typ
Low Gain Error
(Differential or Single-Ended); 0.7% typ
Outputs Short-Circuit Protected
Available In Space-Saving 8-Pin Mini-DIP Package
Low Cost

APPLICATIONS
Audio Mix Consoles
Distribution Amplifiers
Graphic and Parametric Equalizers
Dynamic Range Processors
Digital Effects Processors
Telecommunications Systems
Industrial Instrumentation
Hi-Fi Equipment

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The SSM-2142 is an integrated differential-output buffer amplifier that converts a single-ended input signal to a balanced output signal pair with high output drive. By utilizing low noise thermally matched thin film resistors and high slew rate amplifiers, the SSM-2142 helps maintain the sonic quality of audio systems by eliminating power line hum, RF interference, voltage drops, and other externally generated noise commonly encountered with long audio cable runs. Excellent rejection of common-mode noise and offset errors is achieved by laser trimming of the onboard resistors, assuring high gain accuracy. The carefully designed output stage of the SSM-2142 is capable of driving difficult loads, yielding low-distortion performance despite extremely long cables or loads as low as 600 Ω, and is stable over a wide range of operating conditions.

Based on a cross-coupled, electronically balanced topology, the SSM-2142 mimics the performance of fully balanced transformer-based solutions for line driving. However, the SSM-2142 maintains lower distortion and occupies much less board space than transformers while achieving comparable common-mode rejection performance with reduced parts count.

The SSM-2142 in tandem with the SSM-2141 differential receiver establishes a complete, reliable solution for driving and receiving audio signals over long cables. The SSM-2141 features an Input Common-Mode Rejection Ratio of 100 dB at 60 Hz. Specifications demonstrating the performance of this typical system are included in the data sheet.

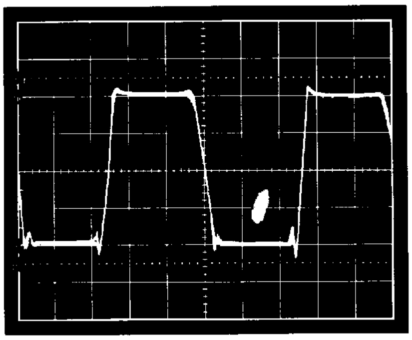


Figure 12. 100 kHz Square Wave Observed at Point B (Differential Mode). V_O = 10 V rms, R1 = R2 = ∞, R_L = 600 Ω

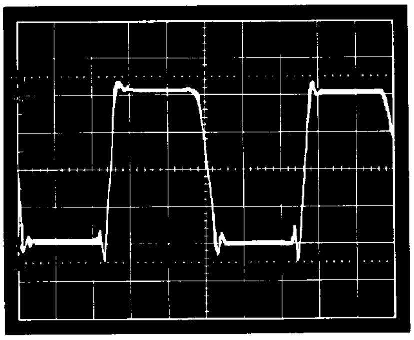


Figure 13. 100 kHz Square Wave at Point B (Differential Mode). V_O = 10 V rms, R1 = R2 = ∞, R_L = 600 Ω, with Series Feedback Capacitors

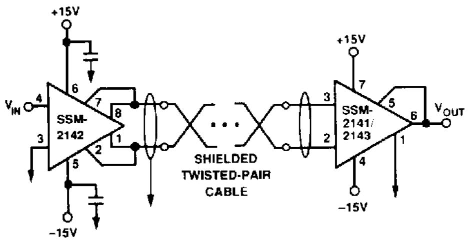


Figure 14. Typical Application of the SSM-2142 and SSM-2141/SSM-2143

APPLICATIONS INFORMATION

The SSM-2142 is designed to provide excellent common-mode rejection, high output drive, and low signal distortion and noise in a balanced line-driving system. The differential output stage consists of twin cross-coupled unity-gain buffer amplifiers with on-chip 50 Ω series damping resistors. The impedances in the output buffer pair are precisely balanced by laser trimming during production. This results in the high gain accuracy needed to obtain good common-mode noise rejection, and excellent separation between the offset error voltages common to the cable pair and the desired differential input signal. As shown in the test circuit, it is suggested that a suitable balanced, high input-impedance differential amplifier such as the SSM-2141 or SSM-2143 be used at the receiving end for best system performance. The SSM-2143 receiver output is configured for a gain of one half following the 6 dB gain of the SSM-2142, in order to maintain an overall system gain of unity.

In applications encountering a large dc offset on the cable or those wishing to ensure optimal rejection performance by avoiding differential offset error sources, dc blocking capacitors may be employed at the sense outputs of the SSM-2142. As shown in the test circuit, these components should present as little impedance as possible to minimize low-frequency errors, such as 10 μF NP (or tantalum if the polarity of the offset is known).

SYSTEM GROUNDING CONSIDERATIONS

Due to ground currents, supply variations, and other factors, the ground potentials of the circuits at each end of a signal cable may not be exactly equal. The primary purpose of a balanced-pair line is to reject this voltage difference, commonly called "longitudinal error." A measure of the ability of the system to reject longitudinal error voltage is output common-mode rejection. In order to obtain the optimal OCMR and noise rejection performance available with the SSM-2142, the user should observe the following precautions:

1. The quality of the differential output is directly dependent upon the accuracy of the input voltage presented to the device. Input voltage errors developed across the impedance of the source must be avoided in order to maintain system performance. The input of the SSM-2142 should be driven directly by an operational amplifier or buffer offering low source impedance and low noise.
2. The ground input should be in close proximity to the single-ended input's source common. Ground offset errors encountered in the source circuitry also impair system performance.
3. Make sure that the SSM-2142 is adequately decoupled with 0.1 μF bypass capacitors located close to each supply pin.
4. Avoid the use of passive circuitry in series with the SSM-2142 outputs. Any reactive difference in the line pair will cause significant imbalances and affect the gain error of the device. Snubber networks or series load resistors are not required to maintain stability in SSM-2142-based systems, even when driving signals over extremely long cables.
5. Efforts should be made to maintain a physical balance in the arrangement of the signal pair wiring. Capacitive differences due to variations in routing or wire length may cause unequal noise pickup between the pair, which will degrade the system OCMR. Shielded twisted-pair cable is the preferred choice in all applications. The shield should not be utilized as a signal conductor. Grounding the shield at one end, near the output common, avoids ground loop currents flowing in the shield which increase noise coupling and longitudinal errors.

SSM-2142

THE CABLE PAIR

The SSM-2142 is capable of driving a 10 V rms signal into 600 Ω and will remain stable despite cable capacitances of up to 0.16 μF in either balanced or single-ended configurations. Low-impedance shielded audio cable such as the standard Belden 8451 or similar is recommended, especially in applications traversing considerable distances. The user is cautioned that the so-called "audiophile" cables may incur four times the capacitance per unit length of the standard industrial-grade product. In situations of extreme load and/or distance, adding a second parallel cable allows the user to trade off half of the total line resistance against a doubling in capacitive load.

SINGLE-ENDED OPERATION

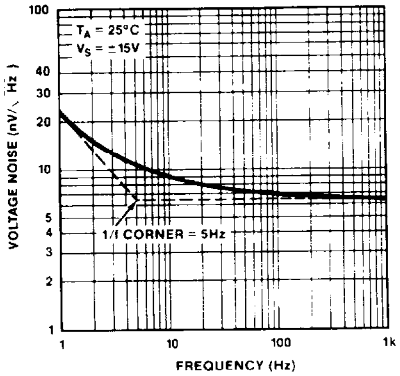
The SSM-2142 is designed to be compatible with existing balanced-pair interface systems. Just as in transformer-based circuits, identical but opposite currents are generated by the output pair which can be ground-referenced if desired and transmitted on a single wire. Single-ended operation requires that the unused side of the output pair be grounded to a solid return path in order to avoid voltage offset errors at the nearby input common. The signal quality obtained in these systems is directly dependent on the quality of the ground at each end of the wire. Also note that in single-ended operation the gain through the device is still 6 dB, and that the SSM-2142 incurs no significant degradation in signal distortion or output drive capability, although the noise rejection inherent in balanced-pair systems is lost.

POWER SUPPLY SEQUENCING

A problem occasionally encountered in the interface system environment involves irregular application of the supplies. The user is cautioned that applying power erratically can inadvertently bias parts of the circuit into a latchup condition. The small geometries of an integrated circuit are easily breached and damaged by short-risetime spikes on a supply line, which usually demonstrate considerable overshoot. The questionable practice of exchanging components or boards while under power can create such an undesirable sequence as well. Possible options which offer improved board-level device protection include: additional bypass capacitors, high-current reverse-biased steering diodes between both supplies and ground, various transient surge suppression devices, and safety grounding connectors.

Likewise, power should be applied to the device before the output is connected to "live" systems which may carry voltages of sufficient magnitude to turn on the output devices of the SSM-2142 and damage the device. In any case, of course, the user must always observe the absolute maximum ratings shown in the specifications.

