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SSI 32F8030
Programmable Electronic Filter

April 1995

DESCRIPTION

The SSI 32F8030 Programmable Electronic Filter provides an electronically controlled low-pass filter with a separate differentiated low-pass output. A seven-pole, 0.05° Equiripple-type linear phase, low-pass filter is provided along with a single-pole, single-zero differentiator. Both outputs have matched delays. The delay matching is unaffected by any amount of programmed high frequency peaking (boost) or bandwidth. This programability, combined with low group delay variation makes the SSI 32F8030 ideal for use in many applications. Double differentiation high frequency boost is accomplished by a two-pole, low-pass with a two-pole, high-pass feed forward section to provide complementary real axis zeros. A variable attenuator is used to program the zero locations, which controls the amount of boost.

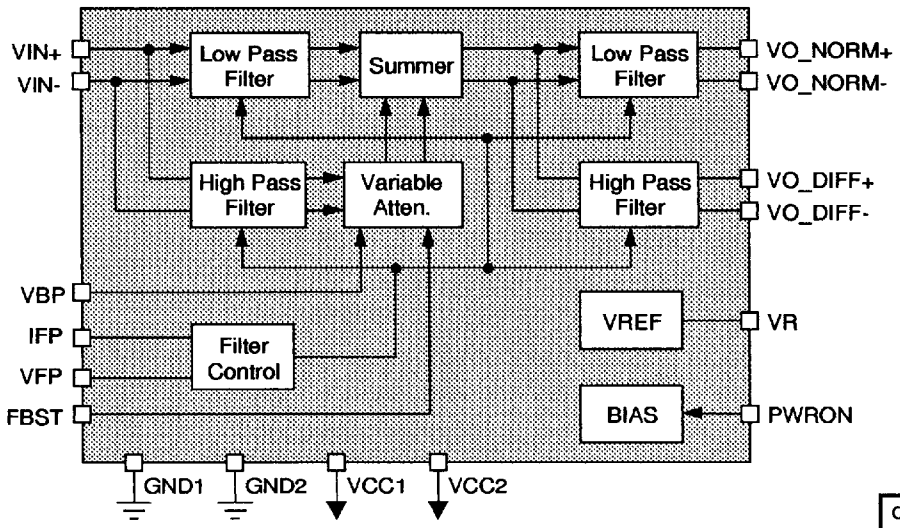
The SSI 32F8030 programmable boost and bandwidth characteristics can be controlled by external DACs or DACs provided in the SSI 32D4661 Time Base Generator. Fixed characteristics are easily accomplished with three external resistors. In addition, boost can be switched in or out by a logic signal.

The SSI 32F8030 requires only a +5V supply and is available in 16-Lead SON, and SOL packages.

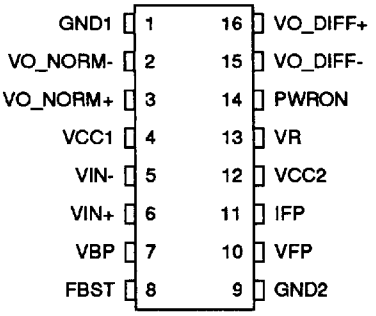
FEATURES

- **Ideal for:**
  - **constant density recording applications**
  - **magnetic tape recording**
- **Programmable filter cutoff frequency (fc = 250 kHz to 2.5 MHz)**
- **Programmable high frequency peaking (0 to 9 dB boost at the filter cutoff frequency)**
- **Matched normal and differentiated low-pass outputs**
- **Differential filter input and outputs**
- **±3.0% group delay variation from 0.2 fc to 1.75 fc, 0.25 MHz ≤ fc ≤ 2.5 MHz**
- **Total harmonic distortion less than 1%**
- **+5V only operation**
- **16-Lead SON, and SOL packages**
- **5 mW idle mode**

BLOCK DIAGRAM



PIN DIAGRAM



CAUTION: Use handling procedures necessary for a static sensitive component.

