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FHP3131 0.4mA, 2.5V to 12V, 70MHz Rail-to-Rail Amplifier

Features at +5V

- 0.4mA supply current
- 70MHz bandwidth at unity gain
- Power down to 30µA
- Output voltage range at $R_L = 1k\Omega : 0.07V$ to 4.8V
- Input extends below negative rail: -0.3V to 4V
- 50V/µs slew rate
- 12nV/Hz input voltage noise
- Small SOT23-6 and MicroPak[™] -6 package options
- Fully specified at +2.7V, +5V, and ±5V supplies

Applications

- Portable/battery-powered applications
- A/D buffer
- Active filters
- Portable test instruments
- Set-top box
- HDTV
- DVD players and recorders
- Coaxial cable drivers
- Video driver

Description

The FHP3131 is a high-performance, voltage-feedback amplifier that consumes only 0.4mA of supply current while providing 70MHz of bandwidth and 50V/ μ s slew rate. The FHP3131 is designed to operate from 2.5V to 12V (±6V) supplies. The common mode voltage range extends below the negative rail and the output provides rail-to-rail performance.

The FHP3131 is fabricated on a complementary bipolar process. The combination of low power, rail-to-rail performance, low voltage operation, and tiny package options make this amplifier well suited for use in many general-purpose, high-speed applications.

For power sensitive applications, the FHP3131 offers unparalleled dynamic performance. It also offers a shutdown feature to lower the supply current draw below 30µA. The FHP3131 is available in space-saving 6-lead SOT23 or MicroPak[™] packages and operates from -40°C to +85°C.



Ordering Information

Part Number	Package	Pb-Free	Operating Temperature Range	Packaging Method
FHP3131IS6X	SOT23-6	Yes	-40°C to +85°C	Reel
FHP3131IL6X	MicroPak-6	Yes	-40°C to +85°C	Reel

Moisture sensitivity level for all parts is MSL-1.

MicroPak™ is a trademark of Fairchild Semiconductor Corporation.

February 2007



Pin Assignments

Pin # SOT/MicroPak	Name	Description
1/6	OUT	Output
2/5	-Vs	Negative supply
3/4	+IN	Positive input
4/3	-IN	Negative input
5/2	DIS	Leave floating or pull high to enable. Pull low to disable.
6/1	+Vs	Positive supply

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Parameter	Min.	Max.	Unit
Supply Voltage	0	12.6	V
Input Voltage Range	-V _s -0.5V	+V _s +0.5V	V

Reliability Information

Paramete	Min.	Тур.	Max.	Unit	
Junction Temperature			150	°C	
Storage Temperature Range	-65		150	°C	
Reflow Temperature (Soldering)				260	°C
De alcana Thammal De sistemas	6-Lead SOT23 ⁽¹⁾		302		°C/W
Package i nermal Resistance	6-Lead MicroPak ^{™(1)}		440		°C/W

Notes:

1. Package thermal resistance (θ_{IA}), JEDEC standard, multi-layer test boards, still air.

ESD Protection

Product	FHP3131
Human Body Model (HBM)	4kV
Charged Device Model (CDM)	2kV

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

Parameter	Min.	Тур.	Max.	Unit
Operating Temperature Range	-40		+85	°C
Supply Voltage Range	2.5		12	V

