# FAN3852

# Microphone Pre-Amplifier with Digital Output

### Description

The FAN3852 integrates a pre−amplifier, LDO, and ADC that converts 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 Analog−to−Digital Converter (ADC) and outputs PDM data. The PDM digital audio has the advantage of noise rejection and easy interface to mobile handset processors.

The FAN3852 features an integrated LDO and is powered from the system supply rails up to 3.63 V, with low power consumption of only 0.85 mW and less than 20 μW in Power−Down Mode.

### Features

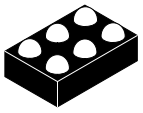
- Optimized for Mobile Handset and Notebook PC Microphone Applications
- Accepts Input from Electret Condenser Microphones (ECM)
- Pulse Density Modulation (PDM) Output
- Standard 5−Wire Digital Interface
- Low Input Capacitance, High PSR, 20 kHz Pre−Amplifier
- Low−Power 1.5 μA Sleep Mode
- Typical 420 μA Supply Current
- SNR of 62 dB (A) for 16 dB Gain
- Total Harmonic Distortion 0.02%
- Input Clock Frequency Range of 1−4 MHz
- Integrated Low Drop−Out Regulator (LDO)
- Small 1.242 mm × 0.842 mm 6−Ball, 0.400 mm pitch standard WLCSP Package
- 1.5 kV HBM ESD on MIC Input

### Typical Applications

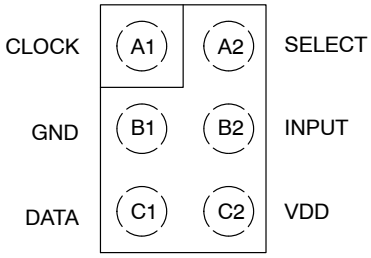
- Electret Condenser Microphones with Digital Output
- Mobile Handset
- Headset Accessories
- Personal Computer (PC)

**ON Semiconductor®**

www.onsemi.com



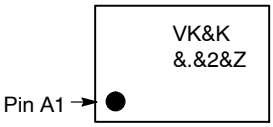
**WLCSP−6**
**CASE 567TS**




Top View

**PIN CONFIGURATION**

**MARKING DIAGRAM**




| | | |
|---|---|---|
| VK | = | Device Identifier |
| K | = | Lot Run Code |
| . | = | Pin A1 Mark |
| 2 | = | Date Code |
| Z | = | Plant Code |

**ORDERING INFORMATION**

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

## ORDERING INFORMATION

| Part Number | Operating Temperature Range | Package | Packing Method† |
|---|---|---|---|
| FAN3852UC16X | −40°C to +85°C | 6 Ball, Wafer−Level Chip−Scale Package (WLCSP) | 3000 Units / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## INTERNAL BLOCK DIAGRAM