FUNCTIONAL DESCRIPTION

The SSI 32F8030, a high performance programmable electronic filter, provides a low pass 0.05° Equiripple-type linear phase seven pole filter with matched normal and differentiated outputs. The device has been optimized for usage with several Silicon Systems products, including the SSI 32D4661 Time Base Generator, the SSI 32P54x family of Pulse Detectors, and the SSI 32P4720 Combo device (Data Separator and Pulse Detector).

CUTOFF FREQUENCY PROGRAMMING

The SSI 32F8030 programmable electronic filter can be set to a filter cutoff frequency from 250 kHz to 2.5 MHz (with no boost).

Cutoff frequency programming can be established using either a current source fed into the IFP pin, whose output current is proportional to the SSI 32F8030 output reference voltage VR, or by means of an external resistor tied from the output voltage reference pin VR to pin VFP. The former method is optimized using the SSI 32D4661 Time Base Generator, since the current source into pin IFP is available at the DAC F output of the 32D4661. Furthermore, the voltage reference input is supplied to pin VR3 of the 32D4661 by the reference voltage VR from the VR pin of the 32F8030. This reference voltage is an internally generated bandgap reference, which typically varies less than 1 % over voltage supply and temperature variation. (For the calculations below IVFP = current into IFP or VFP pins).

The cutoff frequency, determined by the -3dB point relative to a very low frequency value (< 10kHz), is related to the current IVFP injected into pin IFP by the formula

Fc (ideal, in MHz) = 3.125•IFP = 3.125•IVFP•2.2/VR, where IFP and IVFP are in mA, 0.08<IFP<0.8 mA, and VR is in volts.

If a current source is used to inject current into pin IFP, pin VFP should be left open.

If the 32F8030 cutoff frequency is set using voltage VR to bias up a resistor tied to pin VFP, the cutoff frequency is related to the resistor value by the formula

Fc (ideal, in MHz) = 3.125•IFP = 3.125•2.2/(3•Rx) where Rx is in kΩ, & 0.917 kΩ <Rx<9.17 kΩ.

If pin VFP is used to program cutoff frequency, pin IFP should be left open.

SLIMMER HIGH FREQUENCY BOOST PROGRAMMING

The amplitude of the output signal at frequencies near the cutoff frequency can be increased using this feature. Applying an external voltage to pin VBP which is proportional to reference output voltage VR (provided by the VR pin) will set the amount of boost. A fixed amount of boost can be set by an external resistor divider network connected from pin VBP to pins VR and GND. No boost is applied if pin FBST, frequency boost enable, is at a low logic level.

The amount of boost FB at the cutoff frequency Fc is related to the voltage VBP by the formula

FB (ideal, in dB) = 20 $\log_{10}$[1.884(VBP/VR)+1], where 0<VBP<VR.

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
VIN+, VIN-	I	DIFFERENTIAL SIGNAL INPUTS. The input signals must be AC coupled to these pins.
VO_NORM+, VO_NORM-	O O	DIFFERENTIAL NORMAL OUTPUTS. The output signals must be AC coupled.
VO_DIFF+, VO_DIFF-	O	DIFFERENTIAL DIFFERENTIATED OUTPUTS. For minimum time skew, these outputs should be AC coupled to the pulse detector.
IFP	I	FREQUENCY PROGRAM INPUT. The filter cutoff frequency FC, is set by an external current IFP, injected into this pin. IFP must be proportional to voltage VR. This current can be set with an external current generator such as a DAC. VFP should be left open when using this pin.
VFP	I	FREQUENCY PROGRAM INPUT. The filter cutoff frequency can be set by programming a current through a resistor from VR to this pin. IFP should be left open when using this pin.
VBP	I	FREQUENCY BOOST PROGRAM INPUT. The high frequency boost is set by an external voltage applied to this pin. VBP must be proportional to voltage VR. A fixed amount of boost can be set by an external resistor divider network connected from VBP to VR and GND. No boost is applied if the FBST pin is grounded, or at logic low.
FBST	I	FREQUENCY BOOST. A high logic level or open input enables the frequency boost circuitry.
PWRON	I	POWER ON. A high logic level enables the chip. A low level puts the chip in a low power state.
VR	-	REFERENCE VOLTAGE. Internally generated reference voltage.
VCC1, VCC2	I	+5 VOLT SUPPLY.
GND1, GND2	-	GROUND

ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Operation above maximum ratings may damage the device.