Electrical Characteristics at +2.7V

 $T_A = 25^{\circ}C$, $V_s = 2.7V$, $R_f = 1k\Omega$, $R_L = 1k\Omega$ to $V_s/2$, G = 2, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Units
Frequency [Domain Response		1	-		
UGBW	-3dB Bandwidth	G = +1, V _{OUT} = 0.2V _{pp}		70		MHz
BWss	Small Signal Bandwidth	G = +2, V _{OUT} = 0.2V _{pp}		28		MHz
BW _{Ls}	Large Signal Bandwidth	$G = +2, V_{OUT} = 2V_{pp}$		10		MHz
Time Domai	n Response		•			
t _R , t _F	Rise and Fall Time	V _{OUT} = 0.2V step		11		ns
t _S	Settling Time to 0.1%	V _{OUT} = 1V step		85		ns
OS	Overshoot	V _{OUT} = 1V step		4		%
SR	Slew Rate	V _{OUT} = 2V step, G = -1		45		V/µs
Distortion/N	loise Response					
HD2	2nd Harmonic Distortion	V _{OUT} = 1V _{pp} , 1MHz		67		dBc
HD3	3rd Harmonic Distortion	$V_{OUT} = 1V_{pp}$, 1MHz		65		dBc
THD	Total Harmonic Distortion	$V_{OUT} = 1V_{pp}$, 1MHz		63		dB
e _n	Input Voltage Noise	> 100kHz		12		nV/√Hz
DC Perform	ance		1			1
V _{IO}	Input Offset Voltage			1		mV
dV _{IO}	Average Drift			10		µV/°C
I _b	Input Bias Current			1.4		μA
dl _b	Average Drift			3.5		nA/°C
I _{IO}	Input Offset Current			30		nA
PSRR	Power Supply Rejection Ratio	DC		100		dB
A _{OL}	Open-Loop Gain	DC		95		dB
I _S	Supply Current			0.4		mA
Disable Cha	racteristics		1	11		1
T _{ON} /T _{OFF}	Turn-On/Turn-Off Time			0.4/2.2		μs
OFFISO	Off Isolation	5MHz, R _L = 100Ω		65		dB
V _{OFF}	Power Down Input Voltage	Disabled if pin is grounded or pulled below V _{OFF}		V _s -1.75		V
V _{ON}	Enable Input Voltage	Enabled if pin is floating or pulled above V_{ON}		V _s -1.1		V
I _{SD}	Disabled Supply Current	DIS pin grounded		15		μA
Input Chara	cteristics					
R _{IN}	Input Resistance			14		MΩ
C _{IN}	Input Capacitance			1.1		pF
CMIR	Input Common Mode V Range			-0.3 to 1.7		V
CMRR	Common Mode Rejection Ratio	DC, V_{CM} = 0V to V_{s} - 1.5		95		dB
Output Char	racteristics					
		R_L = 1k Ω to V _s /2, G = -1		0.05 to 2.59		V
VOUT	Output voltage Swing	$R_{\rm L}$ = 150Ω to V _s /2, G = -1		0.15 to 2.3		V
I _{OUT}	Linear Output Current			+20,-11		mA
l	Short Circuit Output Current	$\sqrt{-1}$		+25 14		- m A

Electrical Characteristics at +5V

 $T_A = 25^{\circ}C$, $V_s = 5V$, $R_f = 1k\Omega$, $R_L = 1k\Omega$ to $V_s/2$, G = 2, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Units
Frequency [Domain Response					
UGBW	-3dB Bandwidth	G = +1, V _{OUT} = 0.2V _{pp}		70		MHz
BWss	Small Signal Bandwidth	G = +2, V _{OUT} = 0.2V _{pp}		28		MHz
BW _{Ls}	Large Signal Bandwidth	$G = +2, V_{OUT} = 2V_{pp}$		11		MHz
Time Domai	n Response					
t _R , t _F	Rise and Fall Time	V _{OUT} = 0.2V step		11		ns
t _S	Settling Time to 0.1%	V _{OUT} = 2V step		80		ns
OS	Overshoot	V _{OUT} = 0.2V step		2		%
SR	Slew Rate	V _{OUT} = 2V step, G = -1		50		V/µs
Distortion /	Noise Response					
HD2	2nd Harmonic Distortion	$V_{OUT} = 2V_{pp}$, 1MHz		64		dBc
HD3	3rd Harmonic Distortion	$V_{OUT} = 2V_{pp}$, 1MHz		58		dBc
THD	Total Harmonic Distortion	$V_{OUT} = 2V_{pp}$, 1MHz		57		dB
e _n	Input Voltage Noise	> 100kHz		12		nV/√Hz
DG	Differential Gain	NTSC (3.58MHz); AC-coupled		0.04		%
DP	Differential Phase	NTSC (3.58MHz); AC-coupled		0.13		0
DC Perform	ance					1
VIO	Input Offset Voltage ⁽¹⁾		-5	1	5	mV
dVIO	Average Drift			10		µV/°C
l _b	Input Bias Current ⁽¹⁾		-3.5	1.4	3.5	μA
dl _b	Average Drift			3.5		nA/°C
I _{IO}	Input Offset Current ⁽¹⁾			30	350	nA
PSRR	Power Supply Rejection Ratio ⁽¹⁾	DC	70	100		dB
A _{OI}	Open-Loop Gain ⁽¹⁾	DC	65	100		dB
ls	Supply Current ⁽¹⁾			0.40	0.62	mA
Disable Cha	racteristics		II			1
T _{ON} /T _{OFF}	Turn-On/Turn-Off Time			0.5/1.9		μs
OFFISO	Off Isolation	5MHz, R _I = 100Ω		65		dB
V _{OFF}	Power Down Input Voltage ⁽¹⁾	Disabled if pin is grounded or pulled below V _{OFF}			V _s -1.9	V
V _{ON}	Enable Input Voltage ⁽¹⁾	Enabled if pin is floating or pulled above V _{ON}	V _s -1.2			V
I _{SD}	Disabled Supply Current ⁽¹⁾	DIS pin grounded		30	45	μA
Input Chara	cteristics					
R _{IN}	Input Resistance			20		MΩ
C _{IN}	Input Capacitance			1		pF
CMIR	Input Common Mode V Range			-0.3 to 4		V
CMRR	Common Mode Rejection Ratio ⁽¹⁾	DC, V_{CM} = 0V to V_{s} - 1.5	78	100		dB
Output Char	racteristics		I			
		$R_L = 1k\Omega$ to $V_s/2^{(1)}$	0.2	0.07 to 4.8	4.65	V
V _{OUT}	Output Voltage Swing	$R_L = 150\Omega$ to $V_s/2$		0.25 to 4.4		V
I _{OUT}	Linear Output Current	~		+30,-18		mA
I _{SC}	Short-Circuit Output Current	$V_{OUT} = V_s/2$		+35,-24		mA
Note:			ı <u> </u>			1