VOLTAGE NOISE DENSITY vs FREQUENCY



CURRENT NOISE DENSITY vs FREQUENCY

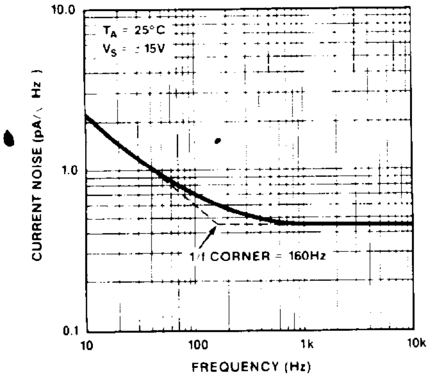


FIGURE 1: Total Noise vs Source Resistance (Including Resistor Noise) at 1kHz

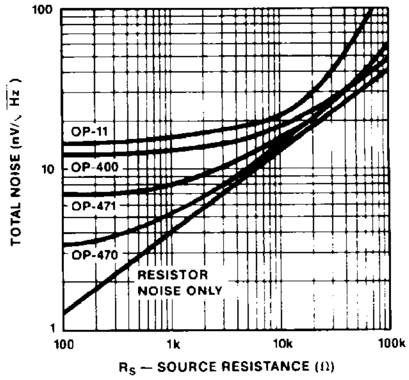
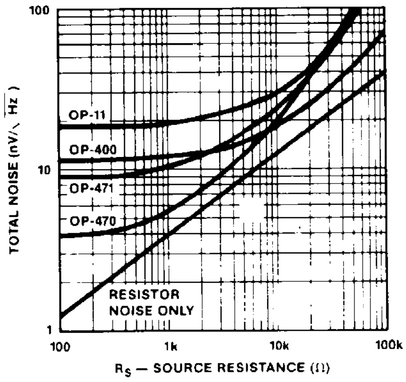
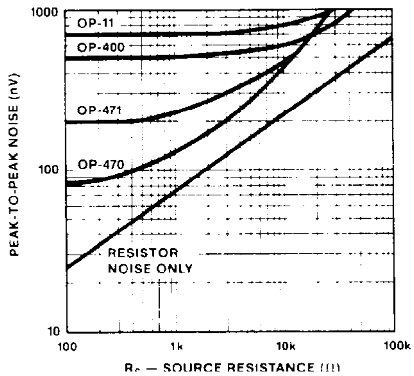


FIGURE 2: Total Noise vs Source Resistance (Including Resistor Noise) at 10Hz





A High Performance Transformer-Coupled Microphone Preamplifier

The SSM-2015 or SSM-2016 low noise differential amplifier is utilized in a transformer-coupled microphone preamplifier. The circuit shown in Figure 1 represents a microphone preamplifier with high performance, wide dynamic range, and ultra low noise. The design features a Jensen transformer-coupled preamplifier circuit with balanced/floating input, 1500Ω input loading, three step input attenuator, phantom microphone powering, and twelve amplifier gain choices. Although the design shown includes a twelve position gain selector, fixed gain applications can utilize the component value calculations and formula provided.

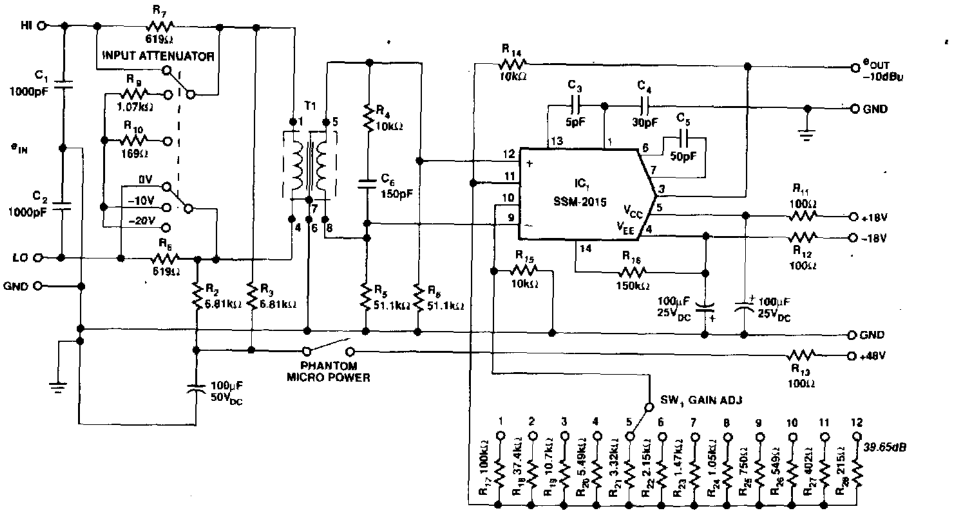
The design provides microphone input loading of 1500Ω. Input loading is capacitive reactive, and at higher input voltage frequencies, the low-pass network and transformer characteristics help attenuate unwanted normal-mode RF and ultrasonic voltages that might be present at the input terminals.

The input circuit contains a three-position input attenuator used to optimize source levels versus amplifier headroom. As usual, it's a compromise of headroom and preamplifier signal-to-noise. The attenuation is 0dB, −10dB, and −20dB while maintaining an input impedance of 1500Ω.

A phantom microphone powering circuit is included for condenser microphones that require 24 to 48 volts DC power.

The common-mode voltage range is limited only by the transformer's primary-to-shield breakdown voltage. Common-mode rejection is a product of the primary-to-secondary isolation and provides detachment of the microphone wiring environment. Although the balanced single-pole low-pass filter at the input terminals provides protection from radio frequency interference, this network, along with the capacitive effect of the primary winding to the grounded shield, plus the phantom powering resistors present a circuit path for external RF voltages to enter the preamplifier's circuit ground. A carefully planned single point (power supply) grounding, and the true balanced and differential input topology of the SSM-2015/2016 amplifier will eliminate unwanted external noise signals.

The network composed of R_4 and C_6 at the transformer secondary serves two functions. It minimizes transformer rising secondary winding signal amplitude with rising input frequency and deters secondary ringing, while helping to prevent amplifier input slewing. The SSM-2015/2016 differential input improves transformer performance substantially as compared with the conventional unbalanced design.



The circuit design incorporates a gain switch with twelve (12) calculated gain settings. The Jensen transformer, model JE-110K-HPC used in this application has a voltage gain of 17.9dB. For an output voltage of −10dBu, the microphone amplifier circuit has an input sensitivity range of −65dBu to −17.5dBu, with a typical output headroom of 33dB. The preamplifier circuit shown is gain adjustable from 9.6dB to 39.6dB in 2.5dB steps.

PMI's SSM-2015/2016 input circuit utilizes two identical low noise bipolar transistors, with access to the emitters, that provide the gain adjustment. The output circuit topology is complementary bipolar producing 6V/µs (2015) and 10V/µs (2016) slew rate into a 2kΩ unbalanced load.

R_G (R_{17} through R_{28}) sets the amplifier gain using the equation:

$$V_G = 3.5 + \left(\frac{20 \times 10^3}{R_G}\right)$$

for R_{14}, and R_{15} = 10.0kΩ.

SW	G_{dB}	*e_{IN}(dB)	R_G	VALUE (Ω)
1	9.6	−37.5	R_{17}	100k
2	12.1	−40.0	R_{18}	37.4k
3	14.6	−42.5	R_{19}	10.7k
4	17.1	−45.0	R_{20}	5.49k
5	19.6	−47.5	R_{21}	3.32k
6	22.1	−50.0	R_{22}	2.15k
7	24.6	−52.5	R_{23}	1.47k
8	27.1	−55.0	R_{24}	1.05k
9	29.6	−57.5	R_{25}	750
10	32.1	−60.0	R_{26}	549
11	34.6	−62.5	R_{27}	402
12	39.6	−65.0	R_{28}	215

*Input attenuator set to the 0dB position.

Unspecified overall circuit gain can be calculated from the equation:

$$G_{dB} = 20 \log\left[3.5 + \left(\frac{20 \times 10^3}{R_G}\right)\right] + 17.9$$

TYPICAL PERFORMANCE

Frequency response versus amplitude is ±0.2dB from 20 to 20,000Hz, and THD + noise is better than 0.03% over gain and frequency range described, with a typical EIN (Equivalent Input Noise) of −127dBu. See Table 1 for detailed performance specifications.

For applications where additional headroom is required, the SSM-2016 should be used. The SSM-2016 can be powered with up to ±36V_{DC} rails and drive 600Ω loads. If ±24V_{DC} rails are used, headroom increases to 35.7dB (typically), while the EIN remains at −127dB. As a consequence of the increased power supply voltage, the SSM-2016 package power dissipation will typically be 600mW with ±24V_{DC} rails (no signal), and will rise to 725mW with worst case signal conditions into 600Ω load.

For ±36V_{DC} power rails, although the headroom increases to 39.3dB, the SSM-2016 will dissipate 1.2 watts with no signal applied, and 1.5 watts worst case signal conditions into 600Ω load. Therefore, IC package cooling should be taken into consideration. Please see the SSM-2016 data sheet for IC pin-out connections and recommended compensation capacitor values. All other circuit component values shown here apply.

The transformer-coupled microphone preamplifier circuit described above demonstrates robust, real-world usage refinements, along with most operational features required by equipment designers to deliver the highest performance. It will handle the most hostile microphone environments without distress to either the circuit or the user.

TABLE 1: Circuit Performance Specifications

Frequency Response (20Hz to 20kHz, −60dBu, 50dB gain)	±0.15dB
THD + Noise (20Hz to 20kHz, −60dBu, 50db gain)	0.045%
IMD (+23dBu, SMPTE 60Hz and 4kHz, 4:1)	0.05%
EIN (Equivalent Input Noise, 150Ω source)	−127dB
Input Impedance (20Hz to 5kHz)	1500Ω
Source Impedance	150Ω
CMR at 1kHz (common-mode rejection at 1kHz)	120dB
CMVR (common-mode voltage range)	±150V_{DC}
Slew Rate (overall circuit)	6V/µs
Gain Range (overall circuit)	17.5dB to 36dB
Output Voltage	
SSM-2015 (±18V_{DC}, 2kΩ load)	+23dBu or 11V_{RMS}
SSM-2016 (±24V_{DC}, 2kΩ load)	+25.7dBu or 15V_{RMS}
Output Headroom (SSM-2015, 2kΩ load, −10dBu nominal)	33dB

Balanced Low Noise Microphone Preamplifier Design

The SSM-2015 differential amplifier is utilized in a transformerless, active-balanced input amplifier. The circuit shown in Figure 1 provides a microphone preamplifier design with excellent performance and low noise. The design features a transformerless preamplifier circuit with true-balanced input, 1500Ω input loading, phantom microphone powering, and high common-mode rejection. The design shown also includes a twelve position gain selector, or for fixed gain usage, component value calculations.

