HA16830F

Voice Signal and Busy Tone Detection IC for Answerphone Use

The HA16830 is a system IC developed for use in answerphone voice signal and busy tone detection. It employs a phased-lock loop for detection of the 400-Hz busy tone (BT) and a rectified wave for voice signal (VOX) detection, thereby providing on-chip functions for call termination detection. This device operates on a supply voltage of 5 V (typ), with an operating voltage range of 4.5 to 6.5 V.

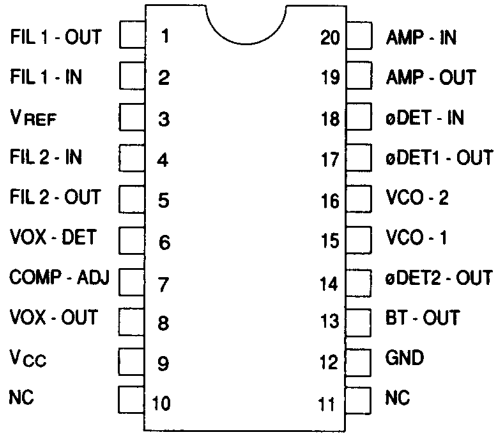
Features

- Functions for call termination detection (BT and VOX) are incorporated on a single chip.
- It provides a wide capture range that can be adjusted by attaching external devices.
- The VOX detection level can be varied by attaching an external resistor.
- A two-stage filter amplifier facilitates adjustment of frequency characteristics.
- The VOX detection circuit is composed of a comparator with intrinsic hysteresis, filter amplifier, and VOX amplifier; the BT detection circuit consists of a filter amplifier, ϕ-detector 1, ϕ-detector 2, VCO, and com-parator.

System Outline

Function	Description	Remarks
VOX detection	BPF	0.3 – 3.4 kHz
	VOX amp	25 dB
	Comparator 1	
BT detection	Amp	
	Phase comparator 1	
	Phase comparator 2	
	VCO	f_O = 400 Hz
	Comparator 2	
Package	FP– 20 DN	
Supply voltage	4.5V to 6.5V	
Operating temperature	– 20°C to + 70°C	

