



# FAN3850T

## Microphone Pre-Amplifier with Temperature Compensation and Digital Output

### Features

- Optimized for Mobile Handset and Notebook PC Microphone Applications
- Accepts Input from Electret Condenser Microphones
- Pulse Density Modulation (PDM) Output
- Standard 5-Wire Digital Interface
- Amplifier Gain: 15.7dB or 13.7dB
- Negative Temperature Coefficient to Compensate for ECM Positive Temperature Coefficient
- Low Input Capacitance, High PSR, 20kHz Pre-Amplifier
- Low-Power, 1.5µA Sleep Mode
- Typical 420µA Supply Current
- Signal to Noise Ratio of 62.4dB(A)
- Total Harmonic Distortion: 0.01%
- Input Clock Frequency Range of 1-4MHz
- Integrated Low Drop-Out Regulator (LDO)
- Small 1.26mm x 0.86mm 6-Ball WLCSP

### Applications

- Electret Condenser Microphones with Digital Output
- Mobile Handsets
- Headset Accessories
- Personal Computers (PC)

### Description

The FAN3850T integrates a pre-amplifier, LDO, and Analog-to-Digital Converter (ADC) to convert Electret Condenser Microphone (ECM) outputs to digital Pulse Density Modulation (PDM) data streams. The pre-amplifier accepts analog signals from the ECM and drives an over-sampled sigma delta ADC and outputs PDM data. The PDM digital audio has the advantage of noise rejection and interface-to-mobile handset processors.

The FAN3850T is powered from the system supply rails up to 3.63V, with a low power consumption of only 0.85mW, and less than 20µW in Power-Down Mode. The device compensates for the temperature variation of the microphone element to achieve a flat sensitivity response over-temperature.

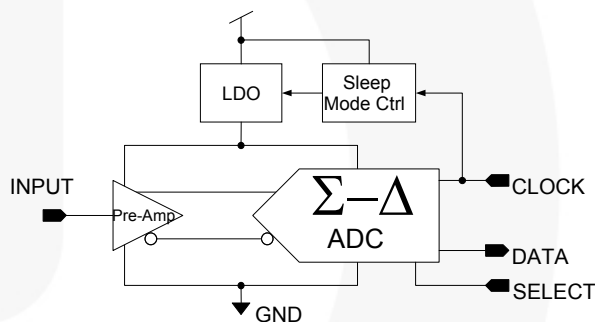


Figure 1. Block Diagram

### Ordering Information

Part Number	Gain Option	Operating Temperature Range	Package	Packing Method
FAN3850TUC15X35	15.7dB	-30°C to +85°C	6-Ball, Wafer-Level Chip-Scale Package (WLCSP)	3000 Unit Tape & Reel
FAN3850TUC13X35	13.7dB			

#### Note:

1. Alternate gain options and temperature coefficient slopes are possible. Please contact a Fairchild representative.

## Pin Configuration

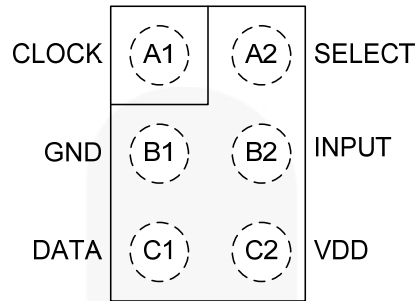


Figure 2. Pin Configuration (Top View)

## Pin Definitions

Pin#	Name	Type	Description
A1	CLOCK	Input	Clock Input
B1	GND	Input	Ground Pin
C1	DATA	Output	PDM Output – 1-Bit ADC
A2	SELECT	Input	Rising or Falling Clock-Edge Select
B2	INPUT	Input	Microphone Input
C2	VDD	Input	Device Power Pin

## 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.

Symbol	Parameter	Min.	Max.	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.3	4.0	V
V <sub>IO</sub>	Analog and Digital I/O	-0.3	V <sub>CC</sub> +0.3	V
ESD	Human Body Model, JESD22-A114 <sup>(2)</sup> , All Pins Except Microphone Input	±7		kV
	Human Body Model, JESD22-A114 <sup>(2)</sup> , Microphone Input	±300		V

### Note:

- This device is fabricated using CMOS technology and is therefore susceptible to damage from electrostatic discharges. Appropriate precautions must be taken during handling and storage of this device to prevent exposure to ESD.

