Single Chip Ultrasonic Alarm Processing Circuit

Description

The DA5546 is a single chip ultrasound signal processing IC, intended for automotive applications for detecting intrusion into an ultrasound field where automatic gain control (AGC) is not required or in applications with a user sensitivity adjustment. The IC was developed as an Application Configurable System Cell (ACSC), either to be used as a stand alone circuit, or as part of a larger custom circuit designed to suit specific application requirements. The DA5546 contains all the circuit functions necessary to implement an advanced low power, high sensitivity ultrasonic movement detection system.

The synchronous demodulator system which monitors both the magnitude and phase of the return signal gives a significant improvement in sensitivity and noise rejection compared to more basic systems. The logic level alarm output of the DA5546 enables it to be part of a microprocessor controlled security system. The DA5546 is implemented in a 1.2um double poly double metal CMOS process and runs from a single 5V supply with a basic power consumption of 5mW (excluding transmit sensor power). The device is available in a 20 pin SOIC package.

Features

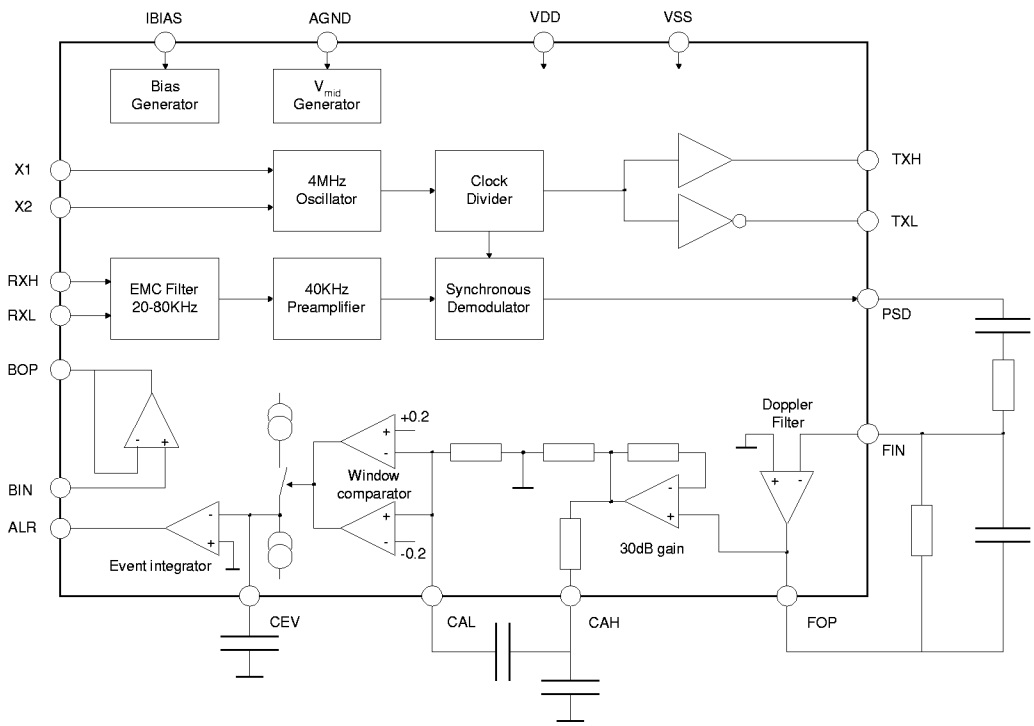
- Complete stand alone system
- Sensitive to both amplitude *and* phase disturbances
- 5mW active power consumption
- Synchronous demodulator to extract Doppler tones caused by moving objects
- A master clock oscillator with an external ceramic resonator
- A clock divider and transmit sensor driver
- A low noise 40kHz preamplifier for the receive sensor
- Second order low-pass and high-pass filters to define the Doppler frequency range and reduce the effect of thermal air movement inside the vehicle
- Threshold detector and time averaging integrator reduces the effect of transient noise and wind
- Compact 20 pin SOIC package

System Overview

The front-end bandpass filter removes out of band noise and interference, particularly the effects of EMC, and prevents amplifier overload. The output of the amplifier is fed to a synchronous demodulator. This gives an output that is proportional to both the amplitude *and* phase of the return signal giving a significant increase in sensitivity, as the phase of the return signal varies much more rapidly than the amplitude when intrusions occur. An additional benefit is the high degree of rejection of wideband noise since only signals coherent with the transmitter excitation are recognised.