Pin Assignment

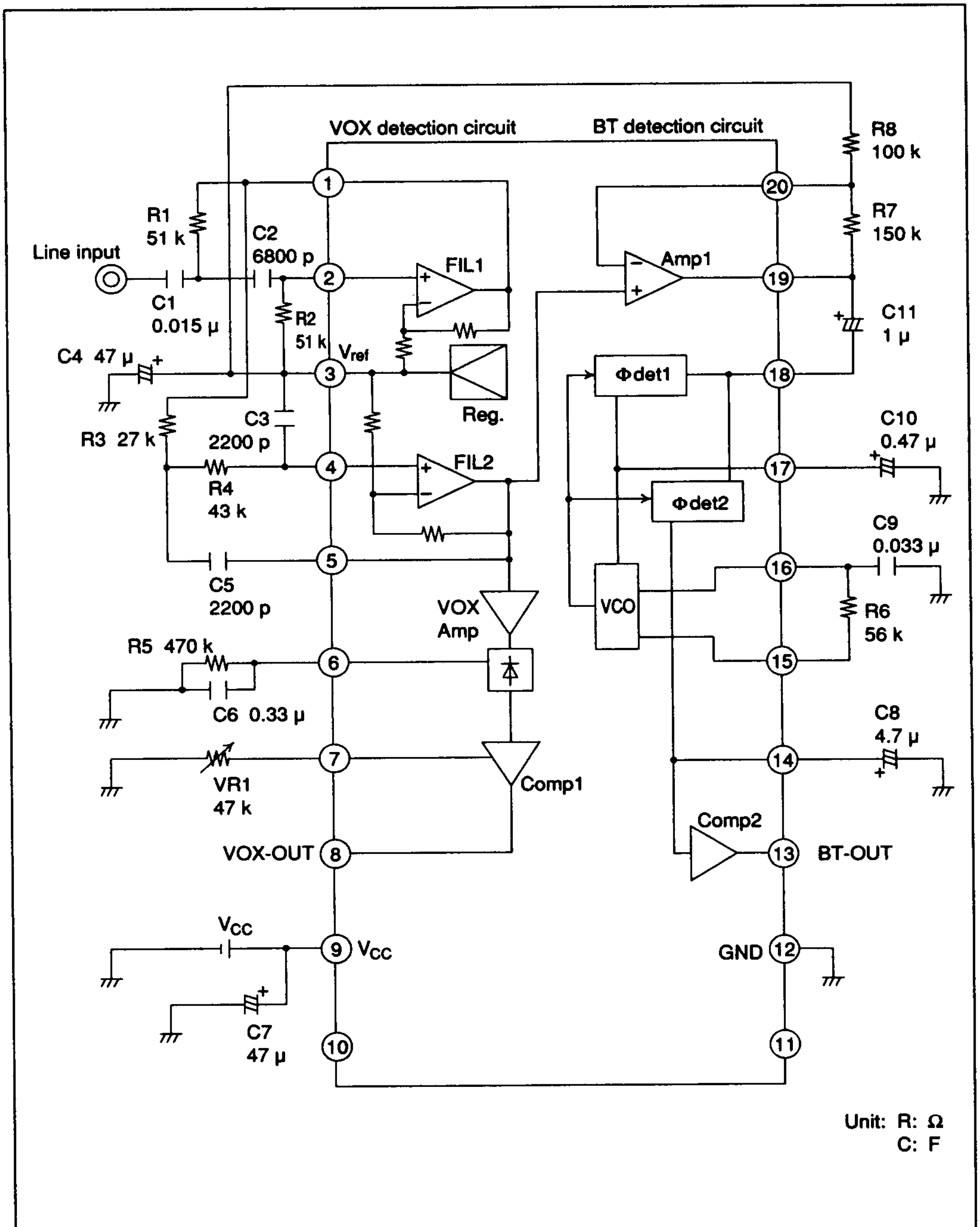


Top View

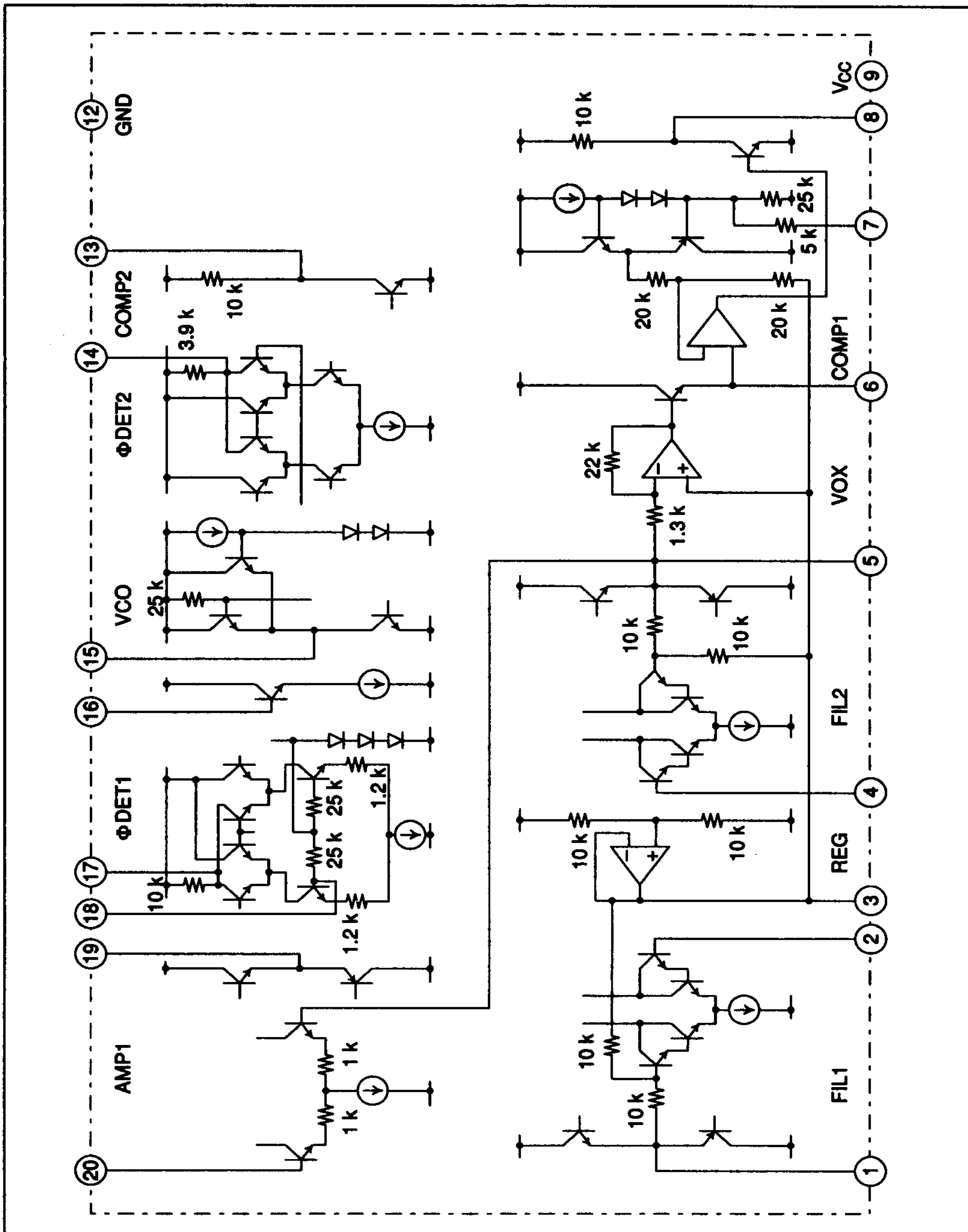
Pin Description

Pin No.	Pin Name	Description
1	FIL1–OUT	Filter 1 output
2	FIL1–IN	Filter 1 input
3	V_{REF}	Reference
4	FIL2–IN	Filter 2 input
5	FIL2–OUT	Filter 2 output
6	VOX–DET	VOX detection
7	COMP–ADJ	Comparator level adjustment
8	VOX–OUT	VOX output
9	V_{CC}	Supply current pin
10	NC	No connection
11	NC	No connection
12	GND	GND
13	BT–OUT	BT output
14	ϕDET2–OUT	ϕ-DET 2 output
15	VCO–1	VCO oscillation frequency adjustment
16	VCO–2	VCO oscillation frequency adjustment
17	ϕDET1–OUT	ϕ-DET 1 output
18	ϕDET–IN	ϕ-DET input
19	AMP–OUT	Amp output
20	AMP–IN	Amp input

Block Diagram



Input and Output Circuits



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I/O Impedance (V_{CC} = 5 V)

Pin No.	DC Bias (V)	I/O Impedance typ (Ω)		Remarks
1	2.5	20		
2	2.5	30 M min		
3	2.5	20		
4	2.5	30 M min		
5	2.5	20		
6				Peak detection
7		30 k		
8		ON	10	
		OFF	10 k	
9	5.0			V_{CC}
10	—			No connection
11	—			No connection
12	0			GND
13		ON	10	
		OFF	10 k	
14		3.9 k		
15				Triangular wave oscillation
16		100 k		
17		10 k		
18	2.1	25 k		
19	2.5	20		
20	2.5	200 k		

Functional Explanation

1. Filter Amplifier

The filter amplifier of the HA16830F consists of FIL 1 (HPF) and FIL 2 (LPF) and functions as a band-pass filter, transmitting pin 5 output in relation to pin 2 input.