1. 100% tested at 25°C.

Electrical Characteristics at ±5V

 $T_A = 25^{\circ}C$, $V_s = \pm 5V$, $R_f = 1k\Omega$, $R_L = 1k\Omega$ to GND, G = 2, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Units
Frequency [Domain Response					
UGBW	-3dB Bandwidth	G = +1, V _{OUT} = 0.2V _{pp}		70		MHz
BW _{ss}	Small Singal Bandwidth	G = +2, V _{OUT} = 0.2V _{pp}		28		MHz
BWLs	Large Signal Bandwidth	$G = +2, V_{OUT} = 2V_{pp}$		11		MHz
Time Domai	n Response					
t _R , t _F	Rise and Fall Time	V _{OUT} = 0.2V step		11		ns
t _S	Settling Time to 0.1%	V _{OUT} = 2V step		80		ns
OS	Overshoot	V _{OUT} = 0.2V step		2		%
SR	Slew Rate	V _{OUT} = 2V step, G = -1		45		V/µs
Distortion/N	loise Response				1	
HD2	2nd Harmonic Distortion	$V_{OUT} = 2V_{pp}$, 5MHz		64		dBc
HD3	3rd Harmonic Distortion	$V_{OUT} = 2V_{pp}$, 5MHz		58		dBc
THD	Total Harmonic Distortion	$V_{OUT} = 2V_{pp}$, 5MHz		57		dB
e _n	Input Voltage Noise	> 100kHz		12		nV/√Hz
DG	Differential Gain	NTSC (3.58MHz); AC-coupled		0.08		%
DP	Differential Phase	NTSC (3.58MHz); AC-coupled		0.16		0
DC Perform	ance			1	1	
V _{IO}	Input Offset Voltage			1		mV
dV _{IO}	Average Drift			10		µV/°C
Ib	Input Bias Current			1.4		μA
dl _b	Average Drift			3.5		nA/°C
I _{IO}	Input Offset Current			30		nA
PSRR	Power Supply Rejection Ratio	DC		100		dB
A _{OL}	Open-Loop Gain	DC		100		dB
ا _s	Supply Current per Amplifier			0.4		mA
Disable Cha	racteristics					
T _{ON} /T _{OFF}	Turn-On/Turn-Off Time			0.5/2		μs
OFFISO	Off Isolation	5MHz, R _L = 100Ω		65		dB
V _{OFF}	Power Down Input Voltage	Disabled if pin is grounded or pulled below V _{OFF}		V _s -2.9		V
V _{ON}	Enable Input Voltage	Enabled if pin is floating or pulled above V _{ON}		V _s -1.4		V
I _{SD}	Disabled Supply Current	DIS pin grounded		45		μA
Input Chara	cteristics					
R _{IN}	Input Resistance			25		MΩ
C _{IN}	Input Capacitance			1		pF
CMIR	Input Common Mode V Range			-5.3 to 4		V
CMRR	Common Mode Rejection Ratio	DC, V _{CM} = -5V to 3.5V		100		dB
Output Char	racteristics					
		$R_L = 1k\Omega$		±4.8		V
V _{OUT}	Output Voltage Swing	R _L = 150Ω		+2.9,-4.23		V
I _{OUT}	Linear Output Current			+35,-25		mA
I _{SC}	Short-Circuit Output Current	V _{OUT} = 0V		+43,-33		mA

