National Semiconductor

AF133/AF134 PCM Transmit/Receive Filters

General Description

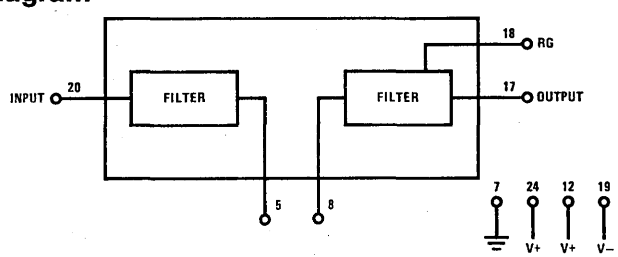
The AF133 and AF134 filter circuits are specifically designed to meet the stringent requirements of the telephone industry. Special attention has been given not only to the electrical filtering requirements of the D3 channel bank, but also to the physical size, environmental, life and cost requirements.

The filters are manufactured using a well understood and dependable thick film technology using laser trimmed resistors and the highest quality components.

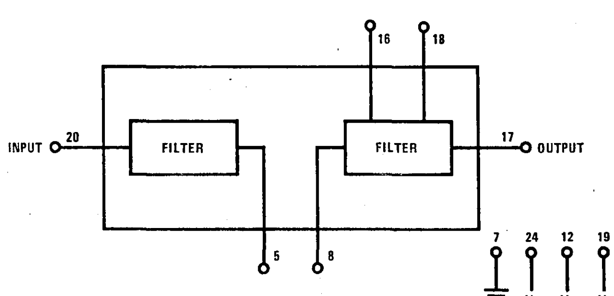
Features

- No external components required
- Active laser trimmed
- Consistent uniform product
- Insensitive to time and temperature
- Designed for D3 system requirements
- Wide power supply range ±12V to ±15V

Connection Diagram



Ceramic Dual-In-Line Package HY24A
AF133-1CJ
AF133-2CJ



Ceramic Dual-In-Line Package HY24A
AF134-1CJ
AF134-2CJ

Absolute Maximum Ratings

Supply Voltage	±18V
Power Dissipation	1W/Package
Input Voltage	±18V
Output Short-Circuit Duration	Continuous
Operating Temperature Range	0°C to +70°C
Storage Temperature Range	−25°C to +100°C

Electrical Characteristics

Unless otherwise noted, these specifications apply over the temperature range from 0°C to +70°C and are tested using ±12V supplies, but are guaranteed for any symmetrical supply operation between ±12V to ±15V.

AF133 Transmit Filter

SYMBOL	PARAMETER	CONDITIONS	AF133-1			AF133-2			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
FREQUENCY RESPONSE									
	Voltage Gain	(Note 2)							
A		f = 3.4 kHz	−1.5	−0.6	0	−0.9	−0.6	0	dB
A		f = 4 kHz		−16	−14		−16	−15	dB
A		f ≥ 4.5 kHz		−33	−30		−33	−32	dB
ΔA	Pass Band Ripple	300 Hz ≤ f ≤ 3 kHz		±0.08	±0.3		±0.08	±0.125	dB
Δt	Differential Delay	1 kHz ≤ f ≤ 2.6 kHz		60	90		60	80	μs
$\Delta A_o/\Delta T$	Gain Stability with Temperature	f = kHz, e_{IN} = 0.1 Vrms		0.0015			0.0015		dB/°C
$\Delta A_o/\Delta t$	Gain Stability with Time	f = 1 kHz, e_{IN} = 0.1 Vrms		0.0005			0.0005		dB/Yr
THD	Distortion	f = 1 kHz, e_{IN} = 0.1 Vrms		0.1	0.5		0.1	0.5	%
e_n	Output Noise Voltage	10 Hz to 50 kHz, e_{IN} = 0V, T_A = 25°C		150	250		150	250	μVp-p
e_o	Output Voltage Swing	V_{CC} = ±12V, R_L = 2k, A = A_o, (Note 2)	10	15		10	15		Vp-p
V_{os}	Output DC Offset		−150		150	−75		75	mV
Z_{IN}	Input Impedance	DC to 10 kHz, T_A = 25°C	100k			100k			Ω
Z_o	Output Impedance	DC to 10 kHz, T_A = 25°C		0.5	1		0.5	1	Ω
PSRR	Power Supply Rejection	120 Hz to 3.4 kHz		97		97			dB
		3.4 kHz to 25 kHz		90		90			dB
P_D	Power Dissipation	V_{CC} = ±12V		135	220		135	220	mW
		V_{CC} = ±15V		190	270		190	270	mW

Note 1: The voltage gain may be adjusted. Refer to application discussion.