Accordingly, when the constants indicated in Figure 1 are obtained, the cut-off frequencies are f_H = 2.12 kHz and f_L = 309 Hz. An example of the measured filter amplifier gain as a function of frequency is shown in figure 2. The adjustment of the resistors and capacitors should be 10 kΩ ≤ R ≤ 100 kΩ and C ≤ 1μ F.

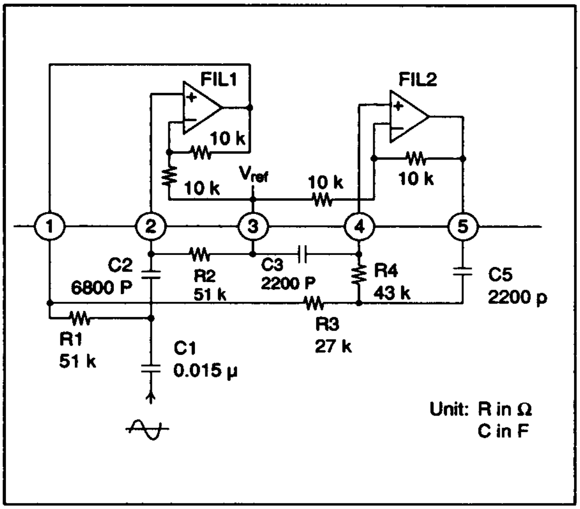

Figure 1 Filter Amplifier Circuit

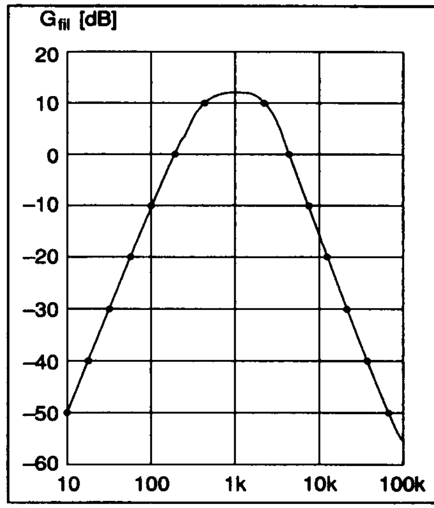

Figure 2 Filter Amplifier Gain vs. Frequency Characteristics

FIL 1

$$\frac{V_{out}}{V_{in}} = T(S) = \frac{2S^2}{S^2 + \left(\frac{1}{R_2C_2} + \frac{1}{R_2C_1} - \frac{1}{R_1C_1}\right)S + \frac{1}{R_1R_2C_1C_2}}$$

$$f_{OL} = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}}$$

FIL 2

$$\frac{V_{out}}{V_{in}} = T(S) = \frac{\frac{2}{R_3R_4C_3C_5}}{S^2 + \left(\frac{1}{R_3C_3} + \frac{1}{R_4C_3} - \frac{1}{R_4C_5}\right)S + \frac{1}{R_3R_4C_3C_5}}$$

$$f_{OH} = \frac{1}{2\pi\sqrt{R_3R_4C_3C_5}}$$

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2. VOX

• **Comparator output**

The output of the pin 8 comparator is designed as an open collector and the pull-up resistance is fixed internally in the IC.

• **Comparator level adjustment**

The comparison level of the comparator can be adjusted with the pin 7 resistor VR1. When VR is large, the comparator inverts at a higher input level. The comparator has an intrinsic hysteresis characteristic.

• **Attack time and recovery time**

The attack time is less than 1 ms at f = 1 kHz and the recovery time is determined by the time constants of the capacitors and resistors.

