

Voltage controlled operational amplifier

BA6110FS

The BA6110FS is a low-noise, low-offset programmable operational amplifier. Offering superb linearity over a broad range, this IC is designed so that the forward direction conductivity (g_m) can be changed, making it ideal for applications such as voltage control amplifiers (VCA), voltage control filters (VCF) and voltage control oscillators (VCO).

Distortion reduction circuitry improves the signal-to-noise ratio by a significant 10dB at a distortion rate of 0.5% in comparison with products not equipped with this feature. When used as a voltage control amplifier (VCA), a high S / N ratio of 86dB can be achieved at a distortion rate of 0.5%.

The open loop gain is determined by the control current and an attached gain determining resistance R_L , enabling a wide range of settings.

In addition, a built-in low-impedance output buffer circuit reduces the number of attachments.

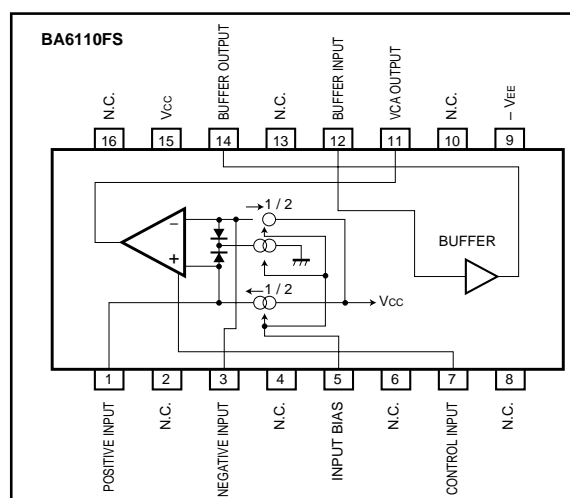
●Applications

Electronic volume controls
 Voltage-controlled impedances
 Voltage-controlled amplifiers (VCA)
 Voltage-controlled filters (VCF)
 Voltage-controlled oscillators (VCO)
 Multipliers
 Sample holds
 Schmitt triggers

●Features

- 1) Low distortion rate.
(built-in distortion reduction bias diode)
- 2) Low noise.
- 3) Low offset voltage. ($V_{IO} = 3m V_{Max}$).
- 4) Built-in output buffer.
- 5) Variable g_m with superb linearity across three decade fields.

●Block diagram



Standard ICs

● Internal circuit configuration

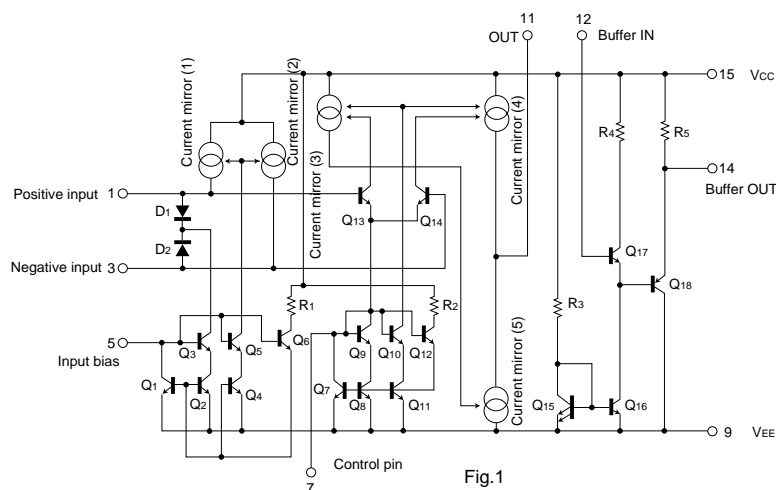


Fig.1

● Absolute maximum ratings (Ta = 25°C)

Parameter	Symbol	Limits	Unit
Power supply voltage	V _{CC}	34	V
Power dissipation	P _d	300*1	mW
Operating temperature	T _{opr}	- 20 ~ + 70	°C
Storage temperature	T _{stg}	- 55 ~ + 125	°C
Maximum control current	I _{C Max.}	500	μA

*1 Reduced by 3mW for each increase in Ta of 1°C each 25°C.