PARAMETER	RATING
Storage Temperature	-65 to +150°C
Junction Operating Temperature, Tj	+130°C
Supply Voltage, VCC1, VCC2	-0.5 to 7V
Voltage Applied to Inputs	-0.5 to VCC + 0.5V
IFP, VFP Inputs Maximum Current	≤1.2 mA

RECOMMENDED OPERATING CONDITIONS

Supply voltage, VCC1, VCC2	4.5 < VCC1,2 < 5.50V
Ambient Temperature	0 < Ta < 70°C

Power Supply Characteristics
Unless otherwise specified, recommended operating conditions apply.

PARAMETER		CONDITIONS	MIN	NOM	MAX	UNIT
ICC	Power Supply Current	PWRON ≤ 0.8V			0.5	mA
ICC	Power Supply Current	PWRON ≥ 2.0V		28	42	mA
PD	Power Dissipation	PWRON ≥ 2.0V		140	231	mW
PD	Power Dissipation	PWRON ≤ 0.8V			3	mW

DC Characteristics

VIH	High Level Input Voltage	TTL input	2.0		VCC+0.3	V
VIL	Low Level Input Voltage		-0.3		0.8	V
IIH	High Level Input Current	VIH = 2.7V			20	µA
IIL	Low Level Input Current	VIL = 0.4V	-1.5			mA

Filter Characteristics
fc = 1.25 MHz unless otherwise stated

FCA	Filter fc Accuracy	using IFP pin: IFP = 0.4 mA or using VFP pin: Rx = 1.84 kΩ	1.125		1.375	MHz
AO	VO_NORM Diff Gain	F = 0.67 fc, FB = 0 dB	0.8		1.20	V/V
AD	VO_DIFF Diff Gain	F = 0.67 fc, FB = 0 dB	0.9AO		1.1AO	V/V
FBA	Frequency Boost Accuracy	VBP = VR	8.0	9.2	10.4	dB
TGD0	Group Delay Variation Without Boost*	0.25 MHz ≤ fc ≤ 2.5 MHz F = 0.2 fc to 1.75 fc	-3		+3	%
TGDB	Group Delay Variation With Boost*	0.25 MHz ≤ fc ≤ 2.5 MHz VBP = VR, F = 0.2 fc to 1.75 fc	-3		+3	%
VIF	Filter Input Dynamic Range	THD = 1% max, F = 0.67 fc (no boost, 1000 pF capacitor across Rx)	1.0			Vpp
VOF	Filter Normal Output Dynamic Range	THD = 1% max, F = 0.67 fc VBP = 0 (1000 pF capacitor across Rx)	1.0			Vpp
VOF	Filter Normal Output Dynamic Range	THD = 1% max, F = 0.67 fc VBP = VR (1000 pF capacitor across Rx)	1.0			Vpp
VOF	Filter Differentiated Output Dynamic Range	THD = 1% max, F = 0.67 fc VBP = 0 (1000 pF capacitor across Rx)	1.0			Vpp
VOF	Filter Differentiated Output Dynamic Range	THD = 1% max, F = 0.67 fc VBP = VR (1000 pF capacitor across Rx)	1.0			Vpp