## Reliability Information

Symbol	Parameter	Min.	Typ.	Max.	Unit
T <sub>J</sub>	Junction Temperature			+150	°C
T <sub>STG</sub>	Storage Temperature Range	-65		+125	°C
T <sub>REFLOW</sub>	Peak Reflow Temperature			+260	°C
θ <sub>JA</sub>	Thermal Resistance, JEDEC Standard, Multilayer Test Boards, Still Air		90		°C/W

## 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.

Symbol	Parameter	Min.	Typ.	Max.	Unit
T <sub>A</sub>	Operating Temperature Range	-30		+85	°C
V <sub>DD</sub>	Supply Voltage Range	1.64	1.80	3.63	V
t <sub>RF-CLK</sub>	Clock Rise and Fall Time			10	ns

## Electrical Characteristics

Unless otherwise specified, all limits are guaranteed for  $T_A=25^\circ\text{C}$ ,  $V_{DD}=1.8\text{V}$ ,  $V_{IN}=94\text{dB (SPL)}$ ,  $f_{CLK}=2.4\text{MHz}$ , duty cycle = 50%, and  $C_{MIC}=15\text{pF}$ .

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$V_{DD}$	Supply Voltage Range		1.64	1.80	3.63	V
$I_{DD}$	Supply Current	INPUT=AC Coupled to GND, CLOCK=On, No Load		420		$\mu\text{A}$
$I_{SLEEP}$	Sleep Mode Current	$f_{CLK}=\text{GND}$		1.4	8.0	$\mu\text{A}$
PSR	Power Supply Rejection <sup>(7)</sup>	INPUT=AC Coupled to GND, Test Signal on $V_{DD}=217\text{Hz}$ Square Wave and Broad Band Noise <sup>(3)</sup> both $100\text{mV}_{P-P}$		-80		dBFS
$I_{NOM}$	Nominal Sensitivity <sup>(4)</sup>	INPUT=94dB SPL		-26		dBFS
SNR	Signal-to-Noise Ratio	$f_{IN}=1\text{kHz}$ 1Pa, A-Weighted		62.4		dB(A)
$e_N$	Input Referred Noise <sup>(7)</sup>	20Hz to 20kHz, A-Weighted 15.7dB Gain		5.3	8.6	$\mu\text{V}_{RMS}$
THD	Total Harmonic Distortion <sup>(5)</sup>	$f_{IN}=1\text{kHz}$ , INPUT=-26dBFS		0.01	0.10	%
THD+N	THD and Noise <sup>(7)</sup>	$50\text{Hz} \leq f_{IN} \leq 1\text{kHz}$ , INPUT=-20dBFS		0.2	1.0	%
		$f_{IN}=1\text{kHz}$ , INPUT=-5dBFS		1.0	5.0	
		$f_{IN}=1\text{kHz}$ , INPUT=0dBFS		5.0	10.0	
$t_c$	Temperature Coefficient <sup>(7,11)</sup>	Gain Measured at $50^\circ\text{C}$ and $-10^\circ\text{C}$		-0.035		dB/ $^\circ\text{C}$
$C_{IN}$	Input Capacitance <sup>(7,11)</sup>	INPUT		0.2		pF
$R_{IN}$	Input Resistance <sup>(7,11)</sup>	INPUT	>100			G $\Omega$
$V_{IL}$	CLOCK & SELECT Input, Logic LOW Level				0.3	V
$V_{IH}$	CLOCK & SELECT Input, Logic HIGH Level		1.5		$V_{DD}+0.3$	V
$V_{OL}$	Data Output, Logic LOW Level				$0.35 \times V_{DD}$	V
$V_{OH}$	Data Output, Logic HIGH Level		$0.65 \times V_{DD}$			V
$V_{IN15dB}$	Maximum Input Signal for 15.7dB of Gain <sup>(5)</sup>	$f_{IN}=1\text{kHz}$ , THD+N < 10%; DC Level=0V			503	mV <sub>PP</sub>
$V_{OUT}$	Acoustic Overload Point <sup>(11)</sup>	THD < 10%	120			dB SPL