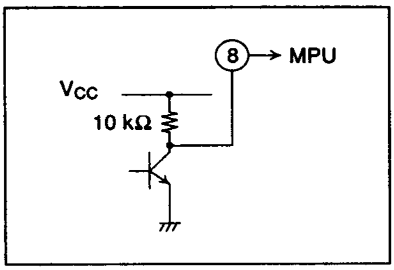

Figure 3 VOX Comparator Output

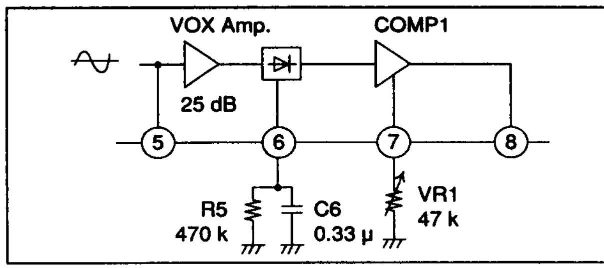

Figure 4 VOX Circuit

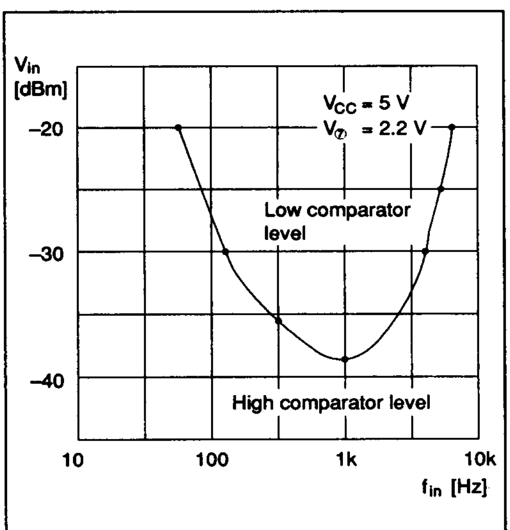

Figure 5 Input Level and Frequency vs. VOX Characteristic

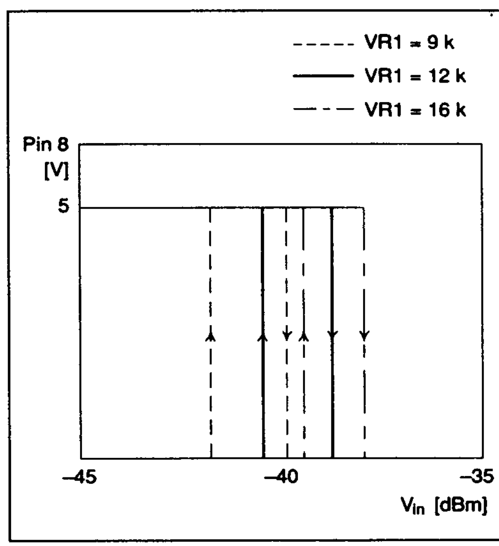

Figure 6 VOX Characteristic

3. Amp 1

Amplifier gain is adjustable using the resistance values of R7 and R8.

$$G_{AP1} = 20 \log \left(\frac{R7}{R8} + 1\right)$$

4. Busy Tone Detection

The 400-Hz busy tone sent from the switch is input at pin 2, detected by the phased-lock loop and output from the comparator at pin 13. A diagram of the BT detection circuit is shown in figure 9.

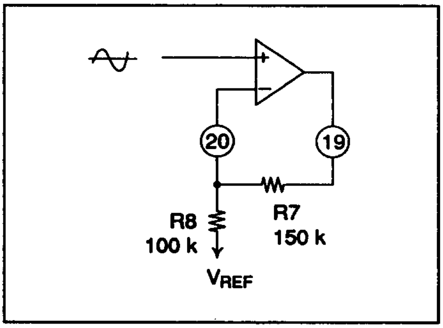

Figure 7 Amp 1 Circuit Diagram

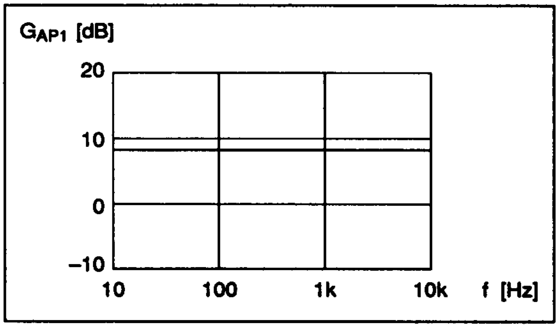

Figure 8 Amp 1 Gain vs. Frequency Characteristic

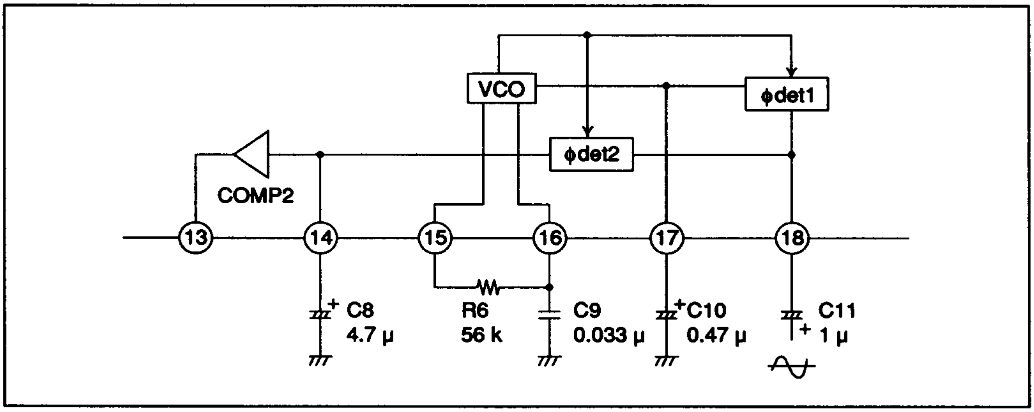

Figure 9 Busy Tone Detection Circuit

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• **Free-running frequency**

The free-running frequency of VCO can be varied externally by R6 and C9. Since variation in the values of these devices can cause the free-running frequency to change, the use of high-accuracy resistors and capacitors is recommended. The free-running frequency is shown in figure 10 as a function of VCO. figure 11 shows the free-running frequency for various values of R6 and C9.

• **Capture range**

The capture range can also be varied with the free-running frequency. Figure 12 shows the BT detection characteristic of the circuit illustrated in figure 9. The capture range is shown in figure 13 for various values of R6 and C9.