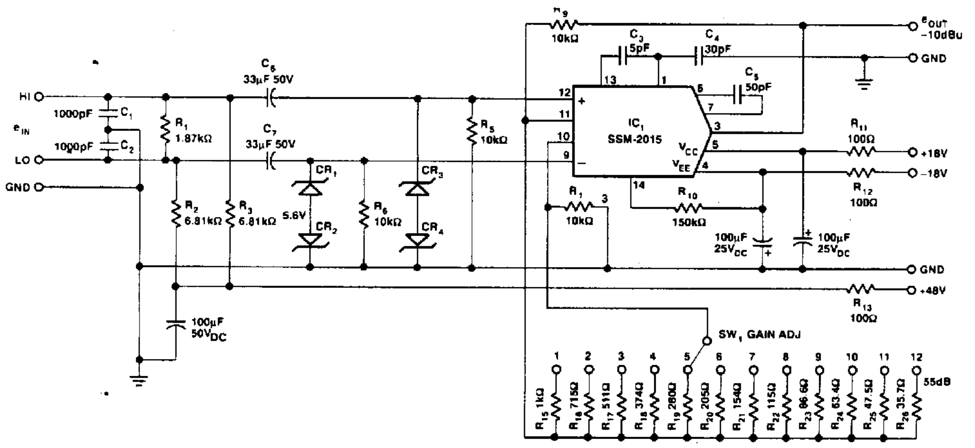
The design includes microphone input loading of 1500Ω, but the load resistor can be changed to accommodate other applications. Input loading is capacitive reactive at higher frequencies to attenuate unwanted RF and ultrasonic voltages at the input terminals.

The phantom microphone powering circuit provides power for condenser microphones that require 24 to 48 volts DC. The zener diodes CR_1, CR_2, CR_3, and CR_4 protect the input transistors of the SSM-2015 when connecting the microphone to the preamplifier circuit.

The common-mode voltage range is ±5.5 volts. Its common-mode rejection is optimized for most applications by the true-balanced and differential input topology of the SSM-2015. A balanced single pole low-pass filter at the input terminals provides protection for the circuit from radio frequency interference and prevents slewing of the SSM-2015 amplifier. The output circuit topology is complementary bipolar producing 6V/µs slew rate, and able to drive a 2kΩ unbalanced load.

The circuit design incorporates a gain switch with twelve (12) calculated gain settings. For an output voltage of −10dBu, the microphone amplifier circuit has an input sensitivity range of −65dBu to −27.5dBu, and an output headroom of 33dB. The overall circuit gain is adjustable from 27.5dB to 55dB in 2.5dB steps.

SW	G_{dB}	e_{IN}(dB)	R_G	VALUE (Ω)
1	27.5	−37.5	R_{15}	1.00k
2	30	−40	R_{16}	715
3	32.5	−42.5	R_{17}	511
4	35	−45	R_{18}	374
5	37.5	−47.5	R_{19}	280
6	40	−50	R_{20}	205
7	42.5	−52.5	R_{21}	154
8	45	−55	R_{22}	115
9	47.5	−57.5	R_{23}	86.6
10	50	−60	R_{24}	63.4
11	52.5	−62.5	R_{25}	47.5
12	55	−65	R_{26}	35.7



SSM-2015 input circuitry utilizes two identical low noise bipolar transistors, with access to the emitters that provide the gain adjustment. R_G (R_{15} through R_{26}) sets the amplifier's gain using the equation:

$$\text{Gain} = 3.5 + \left(\frac{20 \times 10^3}{R_G}\right) \quad \text{for } R_9, \& R_{13} = 10.0k\Omega$$

Unspecified gain can be calculated from the equation:

$$\text{Gain}_{dB} = 20 \log \left[3.5 + \left(\frac{20 \times 10^3}{R_G}\right)\right]$$

The frequency response amplitude is ±0.1dB from 20 to 20,000Hz, and THD + noise of better than 0.03% over the gain range described with a typical EIN (Equivalent Input Noise) of –124dBu.

The transformerless microphone preamplifier circuit described above demonstrates real-world usage refinements and includes most operational features required by equipment designers.

TABLE 1: Circuit Performance Specifications

Frequency Response (20Hz to 20kHz)	±0.1dB
THD + Noise (@ +23dBu, 20Hz to 20kHz)	0.03%
IMD (@ +23dBu, SMPTE 60Hz & 4kHz, 4:1)	0.05%
EIN (Equivalent Input Noise, 150Ω source)	–124dB
CMR (Common-Mode Rejection at 1kHz)	105dB
Slew Rate	6V/µs
Output Voltage (2kΩ load)	+23dBu or $11V_{RMS}$
Output Headroom (2kΩ load, –10dBu nominal)	33dB

ANALOG DEVICES

Audio Dual Matched NPN Transistor

SSM-2210

FEATURES

- **Very Low Voltage Noise .... @ 100Hz, 1nV/√Hz MAX**
- **Excellent Current Gain Match .... 0.5% TYP**
- **Tight V_{BE} Match (V_{OS}) .... 200µV MAX**
- **Outstanding Offset Voltage Drift .... 0.03µV/°C TYP**
- **High Gain-Bandwidth Product .... 200MHz TYP**
- **Low Cost**
- **Direct Replacement For LM394BN/CN**

ORDERING INFORMATION †

PACKAGE		OPERATING TEMPERATURE RANGE
PLASTIC 8-PIN	SO 8-PIN	
SSM2210P	SSM2210S†	XIND*

* XIND = –40°C to +85°C
† For availability on SO package, contact your local sales office.

GENERAL DESCRIPTION

The SSM-2210 is a dual NPN matched transistor pair specifically designed to meet the requirements of ultra-low noise audio systems.

With its extremely low input base spreading resistance (rbb' is typically 28Ω), and high current gain (h_{FE} typically exceeds 600 @ I_C = 1mA), systems implementing the SSM-2210 can achieve outstanding signal-to-noise ratios. This will result in superior performance compared to systems incorporating commercially available monolithic amplifiers.

The equivalent input voltage noise of the SSM-2210 is typically only 0.8nV/√Hz over the entire audio bandwidth of 20Hz to 20KHz.

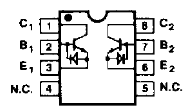
Excellent matching of the current gain (Δh_{FE}) to about 0.5% and low V_{OS} of less than 50µV (typical) make it ideal for symmetrically balanced designs which reduce high order amplifier harmonic distortion.

Stability of the matching parameters is guaranteed by protection diodes across the base-emitter junction. These diodes prevent degradation of Beta and matching characteristics due to reverse biasing of the base-emitter junction.

The SSM-2210 is also an ideal choice for accurate and reliable current biasing and mirroring circuits. Furthermore, since a current mirror's accuracy degrades exponentially with mismatches of V_{BE}'s between transistor pairs, the low V_{OS} of the SSM-2210 will preclude offset trimming in most circuit applications.

The SSM-2210 is offered in an 8-pin epoxy DIP and 8-pin SO, its performance and characteristics are guaranteed over the extended industrial temperature range of –40°C to +85°C.

PIN CONNECTIONS



8-PIN PLASTIC DIP (P-Suffix)

8-PIN SO (S-Suffix)

ABSOLUTE MAXIMUM RATINGS

Collector Current (I_C) 20mA
Emitter Current (I_E) 20mA
Collector-Collector Voltage (BV_{CC}) 40V
Collector-Base Voltage (BV_{CBO}) 40V
Collector-Emitter Voltage (BV_{CEO}) 40V
Emitter-Emitter Voltage (BV_{EE}) 40V
Operating Temperature Range .... –40°C to +85°C
Storage Temperature .... –65°C to +125°C
Junction Temperature .... –65°C to +150°C
Lead Temperature (Soldering, 60 sec) .... +300°C

PACKAGE TYPE	Θ_{JA} (NOTE 1)	Θ_{JC}	UNITS
8-Pin Plastic DIP (P)	110	50	°C/W
8-Pin SO (S)	160	44	°C/W

NOTE:
1. Θ_{JA} is specified for worst case mounting conditions, i.e., Θ_{JA} is specified for device in socket for P-DIP packages; Θ_{JA} is specified for device soldered to printed circuit board for SO packages.

SSM-2210

ELECTRICAL CHARACTERISTICS at V_{CB} = 15V, I_C = 10μA, T_A = 25°C, unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	SSM-2210 MIN	SSM-2210 TYP	SSM-2210 MAX	UNITS
Current Gain	h_{FE}	I_C = 1mA (Note 1) I_C = 10μA	300 200	605 550	– –	
Current Gain Match	Δh_{FE}	10μA ≤ I_C ≤ 1mA (Note 2)	–	0.5	5	%
Noise Voltage Density	e_n	I_C = 1mA, V_{CB} = 0 (Note 3) f_o = 10Hz f_o = 100Hz f_o = 1kHz f_o = 10kHz	 – – – –	 1.6 0.9 0.85 0.85	 2 1 1 1	nV/√Hz
Offset Voltage	V_{OS}	V_{CB} = 0 I_C = 1mA	–	10	200	μV
Offset Voltage Change vs V_{CB}	$\Delta V_{OS}/\Delta V_{CB}$	0 ≤ V_{CB} ≤ V_{MAX} (Note 4) 1μA ≤ I_C ≤ 1mA (Note 5)	–	10	50	μV
Offset Voltage Change vs Collector Current	$\Delta V_{OS}/\Delta I_C$	V_{CB} = 0V 1μA ≤ I_C ≤ 1mA (Note 5)	–	5	70	μV
Breakdown Voltage	BV_{CEO}		40	–	–	V
Gain-Bandwidth Product	f_T	I_C = 10mA, V_{CE} = 10V	–	200	–	MHz
Collector-Base Leakage Current	I_{CBO}	V_{CB} = V_{MAX}	–	25	500	pA
Collector-Collector Leakage Current	I_{CC}	V_{CC} = V_{MAX} (Notes 6, 7)	–	35	500	pA
Collector-Emitter Leakage Current	I_{CES}	V_{CE} = V_{MAX} (Notes 6, 7) V_{BE} = 0	–	35	500	pA
Input Bias Current	I_B	I_C = 10μA	–	–	50	nA
Input Offset Current	I_{OS}	I_C = 10μA	–	–	6.2	nA
Collector Saturation Voltage	$V_{CE(SAT)}$	I_C = 1mA I_B = 100μA	–	0.05	0.2	V
Output Capacitance	C_{OB}	V_{CB} = 15V, I_E = 0	–	23	–	pF
Bulk Resistance	r_{BE}	10μA ≤ I_C ≤ 10mA (Note 6)	–	0.3	1.6	Ω
Collector-Collector Capacitance	C_{CC}	V_{CC} = 0	–	35	–	pF

NOTES:

1. Current gain is guaranteed with Collector-Base Voltage (V_{CB}) swept from 0 to V_{MAX} at the indicated collector currents.
2. Current Gain Match (Δh_{FE}) is defined as:

$$\Delta h_{FE} = \frac{100(\Delta I_B)(h_{FE}min)}{I_C}$$

3. Noise Voltage Density is guaranteed, but not 100% tested.
4. This is the maximum change in V_{OS} as V_{CB} is swept from 0V to 40V.
5. Measured at I_C = 10μA and guaranteed by design over the specified range of I_C.
6. Guaranteed by design.
7. I_{CC} and I_{CES} are verified by measurement of I_{CBO}.