● Electrical characteristics (unless otherwise noted, Ta = 25°C, V_{CC} = 15V, V_{EE} = -15V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Measurement circuit
Quiescent current	I _Q	0.9	3.0	6.0	mA	I _{CONTROL} = 0μA	Fig.2
Pin 7 bias current	I _{7PIN}	—	0.8	5	μA	—	Fig.2
Distortion	THD	—	0.2	1	%	I _{CONTROL} = 200μA, V _i = 5mVrms	Fig.2
Forward transmission conductance	g _m	4800	8000	12000	μS	I _{CONTROL} = 500μA	Fig.2
Pin 6 maximum output voltage	V _{OM6}	12	14	—	V	I _{CONTROL} = 500μA	Fig.2
Pin 8 maximum output voltage	V _{OM8}	9	11	—	V	R _L = 47kΩ	Fig.2
Pin 6 maximum output current	I _{OM6}	300	500	650	μA	I _{CONTROL} = 500μA	Fig.2
Residual noise 1	V _{N1}	—	- 94	- 90	dBm	I _{CONTROL} = 0μA, BPF (30 ~ 320kHz, 3dB, 6dB / OCT)	Fig.2
Residual noise 2	V _{N2}	—	- 74	- 66	dBm	I _{CONTROL} = 200μA, BPF (30 ~ 20kHz, 3dB, 6dB / OCT)	Fig.2
Discontinuous noise	V _{NP2}	—	10.5	11.5	dB	I _{CONTROL} = 200μA, BPF (30 ~ 20kHz, 3dB, 6dB / OCT)	Fig.2
Leakage level	L (Leak)	—	- 94	- 75	dBm	I _{CONTROL} = 0μA, V _{IN} = - 30dBm f _{IN} = 20kHz	Fig.2

Standard ICs

●Attached components

(1) Positive input (Pin 1)

This is the differential positive input pin. To minimize the distortion due to the diode bias, an input resistor is connected in series with the signal source. By increasing the input resistance, distortion is minimized.

However, the degree of improvement for resistances greater than 10kΩ is about the same. An input resistance of 1kΩ to 20kΩ is recommended.

(2) Negative input (Pin 3)

This is the differential negative input pin. It is grounded with roughly the same resistance value as that of the positive input pin. The offset adjustment is also connected to this pin. Make sure a sufficiently high resistance is used, so as not to disturb the balance of the input resistance (see Figure 3).

(3) Input bias diode (Pin 5)

The input bias diode current (I_D) is determined by this pin. The IC input impedance when the diode is biased, if the diode bias current is I_D , is expressed as follows:

$$R_d = \frac{26}{I_D \text{ (mA)}} \text{ (}\Omega\text{)}$$

(4) Control (Pin 7)

This pin controls the differential current. By changing the current which flows into this pin, the gain of the differential amplifier can be changed.

(5) Output (Pin 11)

The differential amplifier gain (A_V) is determined by the resistor R_O connected between the output terminal and the Pin 7 control terminal, as follows:

$$A_V = g_m \cdot R_O = \frac{I_{\text{CONTROL}} \text{ (mA)}}{52 \text{ (mV)}} \times R_O$$

Make sure the resistor is selected based on the desired maximum output and gain.

(6) Buffer input (Pin 12)

The buffer input consists of the PNP and NPN emitter follower. The bias current is normally about 0.8μA. Consequently, when used within a small region of control current, we recommend using the high input impedance FET buffer.

(7) Buffer output resistance (Pin 14)

An 11kΩ resistor is connected between V_{CC} and the output within the IC. When adding an external resistance between the GND and the output, make sure the resistor $R_L = 33k\Omega$.

●Application example

(1) Fig.3 shows a voltage-controlled amplifier (AM modulation) as an example of an application of the BA6110FS.

By changing the I_{CONTROL} current on Pin 7, the differential gain can be changed. The gain (A_V), if the resistance of Pin 11 is R_O , is determined by the following equation:

$$A_V = g_m \cdot R_O = \frac{I_{\text{CONTROL}} \text{ (mA)}}{52 \text{ (mV)}} \times R_O$$

Good linearity can be achieved when controlling over three decades.

By connecting Pin 5 to the V_{CC} by way of a resistor, the input is biased at the diode and distortion is reduced.