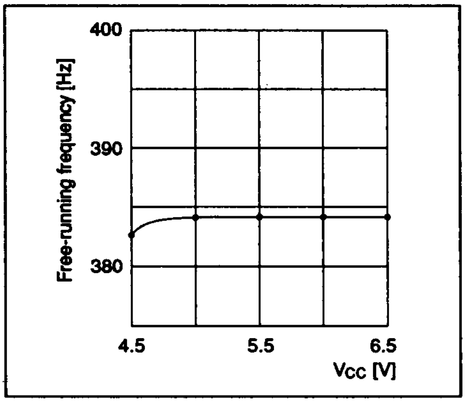


Figure 10 Free-Running Frequency vs. V_{CC}

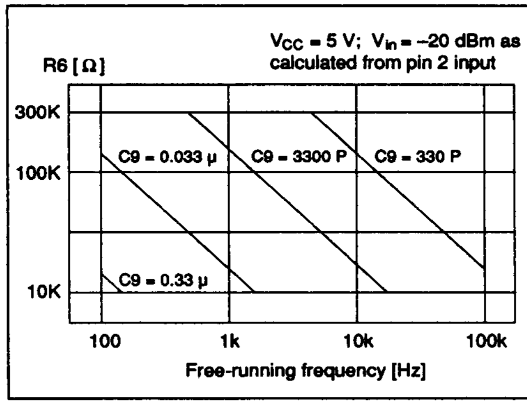


Figure 11 R6 & C9 vs. Free-Running Frequency

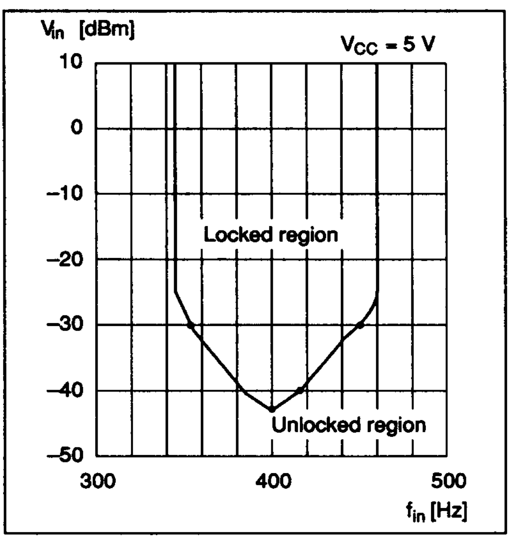


Figure 12 Input Level and Frequency vs. Busy Tone Frequency Caracteristics

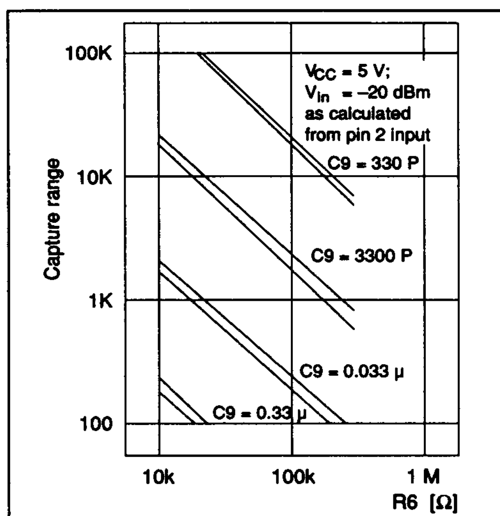


Figure 13 R6 & C9 vs. Capture Range

• Bandwidth

The bandwidth characteristic is shown in Figure 14 as a function of the value of external C10. When the value of C10 is too small or too large, locking may not occur or the bandwidth characteristic may be unacceptable.

• Lock-in time and hold time

The lock-in time and hold time are shown in figure 15 and figure 16, respectively, as a function of the value of external C8. The value of C8 should be set above 0.22µF, since locking does not occur below that level.

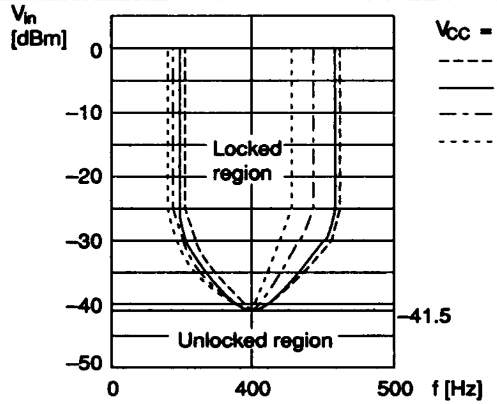
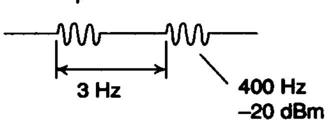