SSM-2210

ELECTRICAL CHARACTERISTICS at V_{CB} = 15V, –40°C ≤ T_A ≤ +85°C, unless otherwise noted.

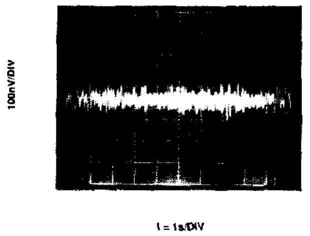
PARAMETER	SYMBOL	CONDITIONS	SSM-2210 MIN	TYP	MAX	UNITS
Current Gain	h_{FE}	I_C = 1mA (Note 1) I_C = 10µA	300 200	– –	– –	
Offset Voltage	V_{OS}	V_{CB} = 0 I_C = 1mA	–	–	220	µV
Average Offset Voltage Drift	TCV_{OS}	10µA ≤ I_C ≤ 1mA, 0 ≤ V_{CB} ≤ V_{MAX} (Note 2) V_{OS} Trimmed to Zero (Note 3)	– –	0.08 0.03	1 0.3	µV/°C
Input Bias Current	I_B	I_C = 10µA	–	–	50	nA
Input Offset Current	I_{OS}	I_C = 10µA	–	–	13	nA
Input Offset Current Drift	TCI_{OS}	I_C = 10µA (Note 4)	–	40	150	pA/°C
Collector-Base Leakage Current	I_{CBO}	V_{CB} = V_{MAX}	–	3	–	nA
Collector-Emitter Leakage Current	I_{CES}	V_{CE} = V_{MAX}, V_{BE} = 0	–	4	–	nA
Collector-Collector Leakage Current	I_{CC}	V_{CC} = V_{MAX}	–	4	–	nA

NOTES:

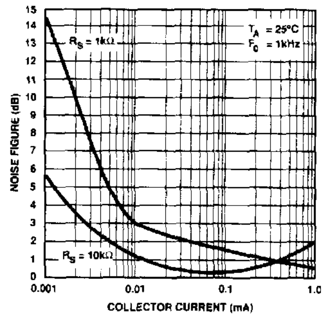
1. Current gain is guaranteed with Collector-Base Voltage (V_{CB}) swept from 0 to V_{MAX} at the indicated collector current.
2. Guaranteed by V_{OS} test ($TCV_{OS} \approx \frac{V_{OS}}{T} \ll V_{BE}$), T = 298K for T_A = 25°C.
3. The initial zero offset voltage is established by adjusting the ratio of I_{C1} to I_{C2} at T_A = 25°C. This ratio must be held to 0.003% over the entire temperature range. Measurements are taken at the temperature extremes and 25°C.
4. Guaranteed by design.

TYPICAL PERFORMANCE CHARACTERISTICS

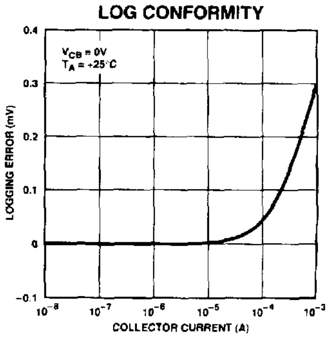
LOW FREQUENCY NOISE (0.1 Hz TO 10 Hz)



NOISE FIGURE vs COLLECTOR CURRENT



EMITTER-BASE LOG CONFORMITY



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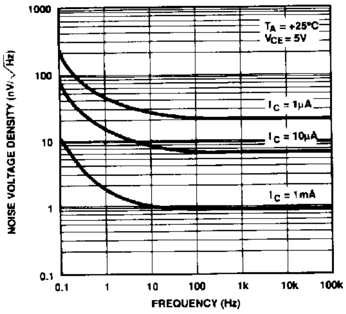
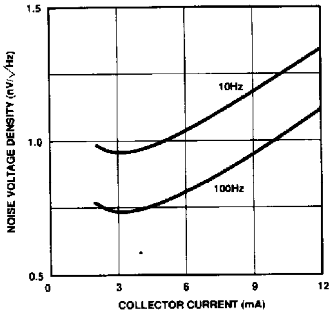
TYPICAL PERFORMANCE CHARACTERISTICS

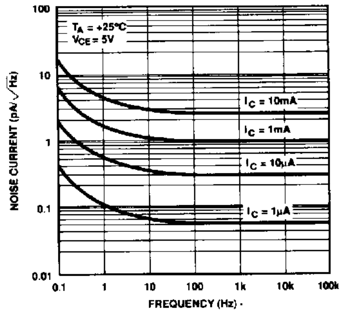
NOISE VOLTAGE DENSITY vs FREQUENCY



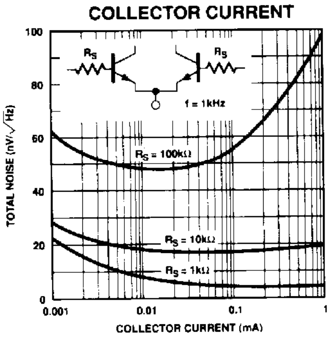
NOISE VOLTAGE DENSITY vs COLLECTOR CURRENT



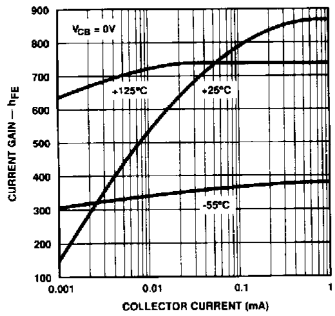
NOISE CURRENT DENSITY vs FREQUENCY



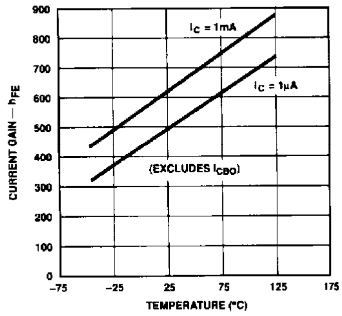
TOTAL NOISE vs COLLECTOR CURRENT



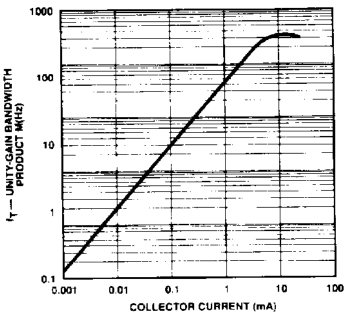
CURRENT GAIN vs COLLECTOR CURRENT



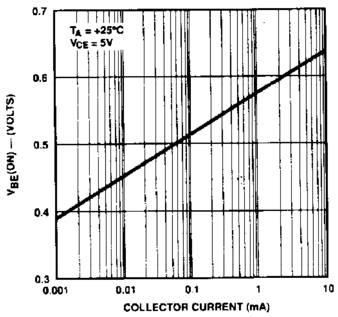
CURRENT GAIN vs TEMPERATURE



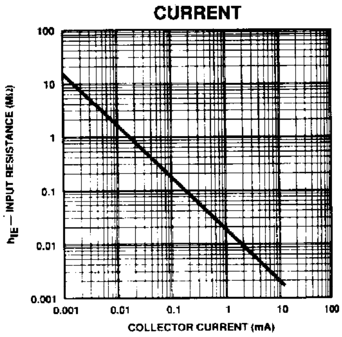
GAIN BANDWIDTH vs COLLECTOR CURRENT



BASE-EMITTER-ON-VOLTAGE vs COLLECTOR CURRENT



SMALL-SIGNAL INPUT RESISTANCE vs COLLECTOR CURRENT



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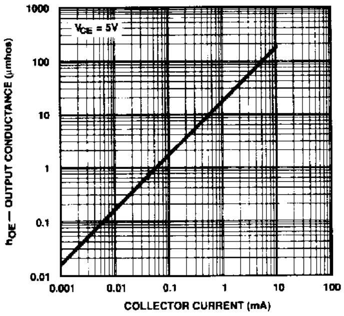
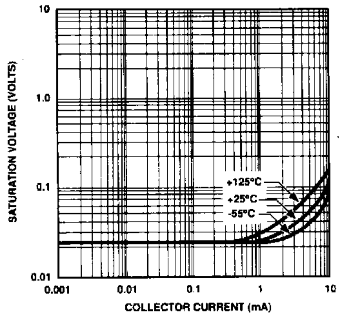
TYPICAL PERFORMANCE CHARACTERISTICS *Continued*

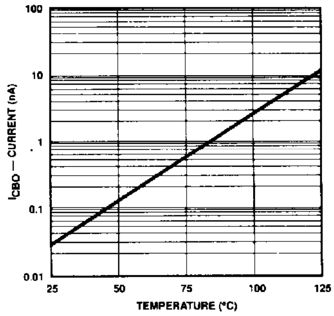
SMALL-SIGNAL OUTPUT CONDUCTANCE vs COLLECTOR CURRENT



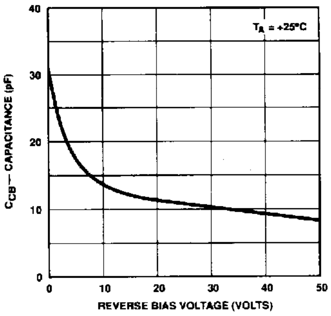
SATURATION VOLTAGE vs COLLECTOR CURRENT



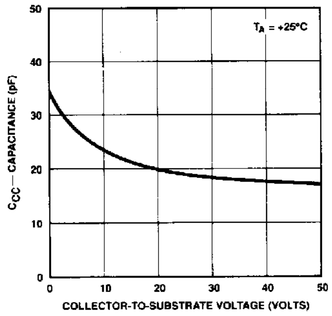
COLLECTOR-TO-BASE LEAKAGE vs TEMPERATURE