The gain in this case is given by the diode impedance R_d and the ratio of the input resistance R_{IN} , as shown in the following:

$$A_V = g_m \cdot R_O \times \frac{R_d}{R_d \times R_{IN}}$$

The diode impedance $R_d = (26 / I_D \text{ (mA)}) \Omega$, so that the Pin 5 bias current $I_D = (V_{CC} - 1V) / R \text{ (Pin 5)}$. The graph in Fig. 6 shows the control current in relation to the open loop gain at the diode bias. In the same way, Fig.7 shows the control current in relation to the THD = 0.5% output at the bias point.

Fig. 8 shows a graph of the control current in relation to the open gain with no diode bias.

Fig. 9 shows a graph of the control current in relation to the SN ratio.

Fig. 10 shows a graph of the diode bias current in relation to the SN ratio.

Fig. 11 shows a graph of the power supply voltage characteristics.

(2) Fig. 4 shows a low pass filter as an example of an application of the BA6110FS.

The cutoff frequency f_o can be changed by changing the Pin 7 control current.

The cutoff frequency f_o is expressed as:

$$f_o = \frac{R_A \cdot g_m}{(R + R_A) 2\pi C}$$

This is attenuated by -6dB / OCT.

Fig. 12 shows a graph of the I_{CONTROL} in relation to the output characteristics.

(3) Fig. 5 shows a voltage-controlled secondary low passfilter as an example of an application of the BA6110FS.

The cutoff frequency f_o can be changed by changing the Pin 7 control current.

$$f_o = \frac{R_A \cdot g_m}{(R + R_A) \cdot 2\pi C}$$

This is attenuated by -12dB / OCT.

Fig. 13 shows a graph of the I_{CONTROL} output characteristic.

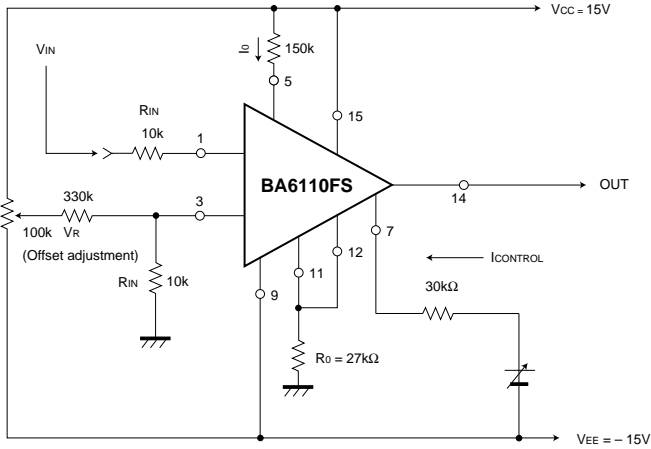


Fig.3 Voltage-controlled amplifier (electronic volume control)