Note 2: The AF133 requires an external gain resistor, (R = 133k typ). All gain measurements assume gain at DC set for 0 dB at 1 kHz.

Electrical Characteristics

AF134 Receive Filter

SYMBOL	PARAMETER	CONDITIONS	AF134-1			AF134-2			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
FREQUENCY RESPONSE									
	Voltage Gain	(Notes 1 and 2)							
		f = 1 kHz	−0.08	0.22	0.52	0.095	0.22	0.345	dB
A_O		f = 3.4 kHz	−1.2	−0.6	0	−0.9	−0.6	0	dB
A		f = 4 kHz		−12	−10		−12	−11	dB
A		f > 4.5 kHz		−25	−24		−26	−25	dB
A		f = 8 kHz		−31	−30		−31	−30	dB
ΔA	Pass Band Ripple	300 Hz $\leq$ f $\leq$ 3 kHz, (Note 2)	−0.3		0.3	−0.125	0	0.125	dB
Δt	Differential Delay	1 kHz $\leq$ f $\leq$ 2.6 kHz		80	90		80	90	µs
$\Delta A_O/\Delta T$	Gain Stability with Temperature	f = 1 kHz, e_{IN} = 0.1 Vrms		0.0015			0.0015		dB/°C
$\Delta A_O/\Delta t$	Gain Stability with Time	f = 1 kHz, e_{IN} = 0.1 Vrms		0.0005			0.0005		dB/Yr
THD	Distortion	f = 1 kHz, e_{IN} = 0.1 Vrms		0.1	0.5		0.1	0.5	%
e_n	Output Noise Voltage	10 Hz to 50 kHz, e_{IN} = 0V, T_A = 25°C		150	250		150	250	µVp p
e_o	Output Voltage Swing	V_{CC} = ±12V, R_L = 2k	10	15		10	15		Vp-p
V_{os}	Output DC Offset	V_{IN} = 0V, T_A = 25°C	−150		150	−75		75	mV
Z_{IN}	Input Impedance	DC to 10 kHz, T_A = 25°C	100k			100k			Ω
Z_o	Output Impedance	DC to 10 kHz, T_A = 25°C		0.5	1		0.5	1	Ω
PSRR	Power Supply Rejection	120 Hz to 3.4 kHz		97		97			dB
		3.4 kHz to 25 kHz		90		90			dB
P_D	Power Dissipation	V_{CC} = ±12V		135	220		135	220	mW
		V_{CC} = ±15V		190	270		190	270	mW

Note 1: The voltage gain may be adjusted. Refer to application discussion.

Note 2: For the AF134, the pass band ripple specifications do not refer to the AF134 itself. This specification is the deviation from the ideal band pass response that would result if the $\left[\frac{\text{SIN}\frac{\pi f}{8000}}{\frac{\pi f}{8000}}\right]$ roll-off characteristic were compensated perfectly, and assumes the inclusion of an ideal sample and hold.

Applications Information

GENERAL

The AF133 and AF134 are both fifth order elliptic low pass filters that have been specifically designed for 8 kHz sampled data systems found in telephone PCM communication systems and some military systems, *(Figure 1)*.

The AF133 transmit filter is designed to (a) provide a very flat band pass response from DC to 3.2 kHz, (b) attenuate signals at 4 kHz (1/2 the sampling rate) by at least 16 dB to prevent "aliasing" or "frequency folding" in the sampled data, and (c) attenuate signals above

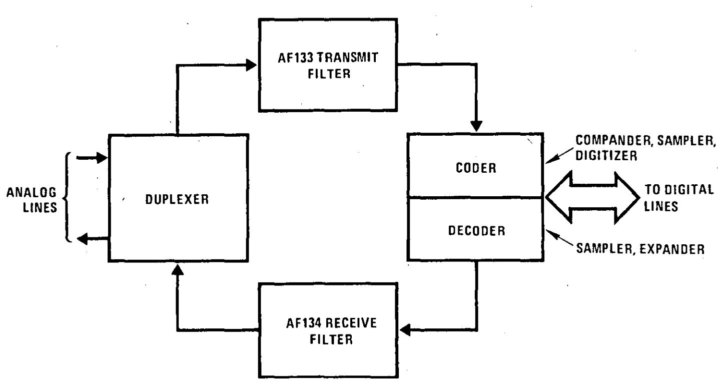


FIGURE 1. PCM Block Diagram

Applications Information (Continued)

4.5 kHz to prevent these signals from occuring in the sampled data.