The demodulator output is high-pass and low-pass filtered and amplified to extract the Doppler tones caused by moving object with velocities in the range of 0.1m/s to 2m/s. Further gain is applied to the signal together with a second high-pass/low-pass filter, to remove the effects of slow air movement caused by convection currents inside the vehicle. The output of the second filter is monitored by a window comparator with +/-200mV thresholds: any Doppler tones larger than this will cause the integration capacitor connected to the CEV pin to be charged up. When this capacitor is charged to 2.5V the alarm output pin ALR will go high. If no Doppler tones are present then the integration capacitor is discharged at a much slower rate. With a capacitor of 47nF fitted between the CEV pin and ground, Doppler tones must be present for a least 400ms before the ALR output goes high.

Functional Block Diagram



Application Notes

A single 5 volt power supply is required. The resistor connected between IBIAS and VDD is used to define the internal operating bias currents. The chip alone typically takes approximately 1mA without a transmit head connected, and 2 - 3 mA with a typical transmit head. The chip generates its own mid-rail reference supply of 2.5V which is brought out at the A_{GND} pin for decoupling (mandatory). Most of the internal analog circuitry is referenced to this voltage. The operating current of the internal circuitry is set by the resistor between the I_{BIAS} pin and the 5 volt supply.

The DA5546 requires a 4MHz ceramic resonator which may be of the two or three pin variety. If the resonator has two pins (as shown) then the correct loading capacitors must be connected as specified by the resonator manufacturer. If a three pin resonator is used then these capacitors are included internally and the user simply needs to ground the centre pin.

The DA5546 must be used with 40kHz piezoelectric heads. These are available from several manufacturers in a wide variety of sizes and styles. In general the smaller transducers have lower sensitivity. The DA5546 chip provides a differential output drive at the TXH & TXL pins to drive the transmit head at 10 volts pk-pk. The polarity of the transmit head is unimportant. If a reduced output can be accepted, then the transmit head may be connected between either TXH or TXL and 0 volts to reduce the power consumption.

The receive head should be connected with the case or 'low' side to RXL and the isolated or 'high' side to RXH. Note that the RXL pin is connected to the A_{GND} reference voltage internally and should **not** be connected to 0V externally.

Application Notes (Continued)

The capacitor connected between pins CEV and ground sets the integration time. A value of 47nF will give approximately 400ms. Intrusions must persist for this time before the ALR pin goes high.

Convection current effects cause air movement which increase rapidly as the interior temperature of the car rises. Opening the ventilation outlets on the dashboard also increases these problems. The effect of air movement is to create large Doppler signals in the 0 to 1 Hz frequency band, whereas signals caused by intrusions are in the 10 to 170 Hz band. Since the air movement effects occupy a different frequency band than the wanted signals, they can be removed by filtering. However, these signals can be very much larger than the wanted signals (up to 50dB), so discrimination is improved with a higher order filter.

In the diagrams below (Figures 2 & 3) various configurations of air movement filter are shown :

- Figure 2 shows a simple 2nd order passive high-pass filter with variable gain. This is necessary for correct operation of the system as it provides good discrimination between air movement and slow moving objects. To increase the sensitivity, increase the value of the 180kΩ resistor and decrease the value of the parallel 4.7nF capacitor connected between FIN and FOP. To decrease the upper Doppler limit, increase both the series 15nF capacitor connected to CAH and the parallel 4.7nF capacitor between FIN and FOP. To increase the lower Doppler limit, decrease the parallel 47nF capacitor between CAH and CAL and decrease the series 100nF capacitor connected to PSD.

  For single vehicle type applications, a fixed gain may be employed as the interior parameters of the application will not change. In this case, the 20kΩ variable resistor may be omitted and the other filter components optimised.

- Figure 3 shows a 3rd order active filter with variable gain using the uncommitted buffer op-amp available at pins BIN and BOP. This will give improved discrimination between air movement and slow moving objects over the passive filters shown in Figure 2. To decrease the upper Doppler limit, increase both the series 15nF capacitor connected to CAH and the parallel 2.2nF capacitor between FIN and FOP. To increase the lower Doppler limit, decrease the parallel 47nF capacitor between CAH and CAL and decrease the two series 100nF capacitors connected to PSD.

The ALR pin is the active high alarm output and is both TTL and CMOS level compatible.