Figure 14 Input Level and Frequency vs. Busy Tone Frequency



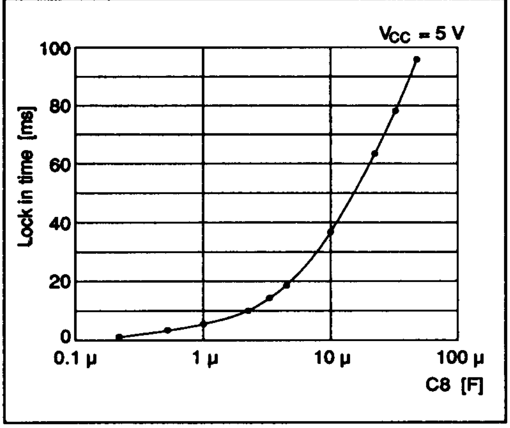


Figure 15 Lock-in Time vs. C8

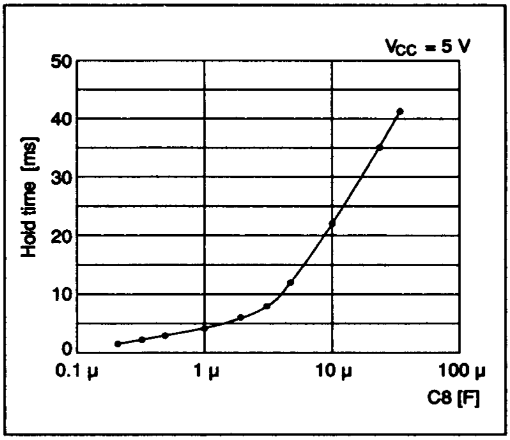


Figure 16 Hold Time vs. C8

- **Busy tone detection for busy tone that is not 400 Hz**

Busy Tone (Hz)	R6 (kΩ), C9 (pF)	Capture register characteristics graph
425	79 (36+43), 2200	Figure 17
435	77 (30+47), 2200	Figure 18
440	51, 3300	Figure 19
450	75, 2200	Figure 20
500	67 (20+47), 2200	Figure 21
525	64 (13+51), 2200	Figure 22