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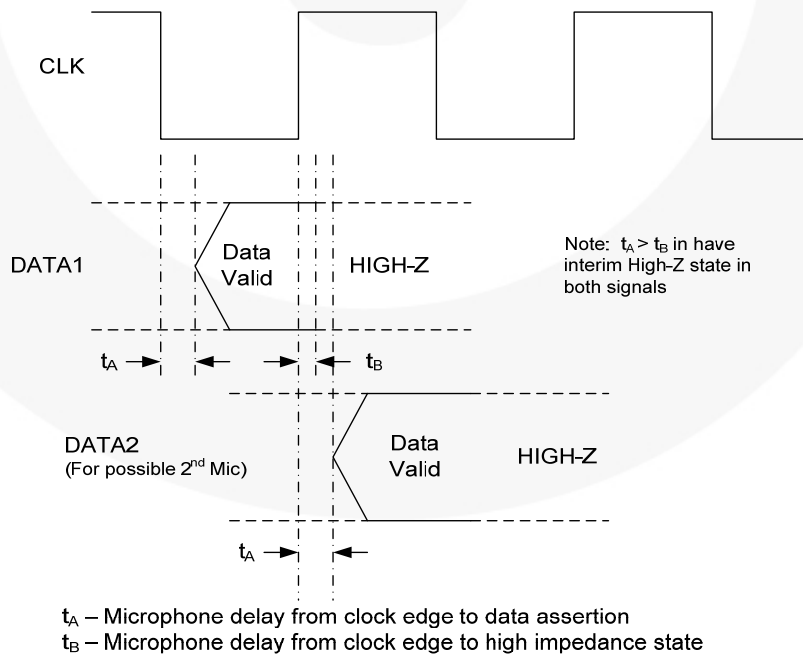
### Electrical Characteristics (Continued)

Unless otherwise specified, all limits are guaranteed for  $T_A=25^\circ\text{C}$ ,  $V_{DD}=1.8\text{V}$ ,  $V_{IN}=94\text{dB (SPL)}$ ,  $f_{CLK}=2.4\text{MHz}$ , duty cycle = 50%, and  $C_{LOAD}=15\text{pF}$ .

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$t_A$	Time from CLOCK Transition to Data Becoming Valid	On Falling Edge of CLOCK, SELECT=GND, $C_{LOAD}=15\text{pF}$	18	43		ns
$t_B$	Time from CLOCK Transition to Data Becoming Hi-Z	On Rising Edge of CLOCK, SELECT=GND, $C_{LOAD}=15\text{pF}$	0	5	16	ns
$t_A$	Time from CLOCK Transition to Data Becoming Valid	On Rising Edge of CLOCK, SELECT= $V_{DD}$ , $C_{LOAD}=15\text{pF}$	18	56		ns
$t_B$	Time from CLOCK Transition to Data Becoming Hi-Z	On Falling Edge of CLOCK, SELECT= $V_{DD}$ , $C_{LOAD}=15\text{pF}$	0	5	16	ns
$f_{CLK}$	Input CLOCK Frequency <sup>(8)</sup>	Active Mode	1.0	2.4	4.0	MHz
$CLK_{dc}$	CLOCK Duty Cycle <sup>(7)</sup>		40	50	60	%
$t_{WAKEUP}$	Wake-Up Time <sup>(9)</sup>	$f_{CLK}=2.4\text{MHz}$		0.35	2.00	ms
$t_{FALLASLEEP}$	Fall-Asleep Time <sup>(10)</sup>	$f_{CLK}=2.4\text{MHz}$	0	0.01	1.00	ms
$C_{LOAD}$	Load Capacitance on Data				100	pF

**Notes:**

3. Pseudo-random noise with triangular probability density function. Bandwidth up to 10MHz.
4. Assumes 120dB(SPL) is mapped to 0dBFS.
5. Assumes an input -41, or -38dBV, depending on the part-specific gain.
6. Verified by design simulation, showing idle tones and low noise level modulation to be typical 96dB.
7. Guaranteed by characterization.
8. All parameters are tested at 2.4MHz. Frequency range guaranteed by characterization.
9. Device wakes up when  $f_{CLK} \geq 300\text{kHz}$ .
10. Device falls asleep when  $f_{CLK} \leq 70\text{kHz}$ .
11. Guaranteed by design.
12. Temperature coefficient is calculated by measuring gain in db at  $50^\circ\text{C}$  and  $-10^\circ\text{C}$  and dividing by 60 (Gain( $50^\circ\text{C}$ ) - Gain( $-10^\circ\text{C}$ )/60).