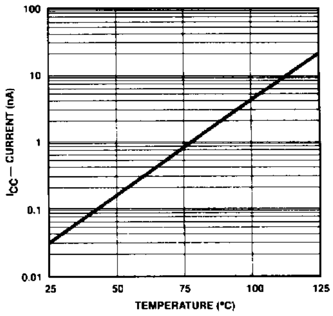
COLLECTOR-BASE CAPACITANCE vs REVERSE BIAS VOLTAGE



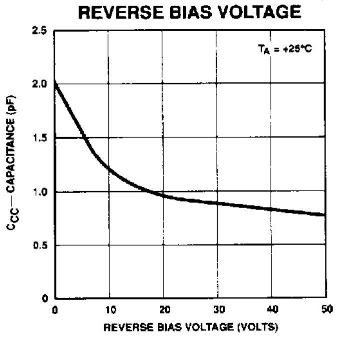
COLLECTOR-TO-COLLECTOR CAPACITANCE vs COLLECTOR-TO-SUBSTRATE VOLTAGE



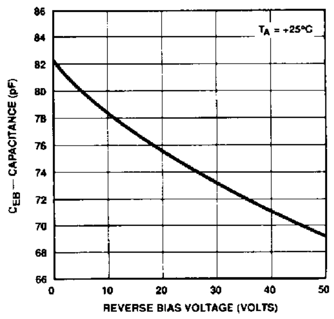
COLLECTOR-TO-COLLECTOR LEAKAGE vs TEMPERATURE



COLLECTOR-TO-COLLECTOR CAPACITANCE vs REVERSE BIAS VOLTAGE



EMITTER-BASE CAPACITANCE vs REVERSE BIAS VOLTAGE



SSM-2210

500pV/√Hz AMPLIFIER

In situations where low output, low-impedance transducers are used, amplifiers must have very low voltage noise to maintain a good signal-to-noise ratio. The design presented in this application is an operational amplifier with only 500pV/√Hz of broadband noise. The front end uses SSM-2210 low-noise dual transistors to achieve this exceptional performance. The op amp has superb DC specifications compatible with high-precision transducer requirements, and AC specifications suitable for professional audio work.

PRINCIPLE OF OPERATION

The design configuration in Figure 6 uses an OP-27 op amp (already a low-noise design) preceded by an amplifier consisting of three parallel-connected SSM-2210 dual transistors. Base spreading resistance (rbb) generates thermal noise which is reduced by a factor of √3 when the input transistors are parallel connected. Schottky noise, the other major noise-generating mechanism, is minimized by using a relatively high collector current (1mA per device). High current ensures a low dynamic emitter resistance, but does increase the base current and its associated current noise. Higher current noise is relatively unimportant when low-impedance transducers are used.

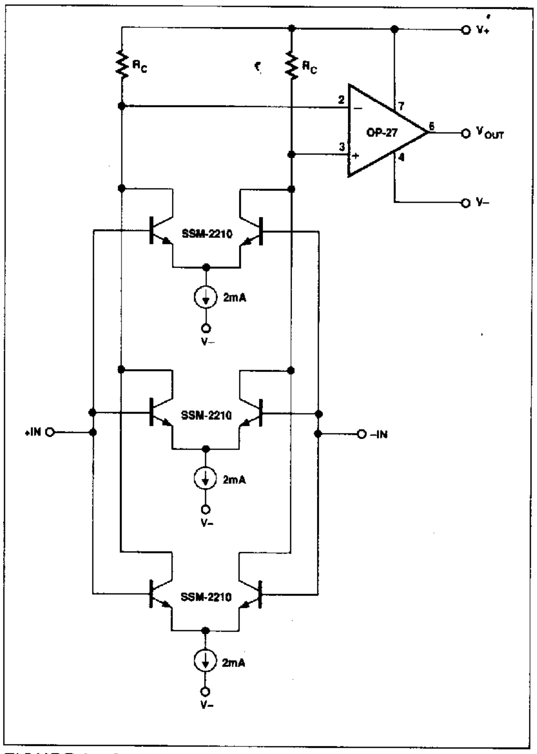


FIGURE 6: *Simplified Schematic*

SSM-2210

CIRCUIT DESCRIPTION

The detailed circuit is shown in Figure 7. A total input-stage emitter current of 6mA is provided by Q_4. The transistor acts as a true current source to provide the highest possible common-mode rejection. R_1, R_2, and R_3 ensure that this current splits equally among the three input pairs. The constant current in Q_4 is set by using the forward voltage of a GaAsP light-emitting diode as a reference. The difference between this voltage and the base-emitter voltage of a silicon transistor is predictable and constant (to within a few percent) over the military temperature range. The voltage difference, approximately 1V, is impressed across the emitter resistor R_{12} which produces a temperature-stable emitter current.

R_6 and C_1 provide phase compensation for the amplifier and are sufficient to ensure stability at gains of ten and above.

R_7 is an input offset trim that provides approximately ±300µV trim range. The very low drift characteristics of the SSM-2210 make it possible to obtain drifts of less than 0.1µV/°C when the offset is nulled close to zero. If this trim is not required, the R_4, R_7, and R_8 network should be omitted and R_5/R_9 connected directly to V+.

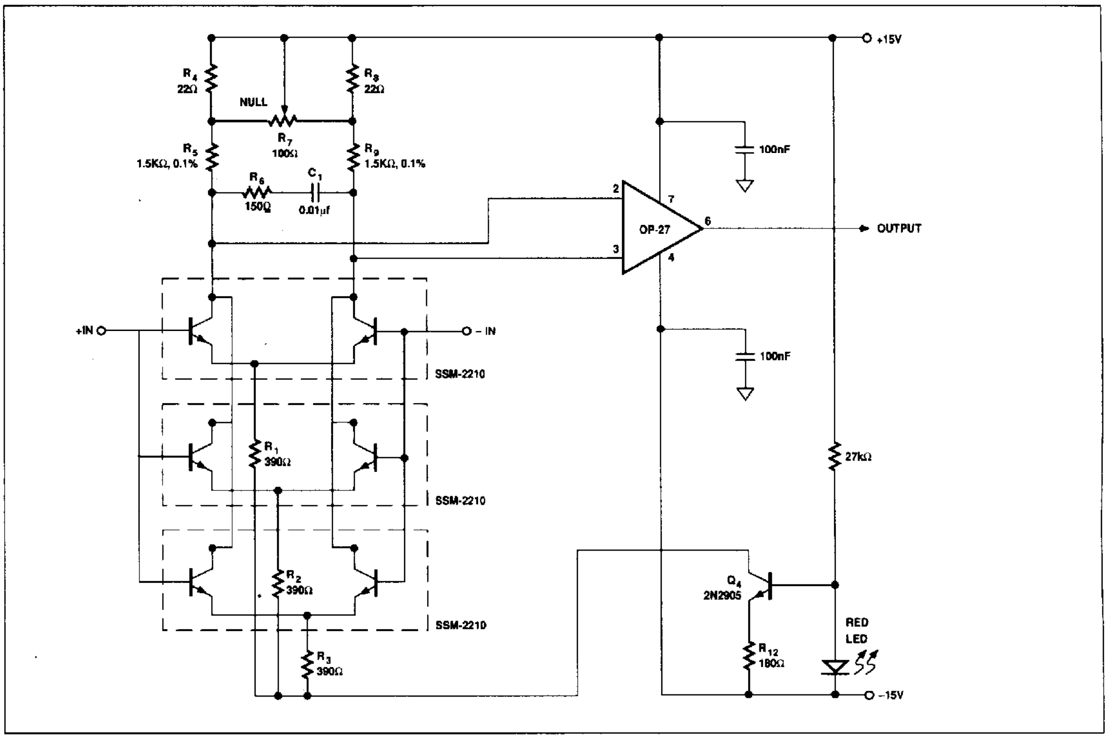


FIGURE 7: *Complete Amplifier Schematic*

SSM-2210

AMPLIFIER PERFORMANCE

The measured performance of the op amp is summarized in Table 2. Figure 8 shows the broadband noise spectrum which is flat at about 500pV/√Hz. Figure 9 shows the low-frequency spectrum which illustrates the low 1/f noise corner at 1.5Hz. The low-frequency characteristic in the time domain from 0.1Hz to 10Hz is shown in Figure 10; peak-to-peak amplitude is less than 40nV.

TABLE 2: Measured Performance of the Op Amp

Input Noise Voltage Density at 1kHz		500pV/√Hz
Input Noise Voltage from 0.1Hz to 10Hz		$40nV_{p\text{-}p}$
Input Noise Current at 1kHz		1.5pA/√Hz
Gain-Bandwidth	G = 10	3MHz
	G = 100	600kHz
	G = 1000	150kHz
Slew Rate		2V/µs
Open-Loop Gain		3×10^7
Common-Mode Rejection		130dB
Input Bias Current		3µA
Supply Current		10mA
Nulled TCV_{OS}		0.1µV/°C Max
T.H.D. at 1kHz	G = 1000	0.002%