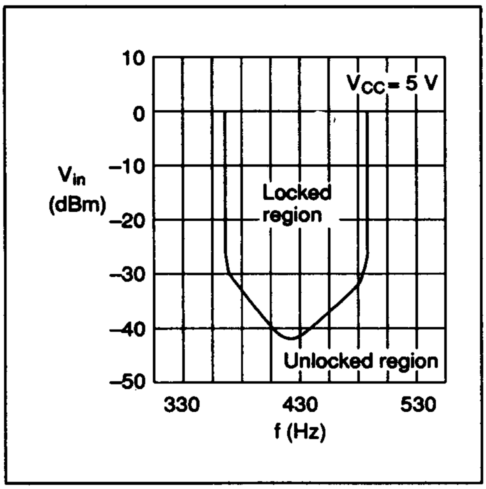


Figure 17

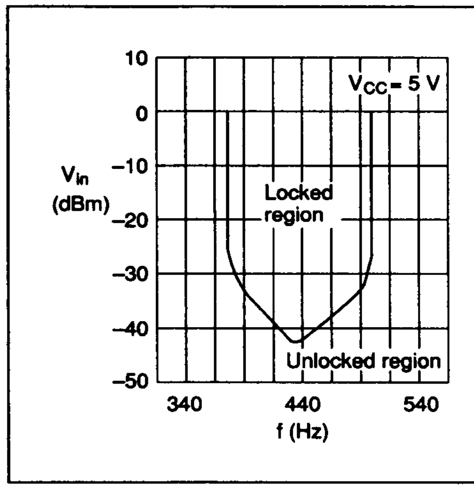


Figure 18

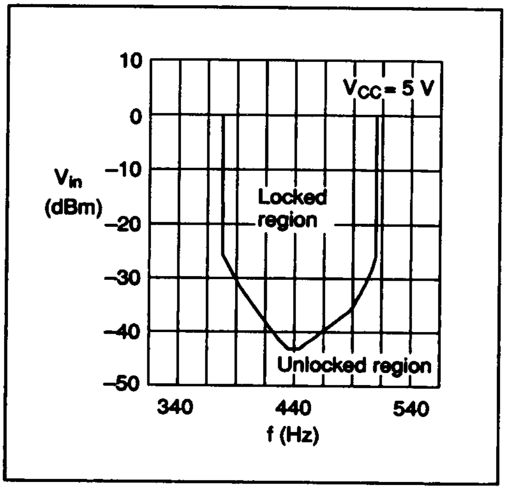


Figure 19

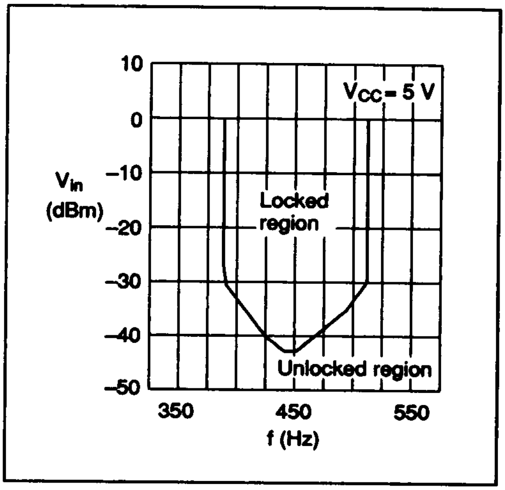


Figure 20

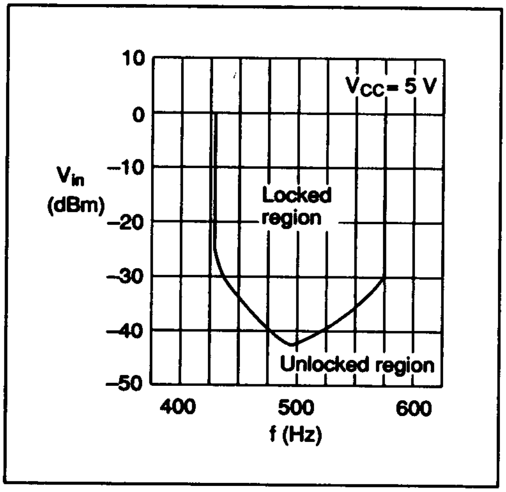


Figure 21

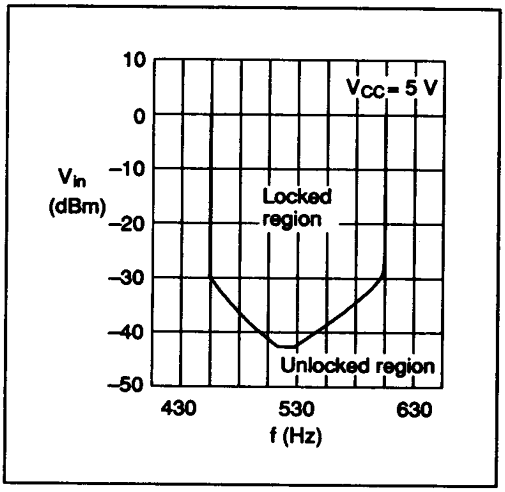


Figure 22

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- **480 Hz and 620 Hz dual tone detection**

Configuring both FIL1 and FIL2 LPFs as shown in figure 23 in order to drop the 620 Hz signal below 480 Hz results in a gain of 26.6 dB at 480 Hz and 23 dB at 620 Hz. The frequency characteristics are shown in figure 24, while figure 25 shows the capture range characteristics at a center frequency of 480 Hz.
In addition to the standard configuration, the value of R8 can be varied and the gain of Amp1 can be increased to 9 dB.