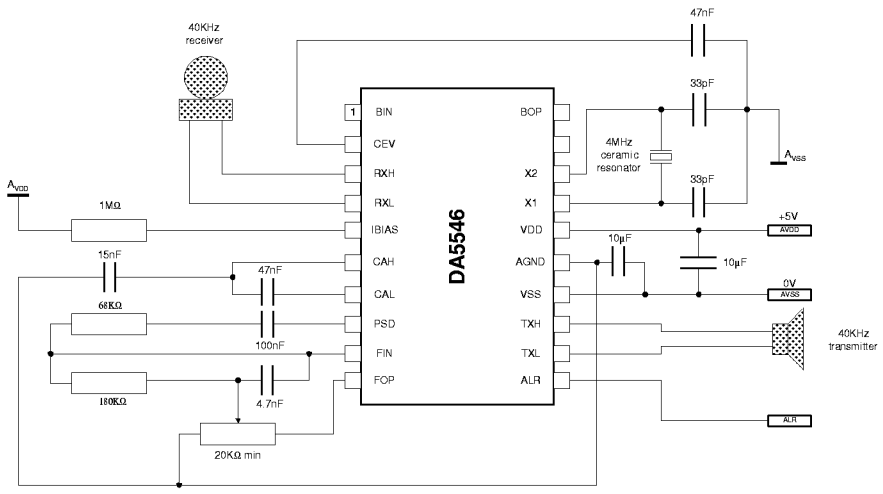


Figure 2 - Simple Filter

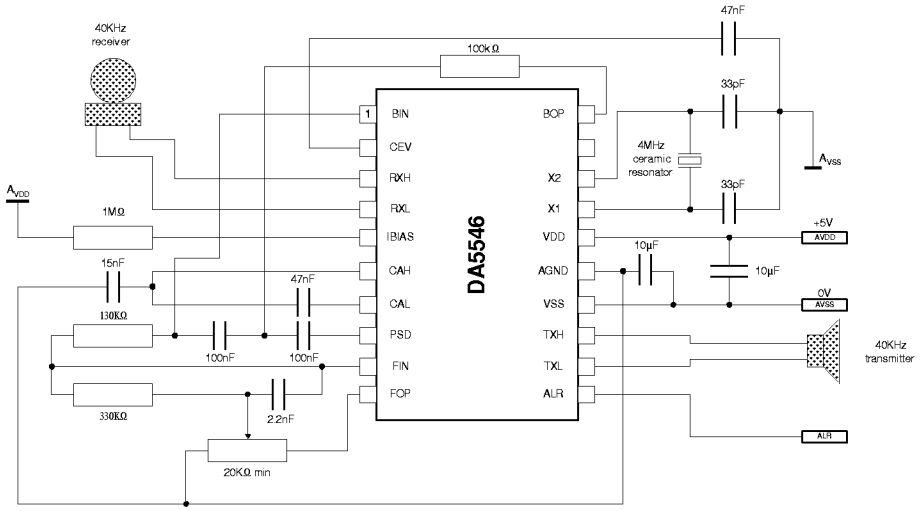


Figure 3 - Extra Air Movement Rejection Filter with Variable Gain

Pin Description

Pin Number	Pin Name	Functional Description
1	BIN	Input to buffer amplifier
2	CEV	Integrator filter capacitor
3	RXH	Receive transducer signal input
4	RXL	Receive transducer signal common
5	IBIAS	Bias current input for internal circuitry
6	CAH	2nd LP/HP capacitor
7	CAL	2nd HP capacitor
8	PSD	Demodulator output to 1st filter
9	FIN	1st filter input
10	FOP	1st filter output
11	ALR	Active high alarm output
12	TXL	Transmit transducer anti-phase drive
13	TXH	Transmit transducer in-phase drive
14	VSS	Negative supply
15	AGND	Internally derived mid-rail reference
16	VDD	Positive supply
17	X1	Oscillator input from ceramic resonator
18	X2	Oscillator output to ceramic resonator
19		Not connected
20	BOP	Output from buffer amplifier

Absolute Maximum Ratings

V_{DD} to V_{SS}	-0.3V, + 7V
All other pins	V_{SS} - 0.3V, V_{DD}+0.3V
Continuous power dissipation	500mW
Operating temperature range	-40°C to +85°C
Storage temperature range	-65°C to +1 60°C
Lead temp (Soldering, 10 sec)	+300°C

Stresses beyond those listed under 'Absolute Maximum Ratings' may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Electrical Characteristics

Specified at V_{DD} = +5V and V_{SS} = 0V and T_{amb} = 25°C, F_{xtal} = 4MHz, I_{bias} = 4µA

Parameter	Min	Max	Units
Return signal at RXH pin for correct operation	0.2	20	mV rms.
Input impedance at RXH pin	50	200	kΩ
Window comparator thresholds	±180	±220	mV
AGND out voltage	2.4	2.6	V
TXH, TXL output swing with 1kΩ load	1.0	4.0	V
V_{DD} supply current without Tx head		1.5	mA

NB. Typical transmit heads will add 0.5 - 5mA to the supply current depending on the head type and whether differential or single ended drive is used.

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