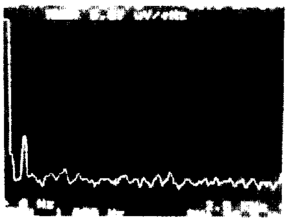


FIGURE 8: *Spectrum Analyzer Display – Broadband*

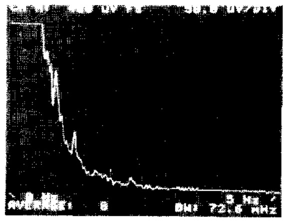


FIGURE 9: *Spectrum Analyzer Display – Low Frequency*

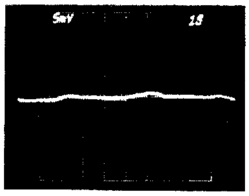
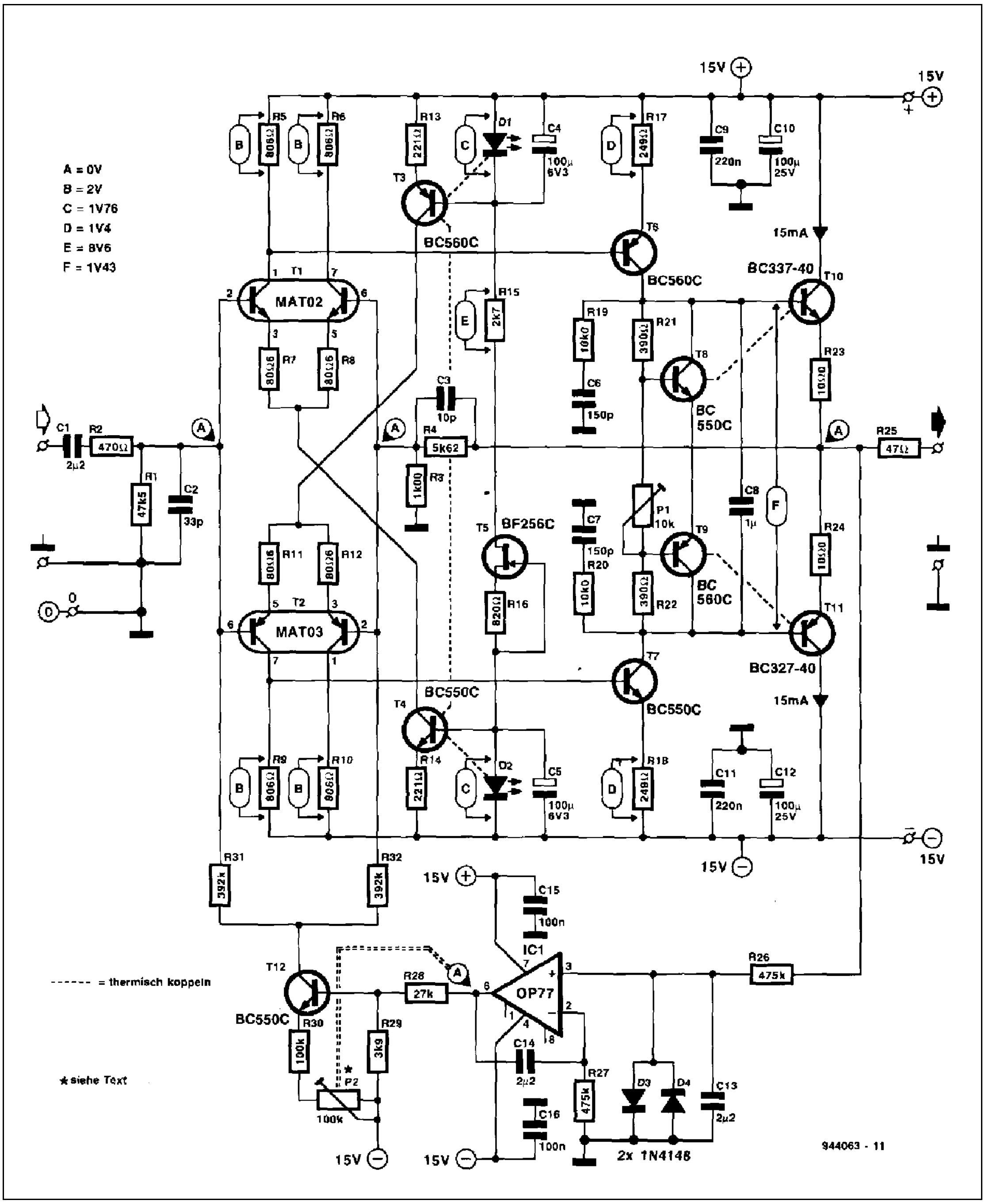


FIGURE 10: *Oscilloscope Display*

CONCLUSION

Using SSM-2210 matched transistor pairs operating at a high current level, it is possible to construct a high-performance, low-noise operational amplifier. The circuit uses a minimum of components and achieves performance levels exceeding monolithic amplifiers.

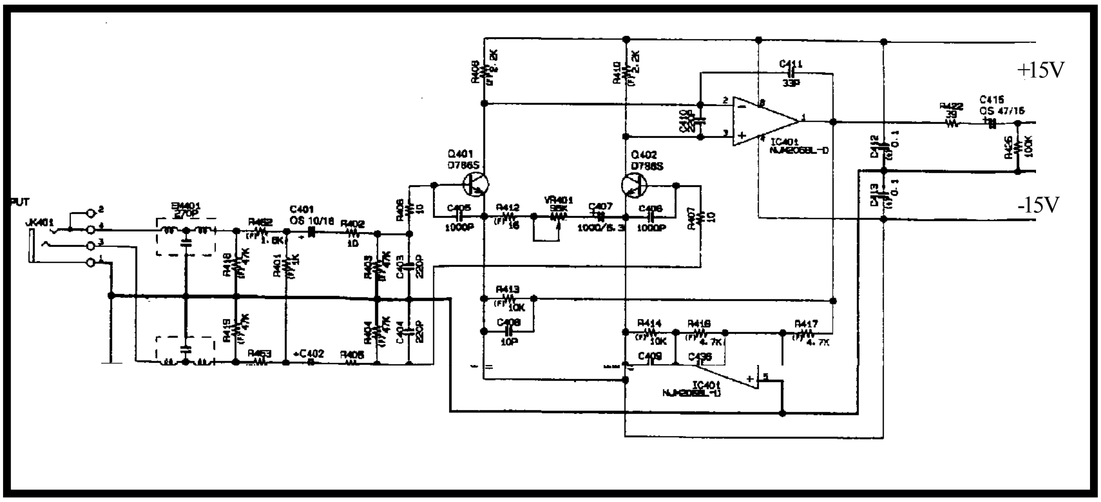
diskret aufgebauter OpAmp



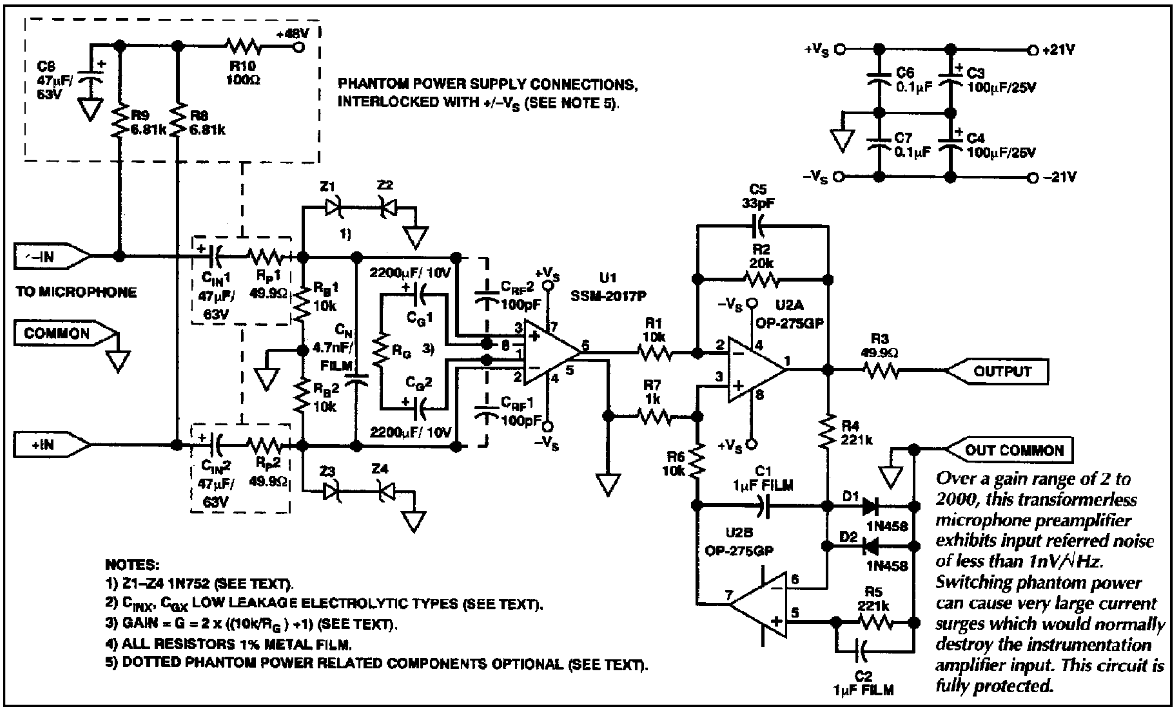
Technische Daten bei 1Veff an 47 kOhm

THD 1kHz <0.00005% (-127 dB) / 20kHz <0.0004% (-108 dB) / 20 Hz - 22 kHz <0.0012% (-95 dB)
Signal to noise (22 Hz - 22 kHz) >104 dB
slew rate 200V/us
Eingangsimpedanz 47 kOhm / Empfindlichkeit 150 mV / max. Ausgagsspannung 9Veff