Filter Characteristics (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
RIN Filter Diff Input Resistance		3.0	4.0	5.0	kΩ
CIN Filter Diff Input Capacitance*			3.0		pF
EOUT Output Noise Voltage* Differentiated Output	BW = 100 MHz, Rs = 50Ω, Ifp = 0.8 mA, VBP = 0.0V		2.7	3.2	mVRms
EOUT Output Noise Voltage* Normal Output	BW = 100 MHz, Rs = 50Ω Ifp = 0.8 mA, VBP = 0.0V		1.6	2.0	mVRms
EOUT Output Noise Voltage* Differentiated Output	BW = 100 MHz, Rs = 50Ω Ifp = 0.8 mA, VBP = VR		3.1	3.8	mVRms
EOUT Output Noise Voltage* Normal Output	BW = 100 MHz, Rs = 50Ω Ifp = 0.8 mA, VBP = VR		1.8	2.2	mVRms
EOUT Output Noise Voltage* Differentiated Output	BW = 10 MHz, Rs = 50Ω, Ifp = 0.08 mA, VBP = 0.0V		1.8	2.1	mVRms
EOUT Output Noise Voltage* Normal Output	BW = 10 MHz, Rs = 50Ω Ifp = 0.08 mA, VBP = 0.0V		1.0	1.2	mVRms
EOUT Output Noise Voltage* Differentiated Output	BW = 10 MHz, Rs = 50Ω Ifp = 0.08 mA, VBP = VR		2.0	2.5	mVRms
EOUT Output Noise Voltage* Normal Output	BW = 10 MHz, Rs = 50Ω Ifp = 0.08 mA, VBP = VR		1.1	1.5	mVRms
IO- Filter Output Sink Current		1.0			mA
IO+ Filter Output Source Current		2.0			mA
RO Filter Output Resistance**	Sinking 1 mA from pin			70	Ω

* Not directly testable in production, design characteristic.
** Single ended

Filter Control Characteristics

VR Reference Voltage Output		2.0		2.40	V
I_{VR} Reference Output Source Current				2.0	mA