**Figure 3. Interface Timing**

### Typical Performance Characteristics

Unless otherwise specified, all limits are guaranteed for  $T_A=25^{\circ}\text{C}$ ,  $V_{DD}=1.8\text{V}$ ,  $V_{IN}=94\text{dB(SPL)}$ ,  $f_{CLK}=2.4\text{MHz}$ , and duty cycle=50%.

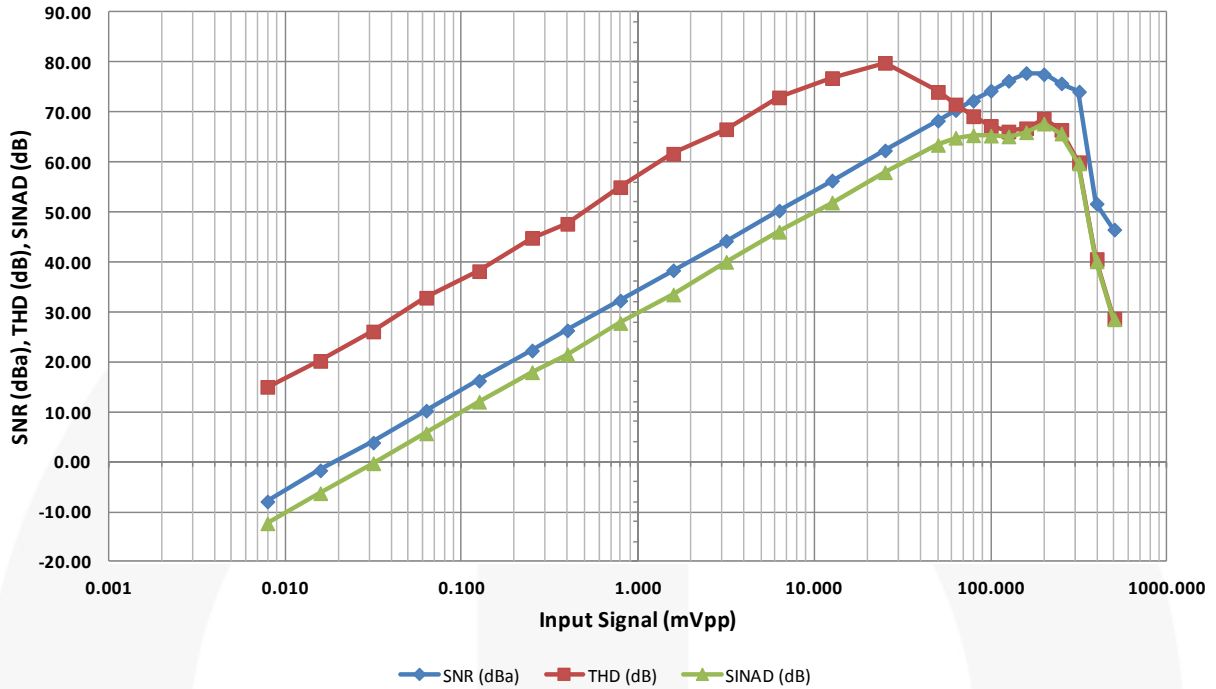


Figure 4. THD, SINAD, and SNR vs. Input Amplitude

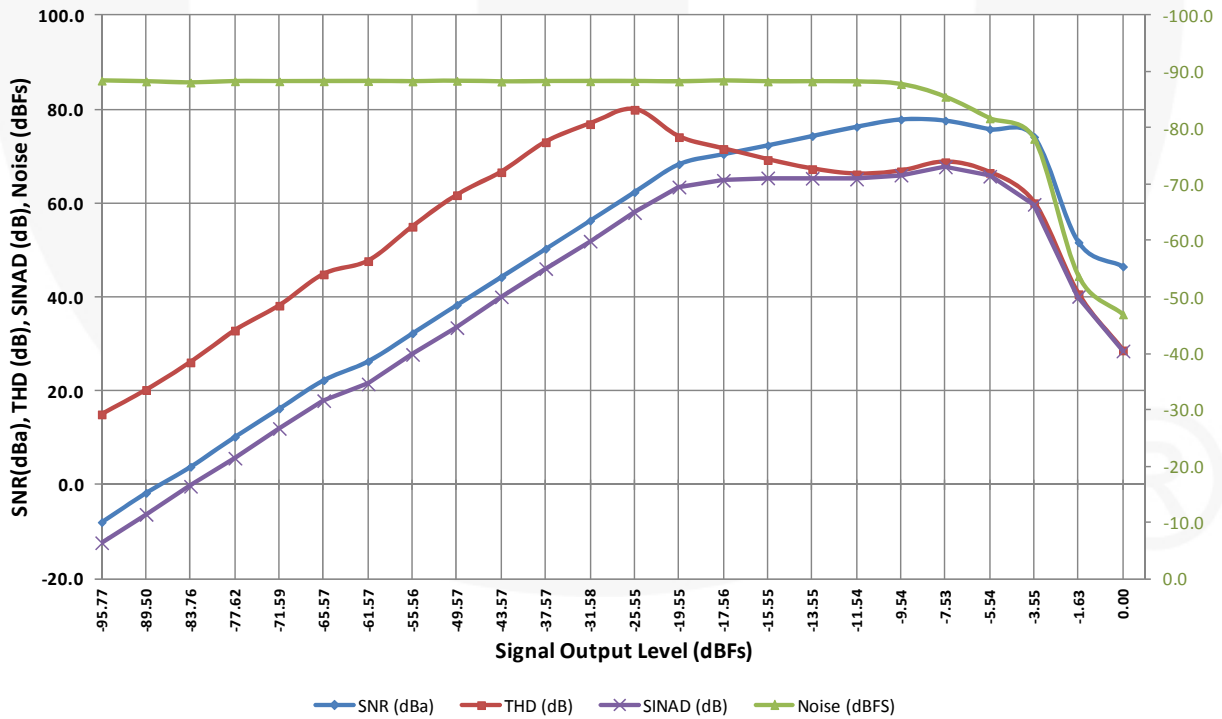