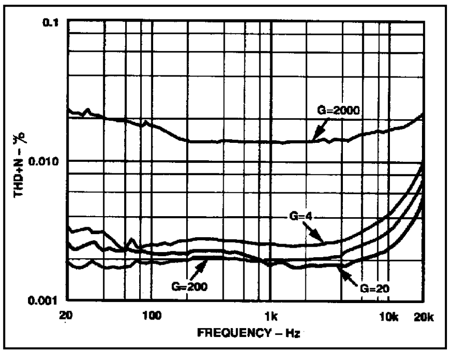
Mikrofonverstärker Mischpult von Akai



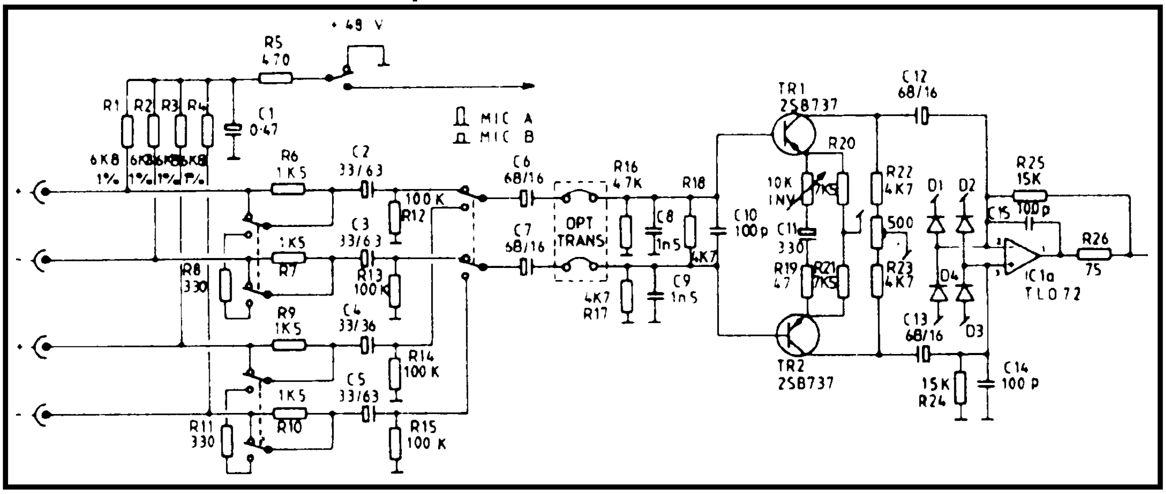
Application mit SSM2017



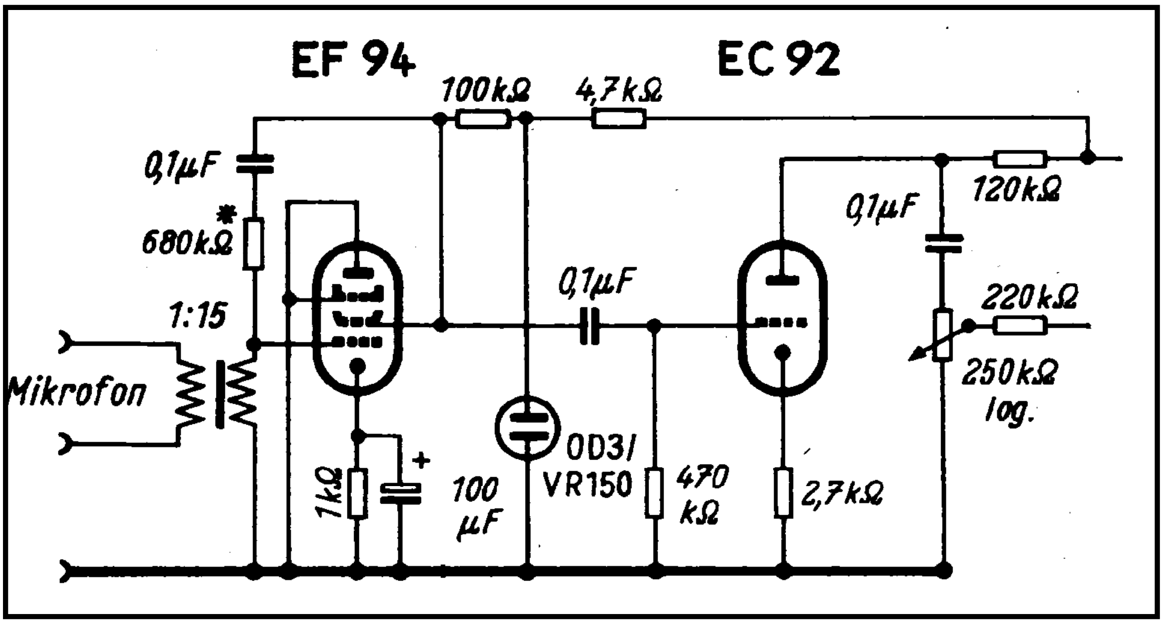
Over a gain range of 2 to 2000, this transformerless microphone preamplifier exhibits input referred noise of less than 1nV/√Hz. Switching phantom power can cause very large current surges which would normally destroy the instrumentation amplifier input. This circuit is fully protected.



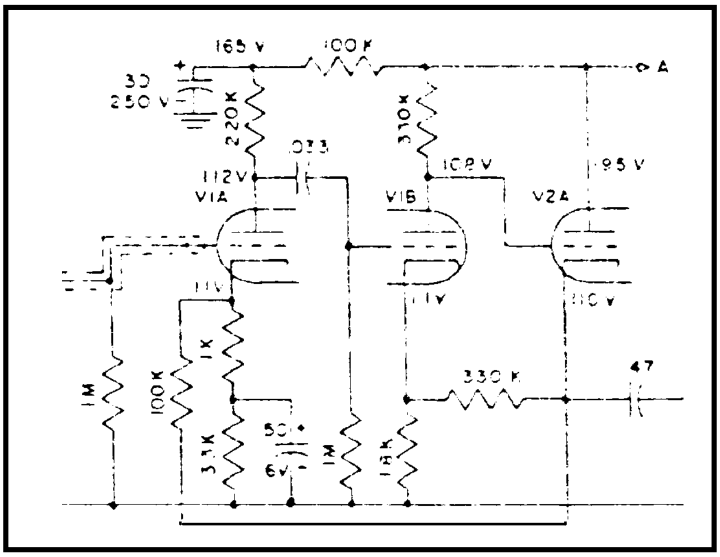
Mikrofonverstärker DDA-Mischpult



Mikrofonverstärker von 1961

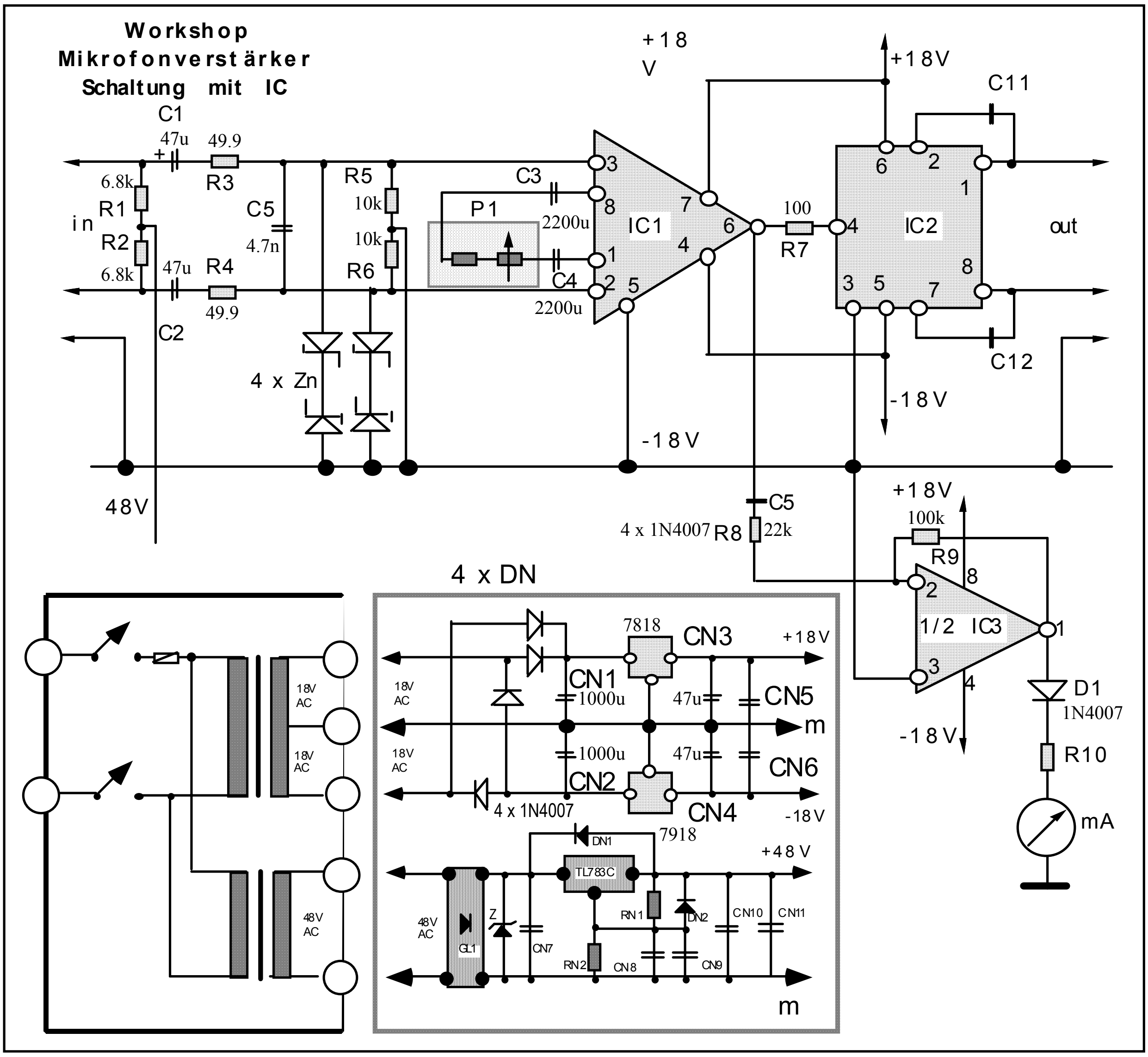


Eingangsstufe McIntosh

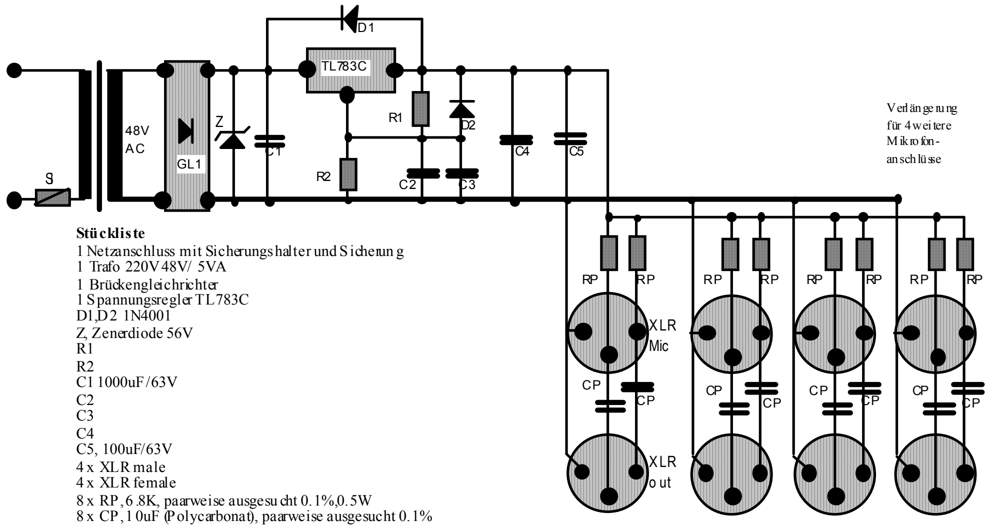


3. Projekte

3.1 Mikrofonverstärker



3.2 Phantomspeisung



Stückliste
1 Netzanschluss mit Sicherungshalter und Sicherung
1 Trafo 220V 48V/ 5VA
1 Brückengleichrichter
1 Spannungsregler TL783C
D1,D2 1N4001
Z, Zenerdiode 56V
R1
R2
C1 1000uF/63V
C2
C3
C4
C5, 100uF/63V
4 x XLR male
4 x XLR female
8 x RP, 6.8K, paarweise ausgesucht 0.1%,0.5W
8 x CP, 10uF (Polycarbonat), paarweise ausgesucht 0.1%