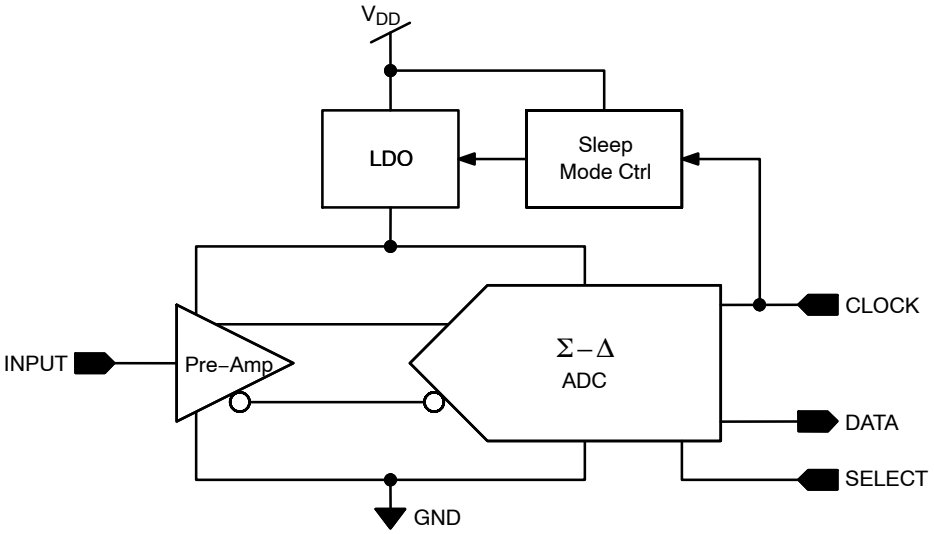



**Figure 1. Block Diagram**

### Table 1. 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 |

### Table 2. ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{DD}$ | DC Supply Voltage | −0.3 | 4.0 | V |
| $V_{IO}$ | Digital I/O | −0.3 | $V_{DD}$ + 0.3 | V |
| | Microphone Input | −0.3 | 2.2 | |
| ESD | Human Body Model, JESD22−A114, All Pins Except Microphone Input | ±8 | | kV |
| | Human Body Model, JESD22−A114 − Microphone Input | ±1.5 | | |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. 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.

**Table 3. RELIABILITY INFORMATION**

| Symbol | Rating | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $T_J$ | Junction Temperature | | | +150 | °C |
| $T_{STG}$ | Storage Temperature Range | −65 | | +125 | °C |
| $T_{RFLW}$ | Peak Reflow Temperature | | | +260 | °C |
| $\Theta_{JA}$ | Thermal Resistance, JEDEC Standard, Multilayer Test Boards, Still Air | | 90 | | °C/W |

2. $T_A$ = 25°C unless otherwise specified

**Table 4. RECOMMENDED OPERATING CONDITIONS**

| Symbol | Rating | Min | Unit | Max | Unit |
|---|---|---|---|---|---|
| $T_A$ | Operating Temperature Range | −400 | | +85 | °C |
| $V_{DD}$ | Supply Voltage Range | 1.64 | 1.80 | 3.63 | V |
| $T_{RF-CLK}$ | Clock Rise and Fall Time | | | 10 | ns |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

**Table 5. DEVICE SPECIFIC ELECTRICAL CHARACTERISTICS**

| Symbol | Value | FAN3852UC16X | | | Unit |
|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | |
| SNR | Signal−to−Noise Ratio<br>$f_{IN}$ = 1 kHz (1 Pa), A−Weighted | | 62 | | dB (A) |
| $e_N$ | Total Input RMS Noise<br>20 Hz to 20 kHz, A−Weighted | | 5.74 | 6.80 | $\mu V_{RMS}$ |
| $V_{IN}$ | Maximum Input Signal<br>$f_{IN}$ = 1 kHz, THD + N < 10%, Level = 0 V | | | 448 | $mV_{PP}$ |

3. Guaranteed by characterization and / or design. Not production tested.

**Table 6. ELECTRICAL CHARACTERISTICS**

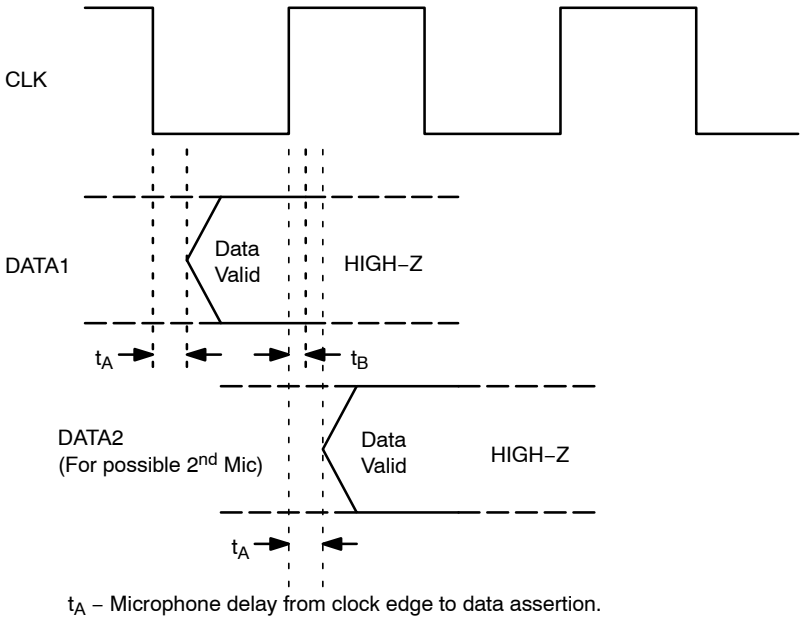
Unless otherwise specified, al limits are guaranteed for $T_A$ = 25°C, $V_{DD}$ = 1.8 V, $V_{IN}$ = 94 dB (SPL) and $f_{CLK}$ = 2.4 MHz. Duty Cycle = 50% and $C_{MIC}$ = 15 pF.