Figure 5. THD, SINAD, and SNR vs. Output Level

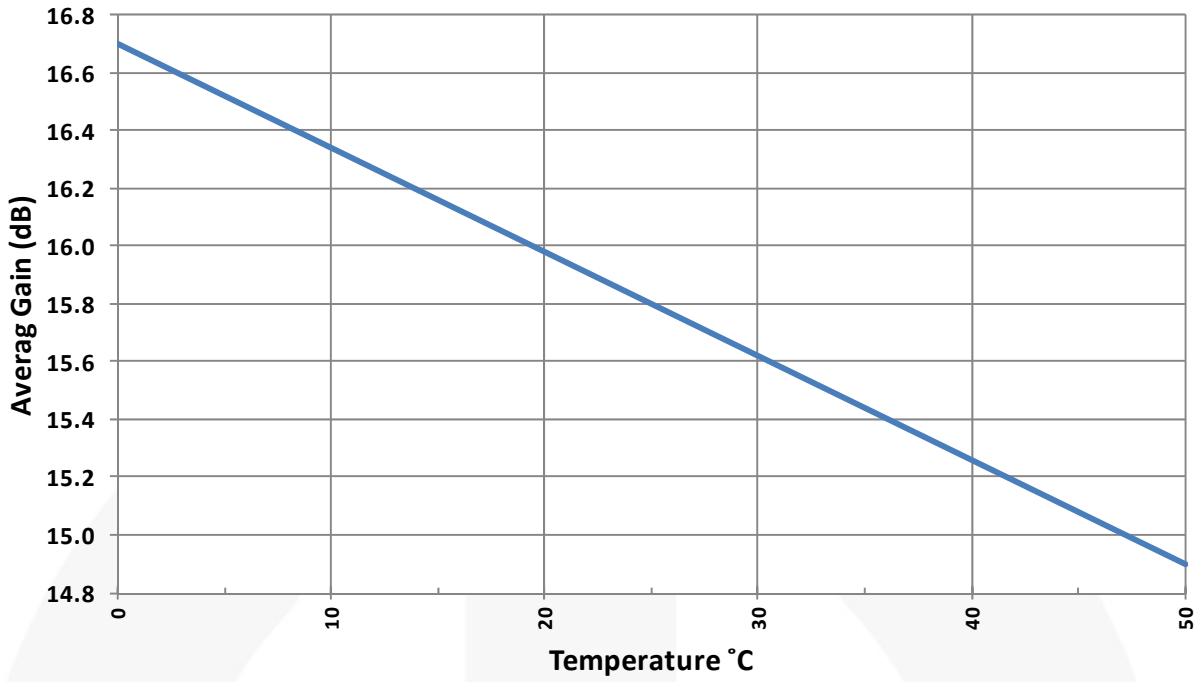
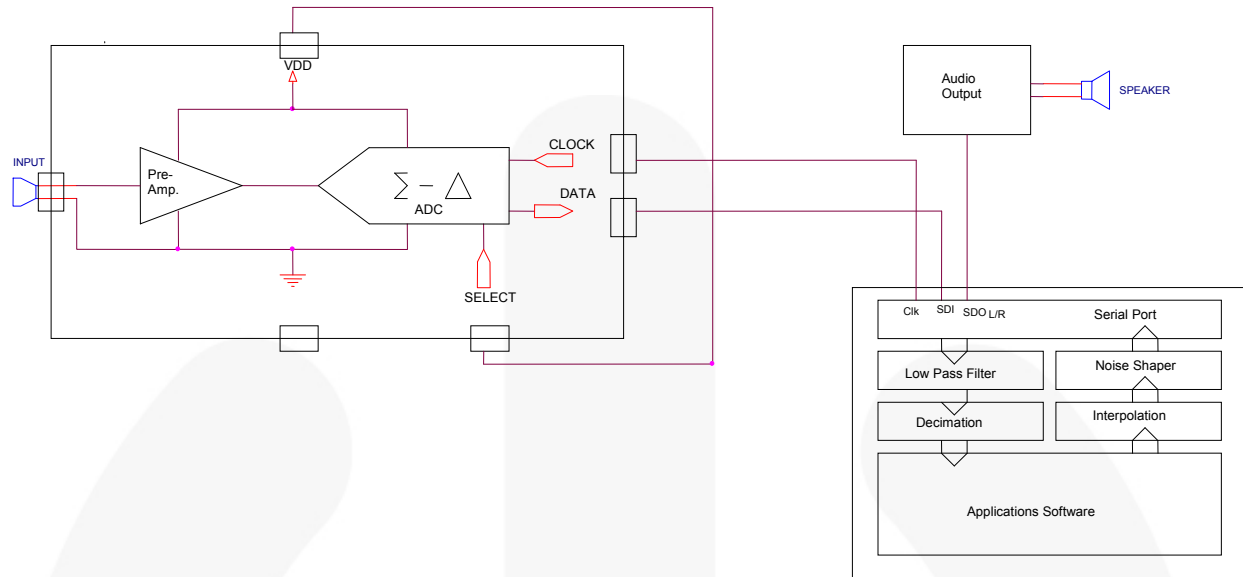


Figure 6. Gain vs. Temperature ( $\sim 0.035\text{dB}/^\circ\text{C}$ )(1)