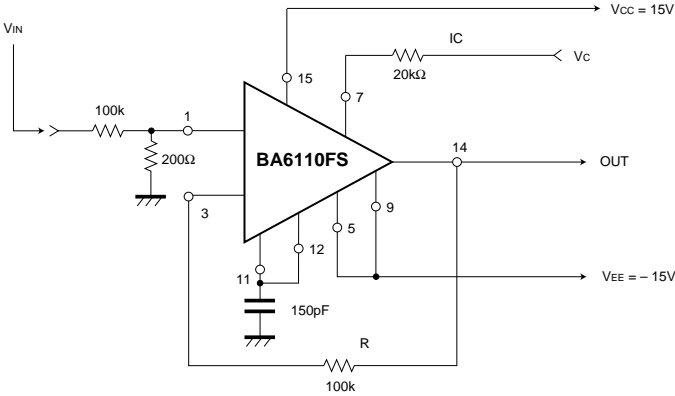


Fig.4 Voltage control low pass filter

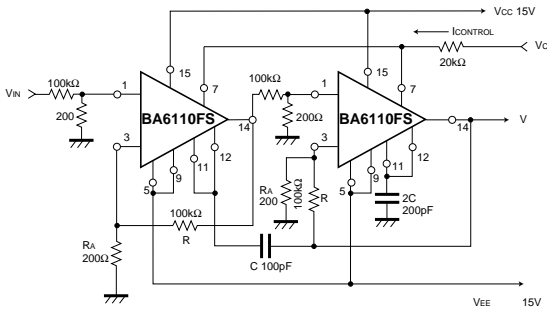


Fig.5 Voltage-controlled secondary low pass filter

Standard ICs

●Electrical characteristic curves

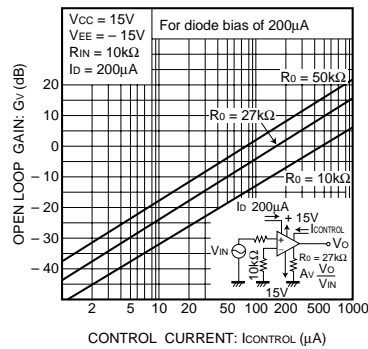


Fig.6 Open loop gain control current characteristics

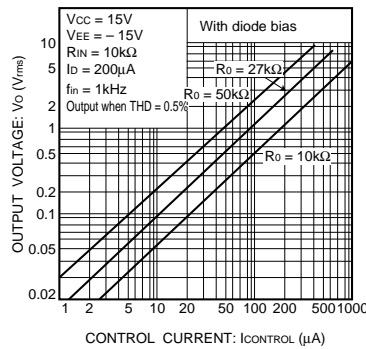


Fig.7 THD 0.5% output control current characteristics

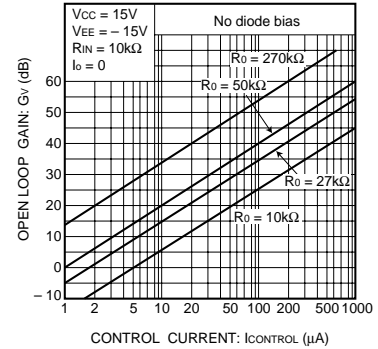


Fig.8 Open loop gain control current characteristics

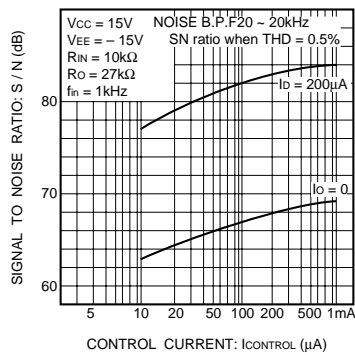


Fig.9 SN ratio vs. control current

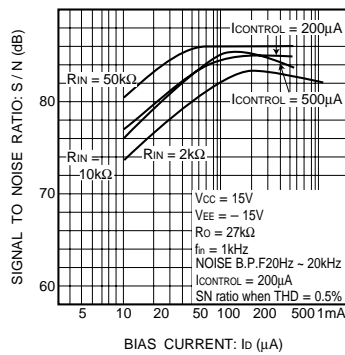


Fig.10 SN ratio vs. diode bias current

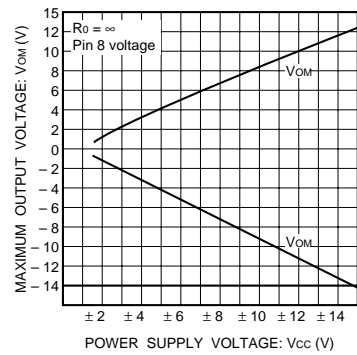


Fig.11 Maximum output voltage vs. power supply voltage

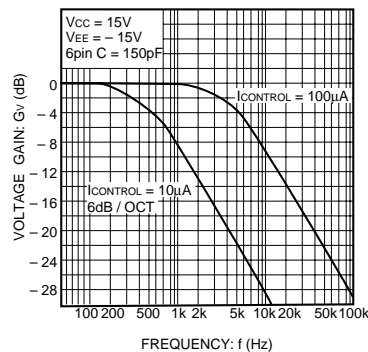


Fig.12 Low pass filter characteristics

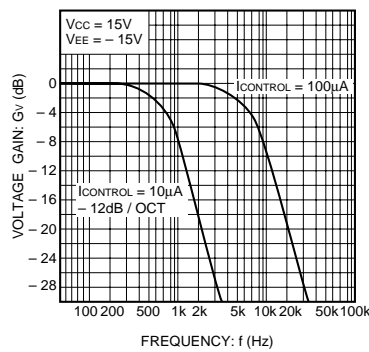


Fig.13 Secondary low pass filter characteristics

Standard ICs

●External dimensions (Units : mm)