The AF134 receive filter is designed to receive the sampled data in order to reconstruct the original analog signal. Because the information has been processed through a sample and hold technique, the amplitude information in the band pass has a characteristic (SIN X)/X response. The purpose of the AF134 filter is to provide the necessary response to compensate for the input signal frequency response and restore the amplitude information to a flat pass band characteristic.

GAIN ADJUST

The block diagram in *Figure 2* indicates the basic connection of the AF133.

It consists of 2 separate sections which are connected together externally by the user by jumpering pin 5 to pin 8.

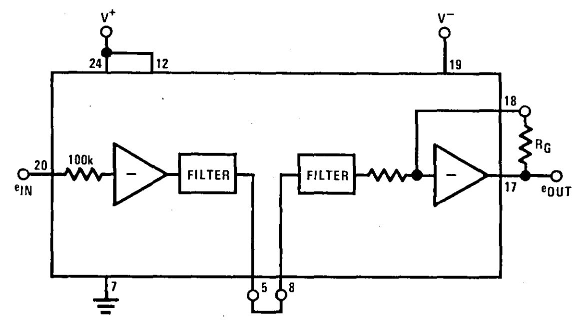
Because it is desirable to have the ability to adjust the voltage gain of the filter, provision has been made to do so *by omitting the gain setting resistor in the feedback path of the output operational amplifier*. For this reason, an external resistor *must* be added between pins 17 and 18 to render the filter operative. The nominal value of the resistor required is 133 kΩ for a 0 dB voltage gain.

All other pins not shown connected should be left open.

Likewise, provision has been made for the user to adjust the gain of the AF134 receive filter as shown in *Figure 3*.

Although R1 and/or R2 are not required for normal operation, it can be easily seen that the addition of R1 (across the internal 100k resistor) will increase the gain, whereas the addition of R2 (across the internal feedback resistor) will decrease the gain.

Obviously, R1 and R2 can be replaced by a single pot with the wiper arm tied to pin 18.



R_G = 133 kΩ for 0 dB gain (nominal)

FIGURE 2. Functional Diagram of AF133

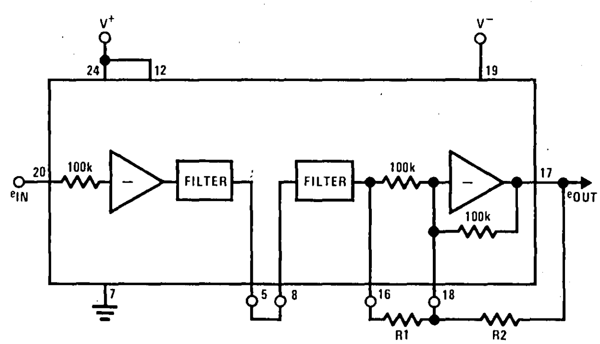


FIGURE 3. AF134 Gain Adjust

PROVIDING LOW FREQUENCY ROLL-OFF

In some systems, it is necessary to have a low frequency high pass filter in front of the transmit filter to attenuate 60 Hz and 120 Hz. Some attenuation can be achieved by capacitively coupling the input signal, with the proper value of capacitor, C, selected to trade off 60 Hz attenuation with the amount of band pass flatness near 300 Hz. The capacitor is easily selected since the input impedance (resistive only) is specified. A second, and more desirable solution, is shown in *Figure 4*. This filter makes use of the AF100 as a second order high pass filter. It provides 22 dB of attenuation of 60 Hz, and has less than 0.03 dB effect on the band pass characteristics at 300 Hz.