| 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 | | μA |
| $I_{SLEEP}$ | Sleep Mode Current | $f_{CLK}$ = GND | | 1.50 | 8.0 | μA |
| PSR | Power Supply Rejection (Note 5) | INPUT = AC Coupled to GND, Test Signal on $V_{DD}$ = 217 Hz, Square Wave and Broadband Noise (Note 4), Both 100 $mV_{P-P}$ | | −74 | | dBFS |
| $IN_{NOM}$ | Nominal Sensitivity (Note 6) | INPUT = 94 dBSPL (1 Pa) | | −26 | | dBFS |
| THD | Total Harmonic Distortion (Note 7) | $f_{IN}$ = 1 KHz, INPUT = −26 dBFS | | 0.02 | 0.20 | % |
| THD+N | THD and Noise (Note 5) | 50 Hz ≤ $f_{IN}$ ≤ 1 kHz, INPUT = −20 dBFS | | 0.2 | 1.0 | % |
| | | $f_{IN}$ = 1 KHz, INPUT = −5 dBFS | | 1.0 | 5.0 | |
| | | $f_{IN}$ = 1 KHz, INPUT = 0 dBFS | | 5.0 | 10.0 | |
| $C_{IN}$ | Input Capacitance (Note 8) | INPUT | | 1.3 | | pF |
| $R_{IN}$ | Input Resistance (Note 8) | INPUT | >10 | | | GΩ |
| $V_{IL}$ | CLOCK & SELECT Input Logic LOW Level | | | | 0.3 | V |

**Table 6. ELECTRICAL CHARACTERISTICS** (continued)
Unless otherwise specified, al limits are guaranteed for $T_A$ = 25°C, $V_{DD}$ = 1.8 V, $V_{IN}$ = 94 dB (SPL) and $f_{CLK}$ = 2.4 MHz. Duty Cycle = 50% and $C_{MIC}$ = 15 pF.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{IH}$ | CLOCK & SELECT Input Logic HIGH Level | | 1.5 | | $V_{DD}$+0.3 | V |
| $V_{OL}$ | Data Output Logic LOW Level | | | | 0.35*$V_{DD}$ | V |
| $V_{OH}$ | Data Output Logic HIGH Level | | 0.65*$V_{DD}$ | | | V |
| $V_{OUT}$ | Acoustic Overload Point (Note 8) | THD+N < 10% | 120 | | | dBSPL |
| $t_A$ | Time from CLOCK Transition to Data becoming Valid | On Falling Edge of CLOCK, SELECT = GND, $C_{LOAD}$ = 15 pF | 18 | 43 | | ns |
| $t_B$ | Time from CLOCK Transition to Data becoming HIGH−Z | On Rising Edge of CLOCK, SELECT = GND, $C_{LOAD}$ = 15 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 pF | 18 | 56 | | ns |
| $t_B$ | Time from CLOCK Transition to Data becoming HIGH−Z | On Falling Edge of CLOCK, SELECT = $V_{DD}$, $C_{LOAD}$ = 15 pF | 0 | 5 | 16 | ns |
| $f_{CLK}$ | Input CLOCK Frequency (Note 9) | Active Mode | 1.0 | 2.4 | 4.0 | MHz |
| $CLK_{dc}$ | CLOCK Duty Cycle (Note 5) | | 40 | 50 | 60 | % |
| $t_{WAKEUP}$ | Wake−Up Time (Note 10) | $f_{CLK}$ = 2.4 MHz | | 0.35 | 2.00 | ms |
| $t_{FALLASLEAP}$ | Fall−Asleep Time (Note 11) | $f_{CLK}$ = 2.4 MHz | 0 | 0.01 | 1.00 | ms |
| $C_{LOAD}$ | Load Capacitance on Data | | | | 100 | pF |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
4. Pseudo−random noise with triangular probability density function. Bandwidth up to 10 MHz.
5. Guaranteed by characterization. Not production tested.
6. Assuming that 120 dB(SPL) is mapped to 0 dBFS.
7. Assuming an input of −45 dBV.
8. Guaranteed by design. Not production tested.
9. All parameters are tested at 2.4 MHz. Frequency range guaranteed by characterization.
10. Device wakes up when $f_{CLK} \geq$ 300 kHz.
11. Device falls asleep when $f_{CLK} \leq$ 70 kHz.