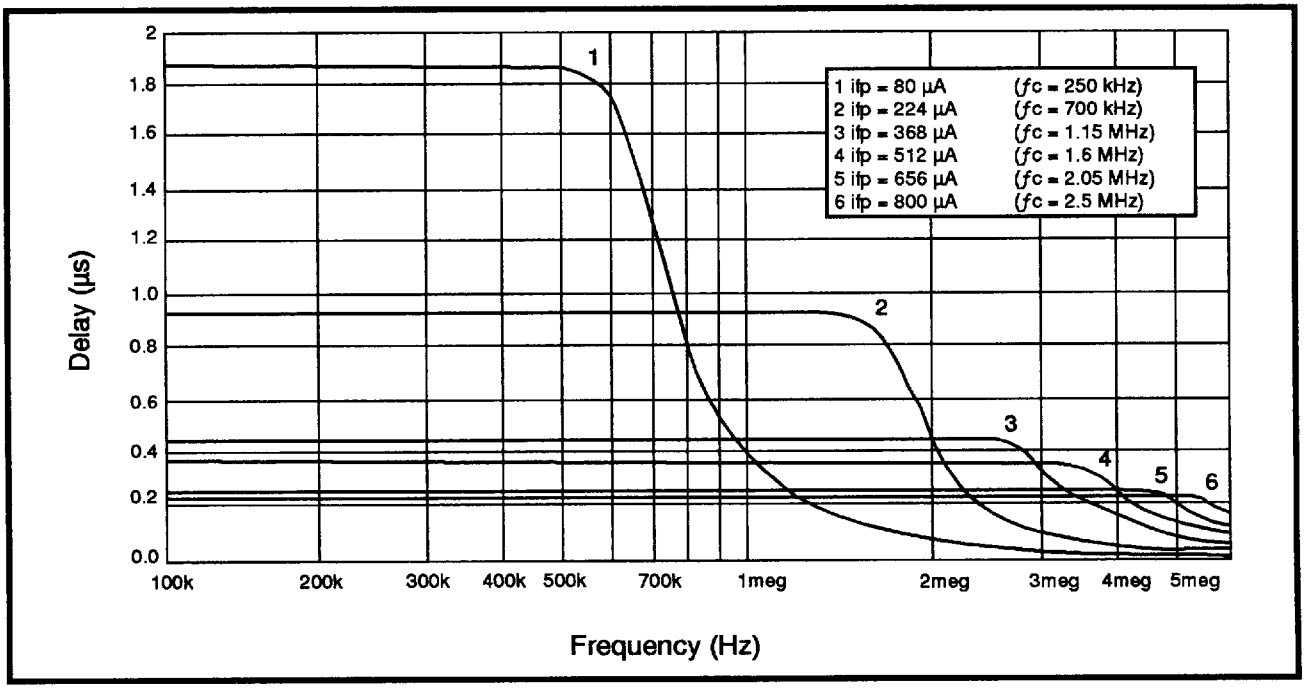


FIGURE 1: Typical Normal/Differentiated Output Group Delay Response

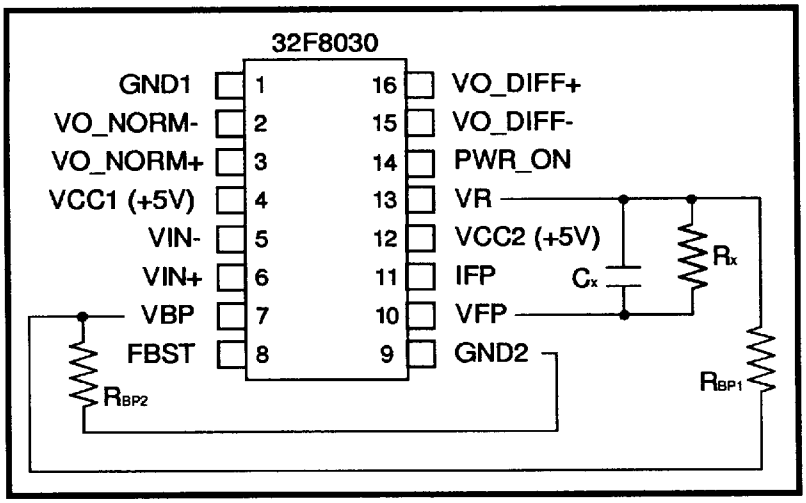


FIGURE 1: 32F8030 Applications Setup 16-Pin SO

VR = 2.2V

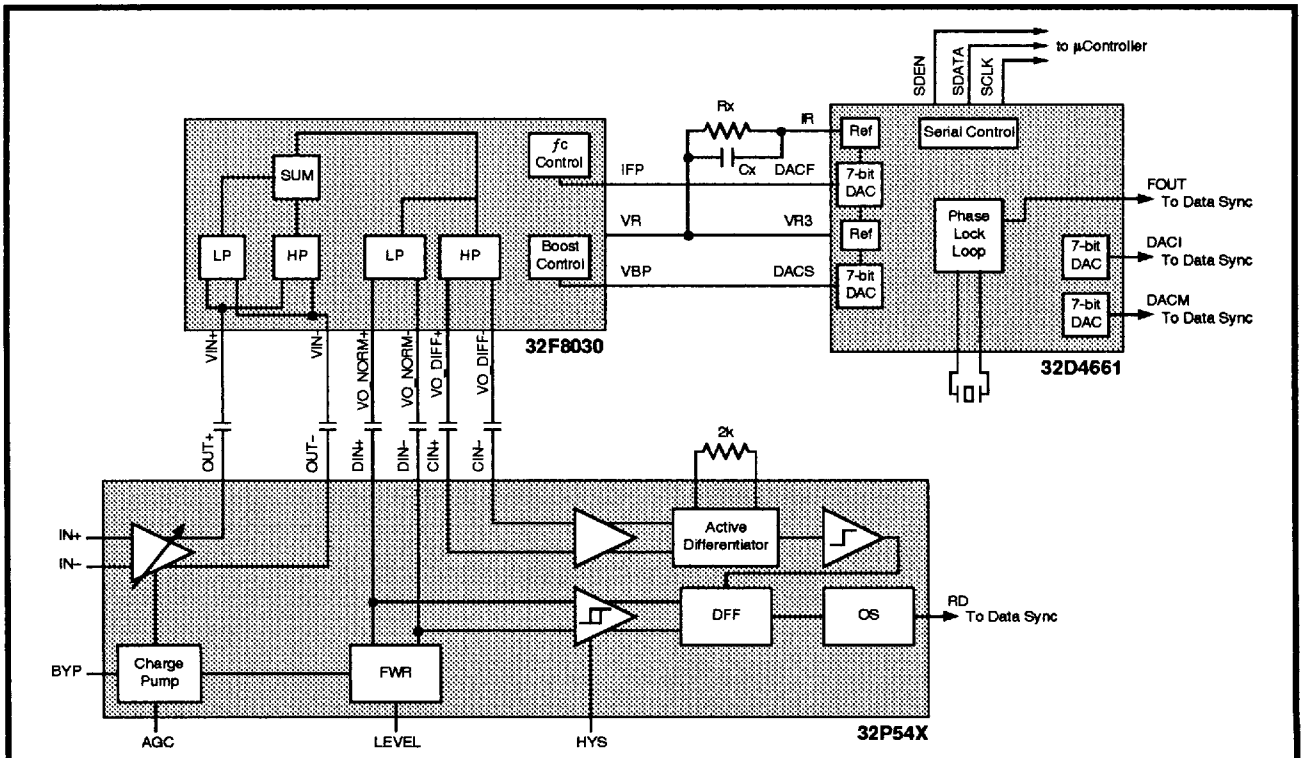
VFP = .667 VR

IVfp = .33VR/Rx

IVfp range: 0.08 mA to 0.8 mA
(0.25 MHz to 2.5 MHz)

Cx = 1000 pF needed for THD at low *fc*

VFP is used when programming current is set with a resistor from VR.
When VFP is used IFP must be left open.