Applications Information (Continued)

FREQUENCY	ATTENUATION
60 Hz	−22 dB
120 Hz	−6 dB
180 Hz	−1.5 dB
300 Hz	−0.03 dB

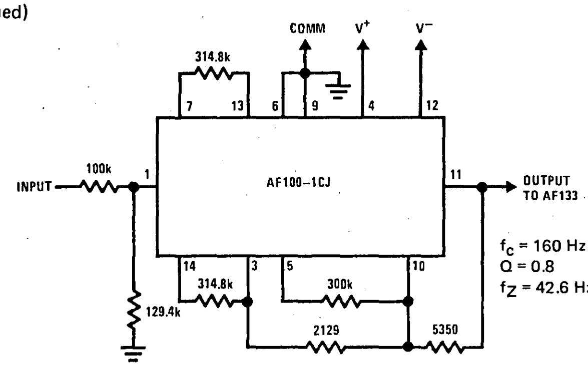


FIGURE 4. Providing 60 Hz Attenuation

TESTING

The circuit shown below is typical of that used by National Semiconductor to test the active filters. In testing and in actual application, the filter must be driven from a low impedance source ($R_S \leq 50\Omega$).

CODEC

National Semiconductor presently manufactures 2 monolithic circuits designed to perform the entire companding coder/decoder function. Before proceeding with your design, please contact National for information about these devices, the MM58100 and the LF2700.

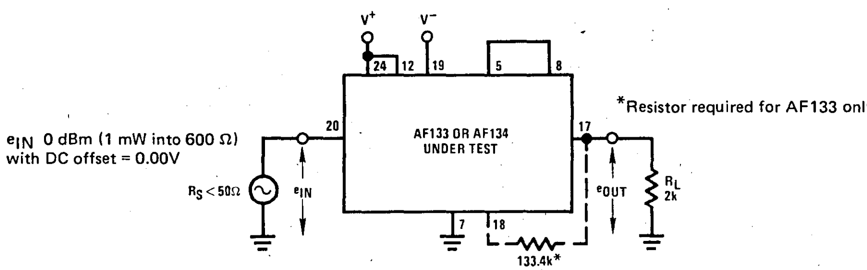


FIGURE 5. Test Circuit

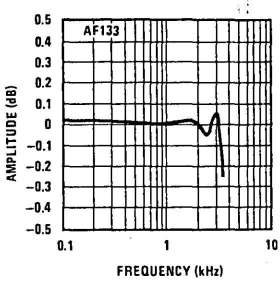


FIGURE 6. AF133 Pass Band Frequency Response

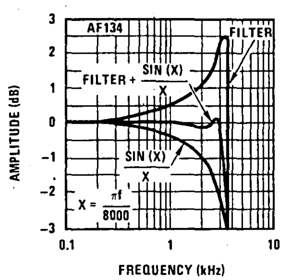


FIGURE 7. AF134 Pass Band Frequency Response

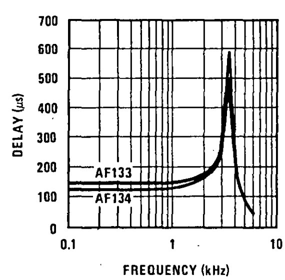


FIGURE 8. Group Delay as a Function of Frequency

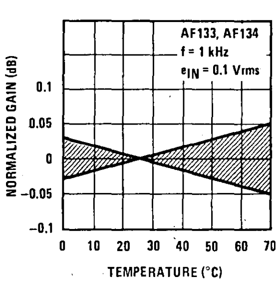


FIGURE 9. Normalized Gain Variation with Temperature

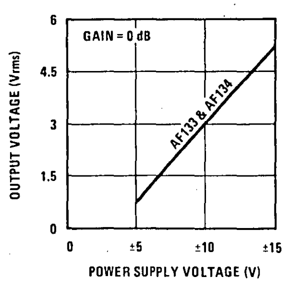


FIGURE 10. Output Voltage Swing vs Power Supply Voltage

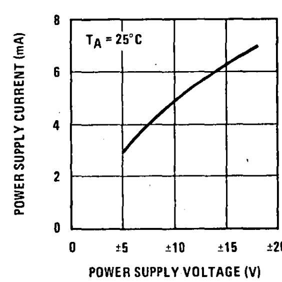


FIGURE 11. Power Supply Current vs Power Supply Voltage