Typical Performance Characteristics

 $T_A = 25^{\circ}C$, $R_L = 1k\Omega$ to $V_s/2$ for $V_s = 5V$ and 2.7V, $R_L = 1k\Omega$ to GND for $V_s = \pm 5V$, G = 2 and $R_f = R_g = 1k\Omega$, unless otherwise noted.



Figure 1. Non-Inverting Freq. Response (±5V)



Figure 3. Non-Inverting Freq. Response (+5V)



Figure 5. Non-Inverting Freq. Response (+2.7V)



Figure 2. Inverting Freq. Response (±5V)



Figure 4. Inverting Freq. Response (+5V)



Figure 6. Inverting Freq. Response (+2.7V)

Typical Performance Characteristics - Continued

 $T_A = 25^{\circ}C$, $R_L = 1k\Omega$ to $V_s/2$ for $V_s = 5V$ and 2.7V, $R_L = 1k\Omega$ to GND for $V_s = \pm 5V$, G = 2 and $R_f = R_g = 1k\Omega$, unless otherwise noted.



Figure 7. Frequency Response vs. CL (+5V)



Figure 9. Large Signal Freq. Response (±5V)



Figure 11. Gain Flatness vs. Frequency



Figure 8. Frequency Response vs. RL (+5V)



Figure 10. Large Signal Freq. Response (+5V)



Figure 12. Open-Loop Gain and Phase (+5V)



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Typical Performance Characteristics - Continued

 $T_A = 25^{\circ}C$, $R_L = 1k\Omega$ to $V_s/2$ for $V_s = 5V$ and 2.7V, $R_L = 1k\Omega$ to GND for $V_s = \pm 5V$, G = 2, and $R_f = R_g = 1k\Omega$, unless otherwise noted.



Figure 19. Small Signal Pulse Response (+2.7V)



Figure 21. Small Signal Pulse Response (+5V)



Figure 23. Large Signal Pulse Response (±5V)



Figure 20. Large Signal Pulse Response (+2.7V)



Figure 22. Large Signal Pulse Response (+5V)



Figure 24. Output Swing: $V_S = +2.7V$; G = 1

Typical Performance Characteristics - Continued

 $T_A = 25^{\circ}C$, $R_L = 1k\Omega$ to $V_s/2$ for $V_s = 5V$ and 2.7V, $R_L = 1k\Omega$ to GND for $V_s = \pm 5V$, G = 2, and $R_f = R_g = 1k\Omega$, unless otherwise noted.







Figure 27. Differential Gain and Phase (±5V)



Figure 29. Input Voltage Noise (+5V)



Figure 26. Disable Time to 10% Settling (+5V)



Figure 28. Differential Gain and Phase (±2.5V)



Application Information

Driving Capacitive Loads

The *Frequency Response vs.* C_L Figure 7 on page 8, illustrates the response of the FHP3131. A small series resistance (R_s) at the output of the amplifier, illustrated in Figure 31, improves stability and settling performance. R_s values in the *Frequency Response vs.* C_L figure were chosen to achieve maximum bandwidth with less than 1dB of peaking. For maximum flatness, use a larger R_s.