IOF = DACF output current

IOF = (0.98F•VR)/127Rx

Rx = (0.98F•VR)/127IOF

Rx = current reference setting resistor

VR = Voltage Reference = 2.2V

F = DAC setting: 0-127

Full scale, F = 127

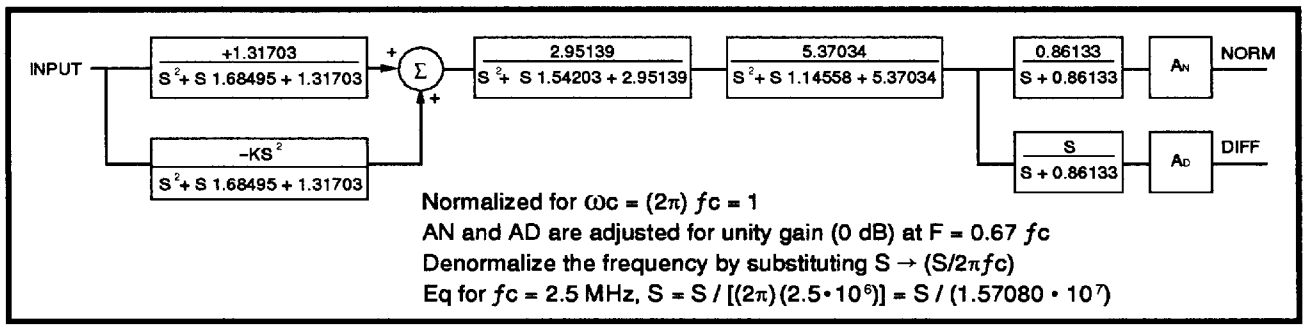
For range of Max fc = 2.5 MHz then IFP = 0.8 mA

Therefore, for Max programming current range to 0.8 mA:

Rx = (0.98)(2.2/0.8) = 2.7 kΩ

Please note that in setups such as this where IFP is used for cutoff frequency programming VFP must be left open.