Gehäuse Jäger 9642.61 spezial
4 x Distanzbolzen 10mm

3.3 Röhren-Vorverstärker, mögliche Schaltungen

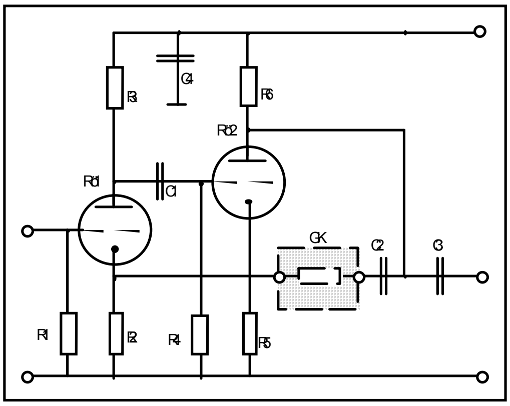


Bild 1 Grundschaltung

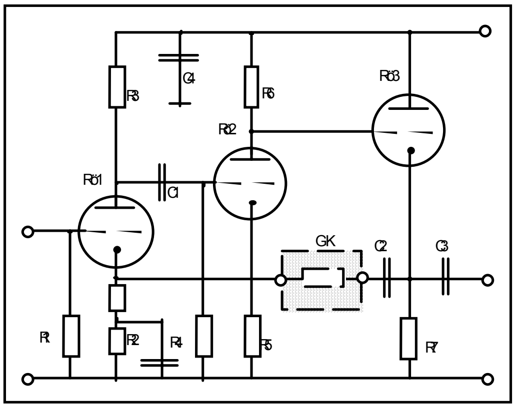


Bild 2 Grundschaltung, ergänzt mit Katodenfolger

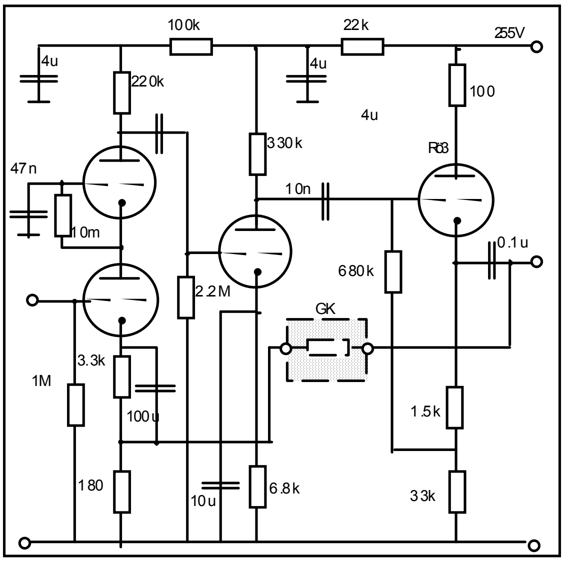


Bild 3 Kaskodenschaltung am Eingang

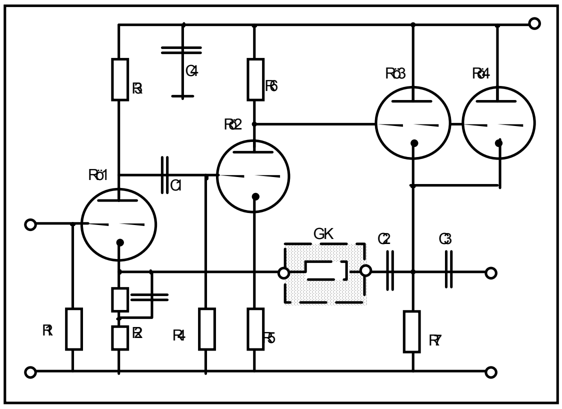


Bild 4 Grundschaltung mit niederohmigem Ausgang

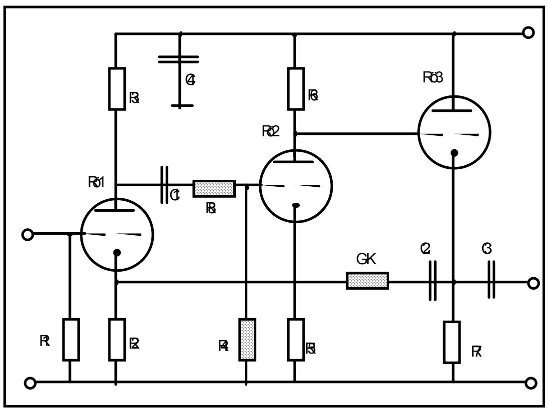


Bild 5 klirrfaktor-optimierte Schaltung

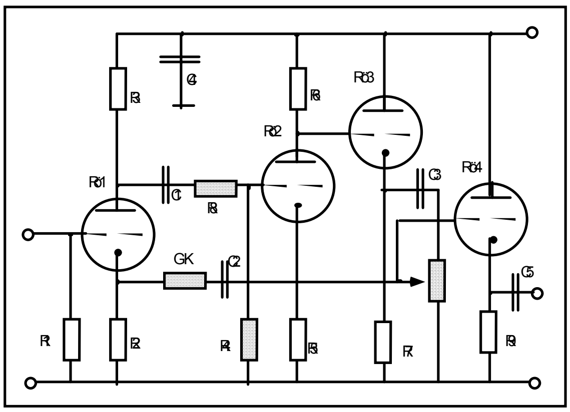


Bild 6 reine Effektschaltung mit konst. Verstärkung

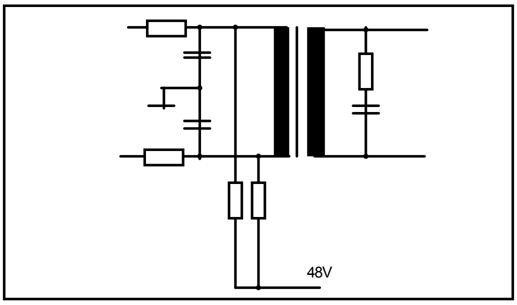


Bild 7 Uebertrager- Eingangsschaltung

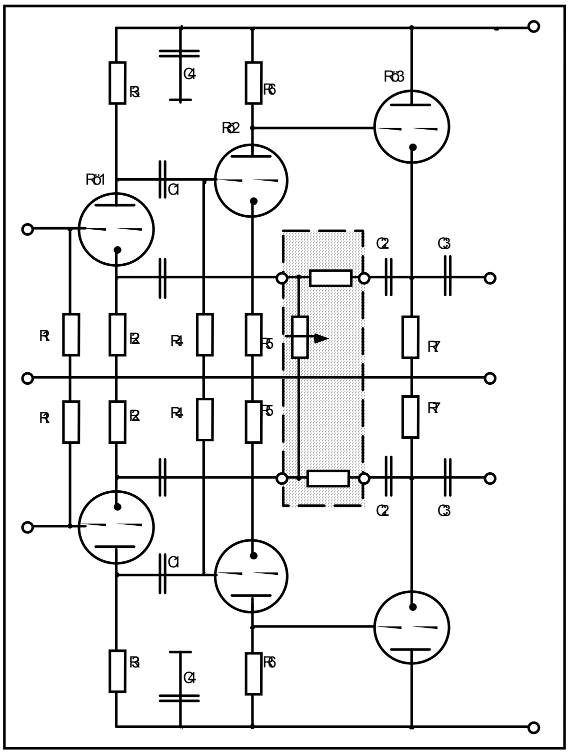


Bild 8 symmetrischer Spannungsverstärker

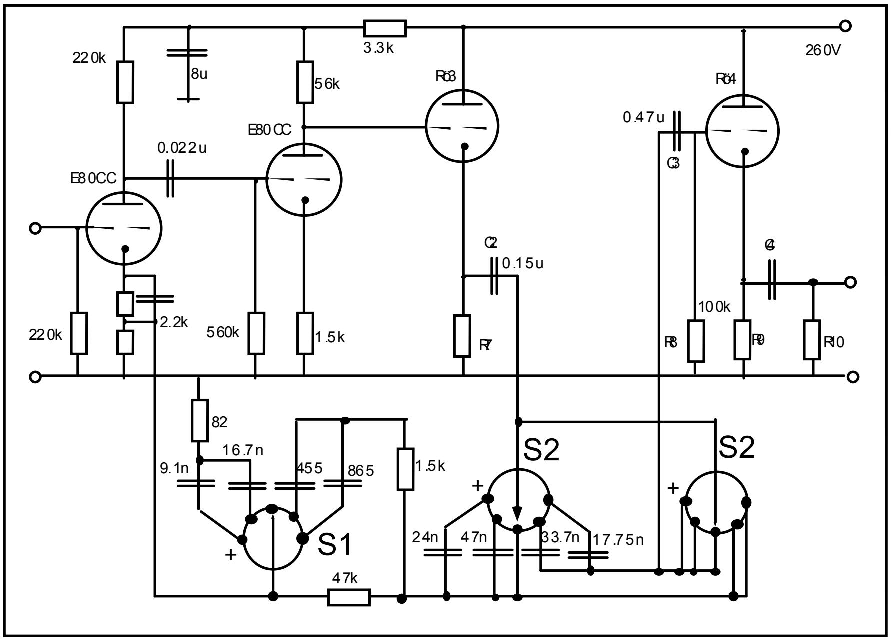


Bild 9 Vorverstärker mit Klangregelung