Figure 31. Typical Topology for Driving Capactive Loads

Enable/Disable Function

The FAN3131 offers an active-low disable pin that can be used to lower its supply current. Leave the pin floating to enable the part. Pull the disable pin to the negative supply (which is ground in a single-supply application) to disable the output. V_{ON} and V_{OFF} thresholds are listed in the table below. During the disable condition, the nominal supply current drops to below 33µA and the output is at high impedance with about 2.8pF capacitance.

At 2	2.7V	At	5V	At ±5V	
V _{ON}	V _{OFF}	V _{ON}	V _{OFF}	V _{ON}	V _{OFF}
V _s -1.1	V _s -1.75	V _s -1.2	V _s -1.9	V _s -1.4	V _s -2.9

±5V Drive Capability

Figure 32 illustrates the drive capability of the FHP3131 during $\pm 5V$ supply voltage operation. The two examples below demonstrate the use of this graph:

- 1. To adequately drive $2V_{pp}$ into a 150 Ω ground-centered load, the FHP3131 must supply ±6.67mA of output current. From the graph, the points created by (-6.7mA, -1V) and (+6.7mA, +1V) both lie within the linear region of the curve. So, the FHP3131 can drive $2V_{pp}$ into a 150 Ω ground-centered load.
- 2. To adequately drive $5V_{pp}$ into a 100Ω load, the FHP3131 must supply ± 25 mA of output current. From the graph, the point created by (+25mA, +2.5V) lies within the linear region of the curve; however, the point created by (-25mA, -2.5V) does not. So, the FHP3131 is not capable of driving $5V_{pp}$ into a 100Ω ground-centered load at $\pm 5V$.



Figure 32. Output Current vs. Output Voltage

Power Dissipation

The maximum internal power dissipation allowed is directly related to the maximum junction temperature. If the maximum junction temperature exceeds 150°C for an extended time, device failure may occur. While the FHP3131 is short-circuit protected, this may not guarantee that the maximum junction temperature (+150°C) is not exceeded under all conditions. RMS Power Dissipation can be calculated using the following equation:

Power Dissipation =

 $I_{s} * (V_{s+} - V_{s-}) + (V_{s+} - V_{OUT(RMS)}) * I_{OUT(RMS)}$ EQ. 1

where I_s is the supply current, V_{s+} is the positive supply pin voltage, V_{s-} is the negative supply pin voltage, V_{OUT(RMS)} is the RMS output voltage, and I_{OUT(RMS)} is the RMS output current delivered to the load. Follow the maximum power derating curves shown in Figure 33 below to ensure proper operation.



Figure 33. Maximum Power Derating

Overdrive Recovery

For an amplifier, an overdrive condition occurs when the output and/or input ranges are exceeded. The recovery time varies based on whether the input or output is overdriven and by how much the ranges are exceeded. The FHP3131 typically recovers in less than 25ns from an overdrive condition. Figure 34 shows the FHP3131 in an overdriven condition.



Figure 34. Overdrive Recovery

Layout Considerations

General layout and supply bypassing play major roles in high-frequency performance. Fairchild has evaluation boards to guide high-frequency layout and aid device testing and characterization. Follow the guidelines below as a basis for high-frequency layout:

- Include 6.8µF and 0.01µF ceramic capacitors.
- Place the 6.8µF capacitor within 0.75 inches of the power pin.
- Place the 0.01µF capacitor within 0.1 inches of the power pin.
- Remove the ground plane under and around the part, especially near the input and output pins, to reduce parasitic capacitance.
- Minimize all trace lengths to reduce series inductances.

Refer to the evaluation board layouts shown in Figures 36-39 for more information.

Evaluation Board Information

The following evaluation boards are available to aid testing and layout of these devices:

Evaluation Board	Products
KEB002	FHP3131IS6X
KEB029	FHP3131IL6X

Evaluation Board Schematic



Figure 35. KEB002/KEB029 Schematic

FHP3131 0.4mA, 2.5V to 12V, 70MHz Rail-to-Rail Amplifier

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Evaluation Board Layouts



Figure 36. KEB002 (Top-side)



Figure 37. KEB002 (Bottom-side)







FHP3131 0.4mA, 2.5V to 12V, 70MHz Rail-to-Rail Amplifier

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Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
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