FIGURE 2: Applications Setup, Constant Density Recording 32F8030, 32P54X, 32D4661



Normalized for $\omega c = (2\pi)\, fc = 1$

AN and AD are adjusted for unity gain (0 dB) at F = 0.67 fc

Denormalize the frequency by substituting $S \rightarrow (S/2\pi fc)$

Eq for fc = 2.5 MHz, $S = S / [(2\pi)(2.5 \cdot 10^6)] = S / (1.57080 \cdot 10^7)$

FIGURE 3: 32F8030 Normalized Block Diagram

TABLE 1: 32F8030 Frequency Boost Calculations - K = 1.31703 ($10^{BOOST(dB)/20}$ -1)

Assuming 9.2 dB boost for VBP = VR

$$\frac{VBP}{VR} \cong \frac{\left(10^{(FB/20)}\right)-1}{1.884}$$

Boost	K	VBP/VR	Boost	K	VBP/VR
1 dB	0.16	0.065	6 dB	1.31	0.528
2 dB	0.34	0.137	7 dB	1.63	0.657
3 dB	0.54	0.219	8 dB	1.99	0.802
4 dB	0.77	0.310	9 dB	2.40	0.965
5 dB	1.03	0.413			

or,

$$\text{boost in dB} = 20\log\left[1.884\left(\frac{VBP}{VR}\right)+1\right]$$

VBP/VR	Boost	VBP/VR	Boost
0.1	1.499 dB	0.6	6.569 dB
0.2	2.777 dB	0.7	7.305 dB
0.3	3.891 dB	0.8	7.984 dB
0.4	4.879 dB	0.9	8.613 dB
0.5	5.765 dB	1.0	9.200 dB

TABLE 2: Calculations

Typical change in *f*-3 dB point with boost

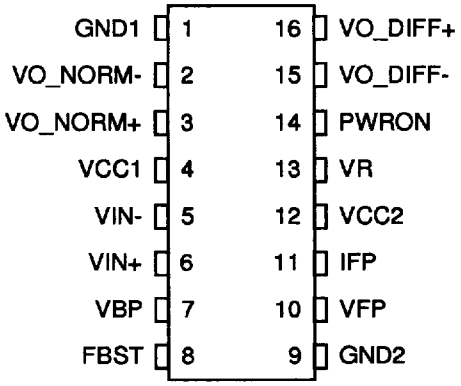
Boost (dB)	Gain @ *fc*(dB)	Gain @ peak(dB)	*f*peak/*fc*	f-3 dB/*fc*
0	-3	0.00	no peak	1.00
1	-2	0.00	no peak	1.21
2	-1	0.00	no peak	1.51
3	0	0.15	0.70	1.80
4	1	0.99	1.05	2.04
5	2	2.15	1.23	2.20
6	3	3.41	1.33	2.33
7	4	4.68	1.38	2.43
8	5	5.94	1.43	2.51
9	6	7.18	1.46	2.59

Notes: 1. *fc* is the original programmed cutoff frequency with no boost
2. *f*-3 dB is the new -3 dB value with boost implemented
3. *f*peak is the frequency where the magnitude peaks with boost implemented

i.e., *fc* = 2.5 MHz when boost = 0 dB
if boost is programmed to 5 dB then f-3 dB = 5.5 MHz
*f*peak = 3.075 MHz

PACKAGE PIN DESIGNATIONS

(Top View)



16-Lead SON, SOL

Thermal Characteristics: θjA

16-lead SON (150 mil)	105° C/W
16-lead SOL (300 mil)	100° C/W

CAUTION: Use handling procedures necessary for a static sensitive component.

ORDERING INFORMATION

PART DESCRIPTION	ORDER NUMBER	PACKAGE MARK
16-lead SON (150 mil)	32F8030-CN	32F8030-CN
16-lead SOL (300 mil)	32F8030-CL	32F8030-CN

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