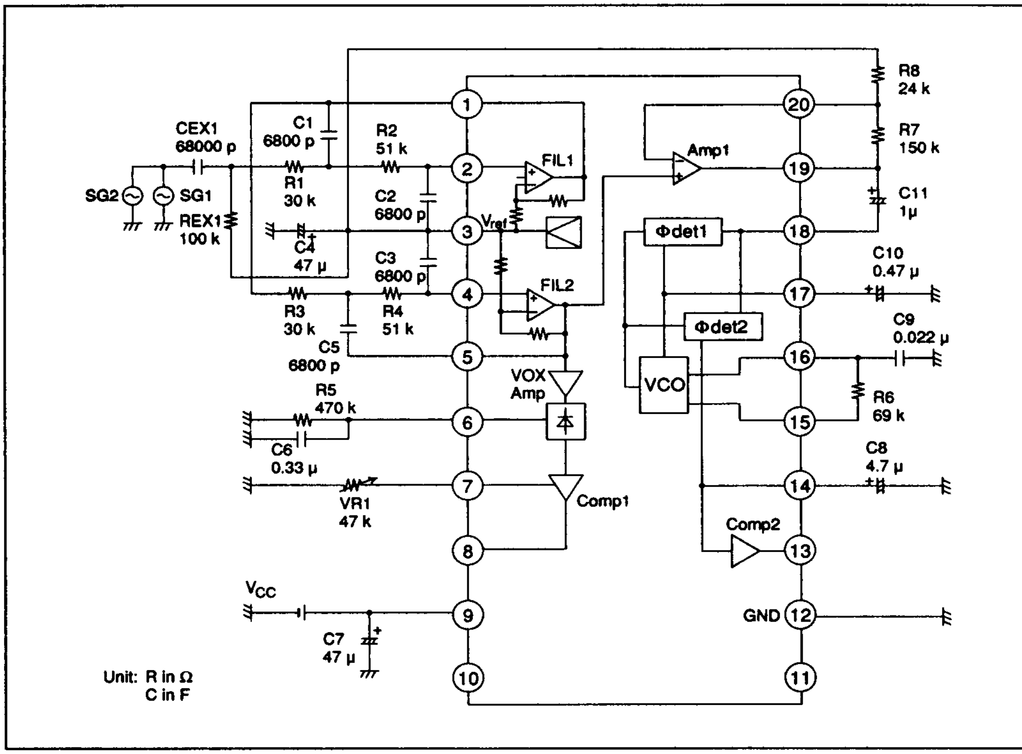

Figure 23

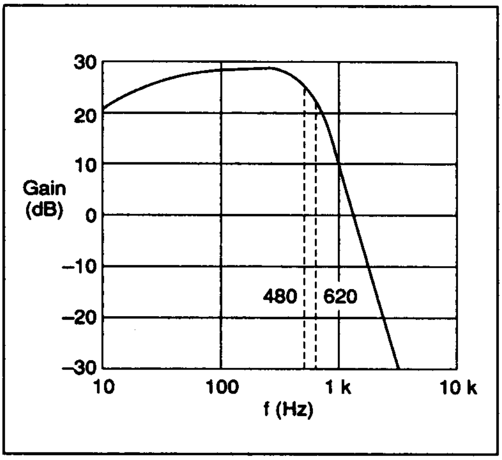

Figure 24

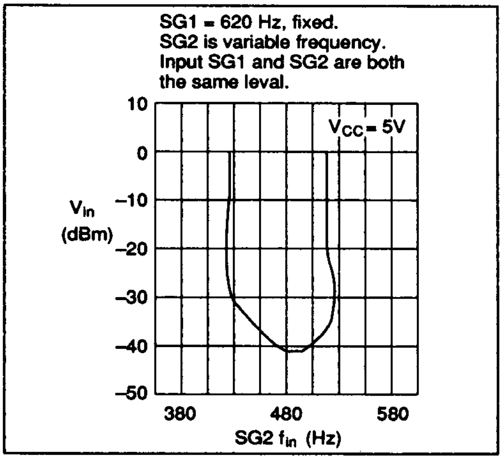

Figure 25

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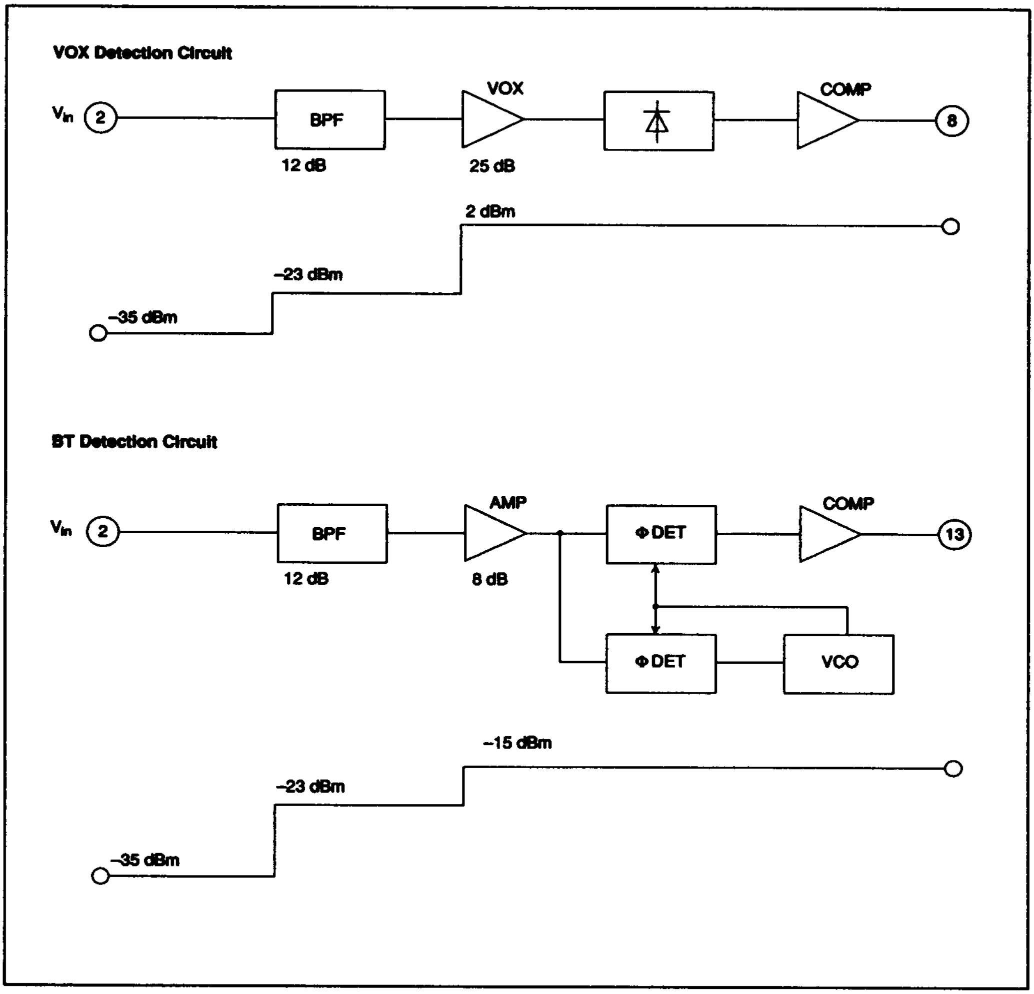
Gain Diagram



Absolute Maximum Ratings

Item	Symbol	Rating	Unit
Supply voltage	V_{CC}	7.0	V
Power dissipation	P_D	300	mW
Operating temperature	T_{opr}	–20 to +70	°C
Storage temperature	T_{stg}	–55 to +125	°C

Electrical Characteristics (V_{CC} = 5 V)

Block	Item	Symbol	Min	Typ	Max	Unit	Test Condition	Remarks
	Quiescent current	I_{CC}	—	5	8	mA		
Filter	Filter gain	G_{fil}	10	12	14	dB	f_{in} = 1 kHz	
Amp	Amp 1 gain	G_{AP1}	6	8	10	dB	f_{in} = 1 kHz	
VOX	VOX minimum detectable level	V_{VOX}	–35	—	—	dBm	f_{in} = 1 kHz V⑦ = 2.2 V	V⑧ ≤ 0.4 V
	VOX undetectable level	V_{n-VOX}	—	—	–45	dBm		V⑧ ≥ 4.5 V
	VOX-H output voltage	V_{OH1}	4.5	5.0	—	V	No signal	
	VOX-L output voltage	V_{OL1}	—	0	0.3	V	V_{in} = –20 dBm f_{in} = 1 kHz	
	Hysteresis range	ΔT_{th}	0	2	5	dBm	VR1 = 20 kΩ	
BT	BT minimum detectable level	VBT	–35	—	—	dBm	f_{in} = 400 Hz	V ⑬ ≤ 0.4 V
	BT undetectable level	Vn–BT	—	—	–45	dBm		V ⑬ ≥ 4.5 V
	BT detectable bandwidth	BW	350	—	450	Hz	V_{in} = –20 dBm	V ⑬ ≤ 0.4 V
	BT undetectable bandwidth Low	Fn–BTL	—	—	300	Hz		V ⑬ ≥ 4.5 V
	BT undetectable bandwidth High	Fn–BTH	500	—	—	Hz		
	BT-H output voltage	V_{OH2}	4.5	5.0	—	V	No signal	
	BT-L output voltage	V_{OL2}		0	0.3	V	V_{in} = –20 dBm f_{in} = 400 Hz	

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Test Circuit