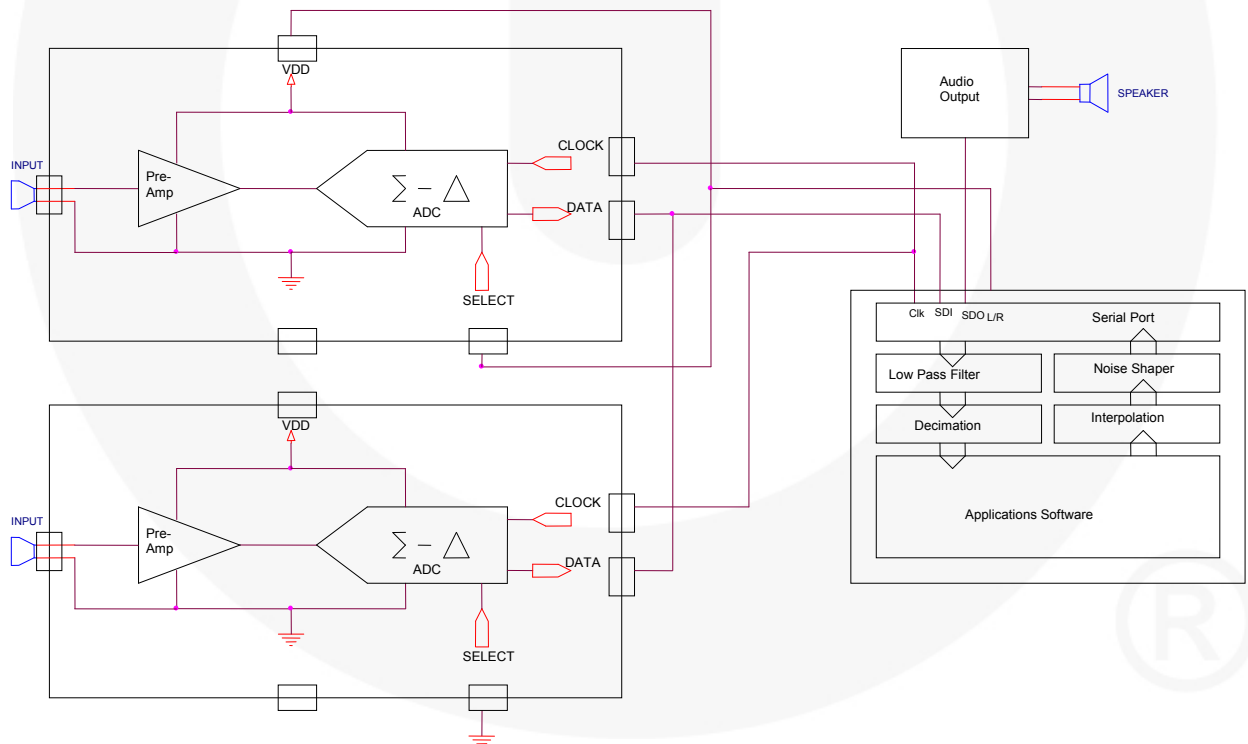
**Note:**

13. Alternate temperature coefficient slopes are possible. Please contact a Fairchild representative.

## Applications Information



**Figure 7. Mono Microphone Application Circuit**



**Figure 8. Stereo Microphone Application Circuit**



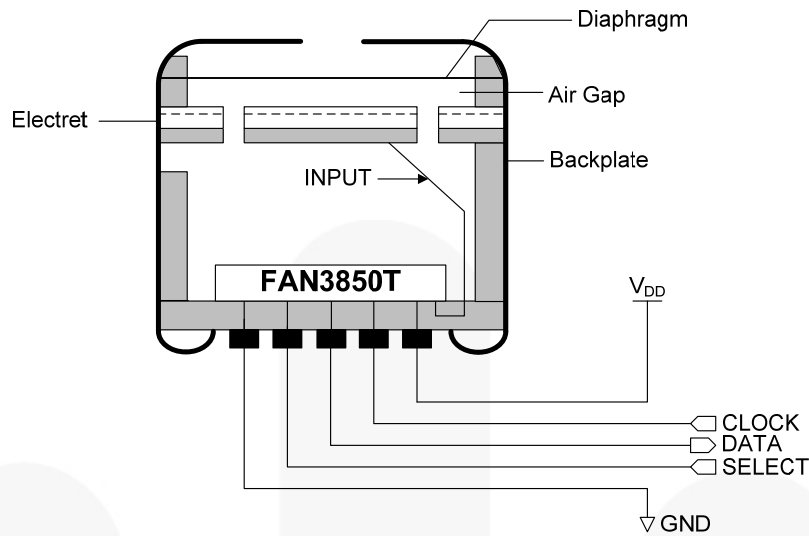


Figure 9. MIC Element Drawing

### Applications Information

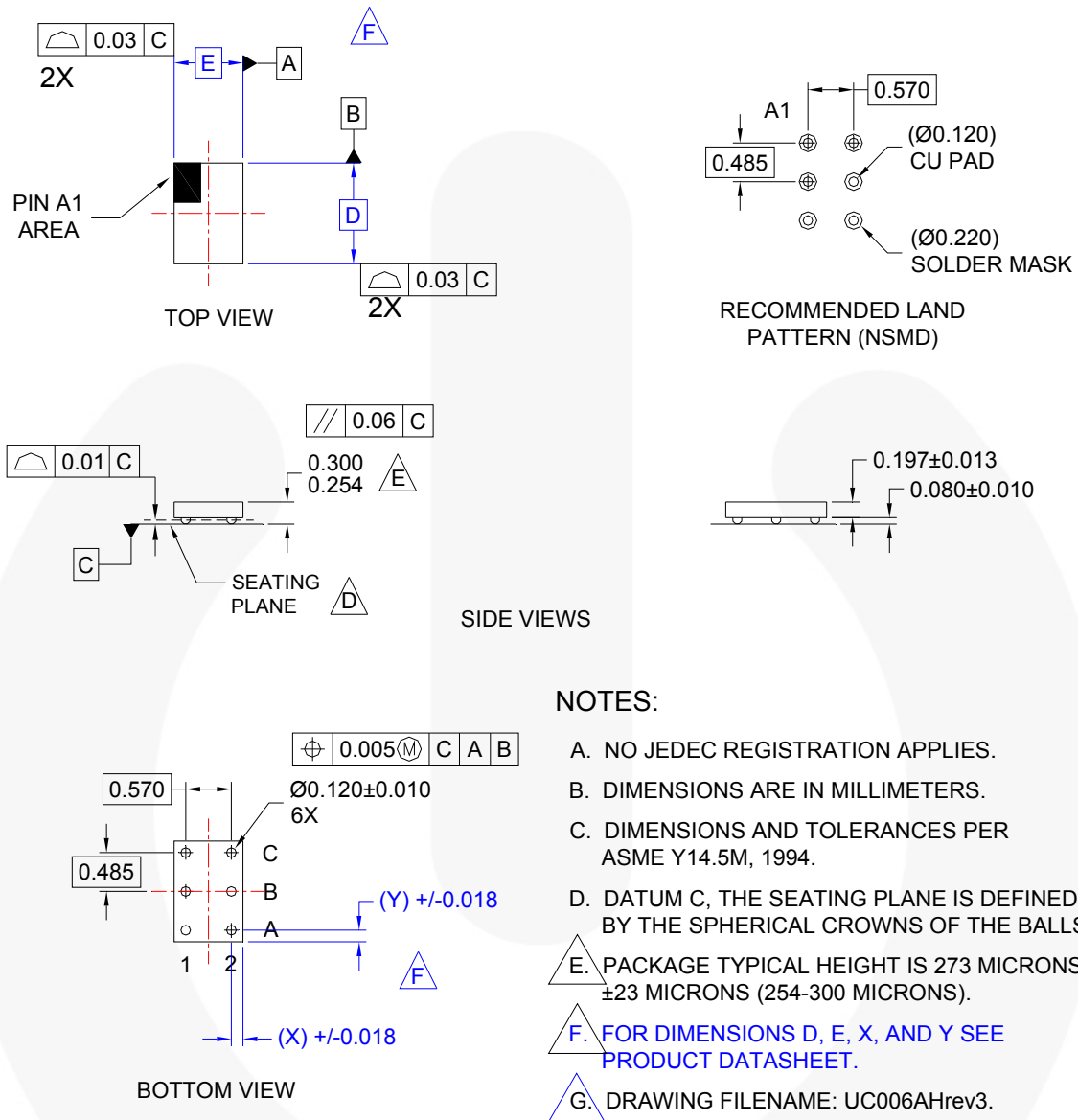
A 0.1 $\mu$ F decoupling capacitor is required for  $V_{DD}$ . It can be located either inside the microphone or on the PCB very close to the  $V_{DD}$  pin.

Due to high input impedance, careful consideration should be taken to remove all flux used during the reflow soldering process.

A 100 $\Omega$  resistance is recommended on the clock output of the device driving the FAN3850T to minimize ringing and improve signal integrity.

For optimal PSR, route a trace to the  $V_{DD}$  pin. Do not place a  $V_{DD}$  plane under the device.

### Physical Dimensions



**Figure 10. 6-Ball, Wafer-Level Chip-Scale Package (WLCSP)**

**Table 1. Product-Specific Dimensions**

D	E	X	Y
1.260mm	0.860mm	0.145mm	0.145mm
Ball Composition: SN97.5-Ag2.5			





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