$t_A$ − Microphone delay from clock edge to data assertion.
$t_B$ − Microphone delay from clock edge to high−impedance state.
$t_A > t_B$ to have interim HIGH−Z state in both signals.

**Figure 2. Interface Timing**

## Typical Performance Characteristics

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

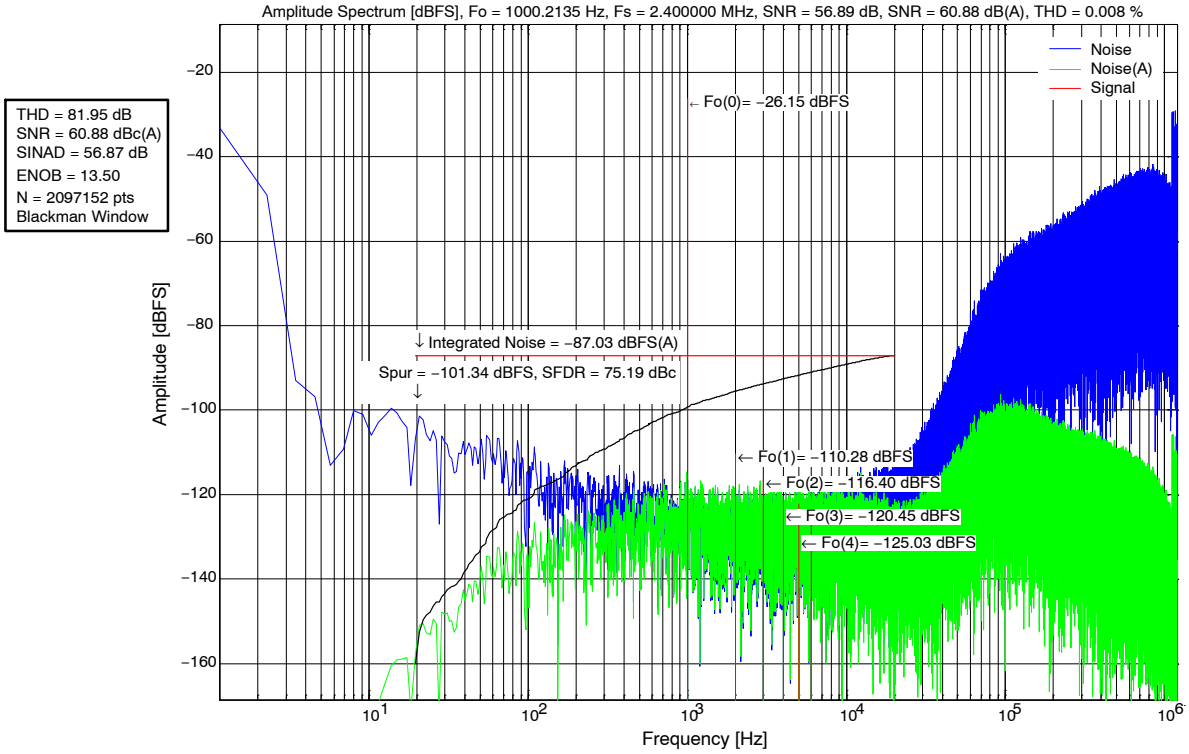



**Figure 3. Noise vs. Frequency**

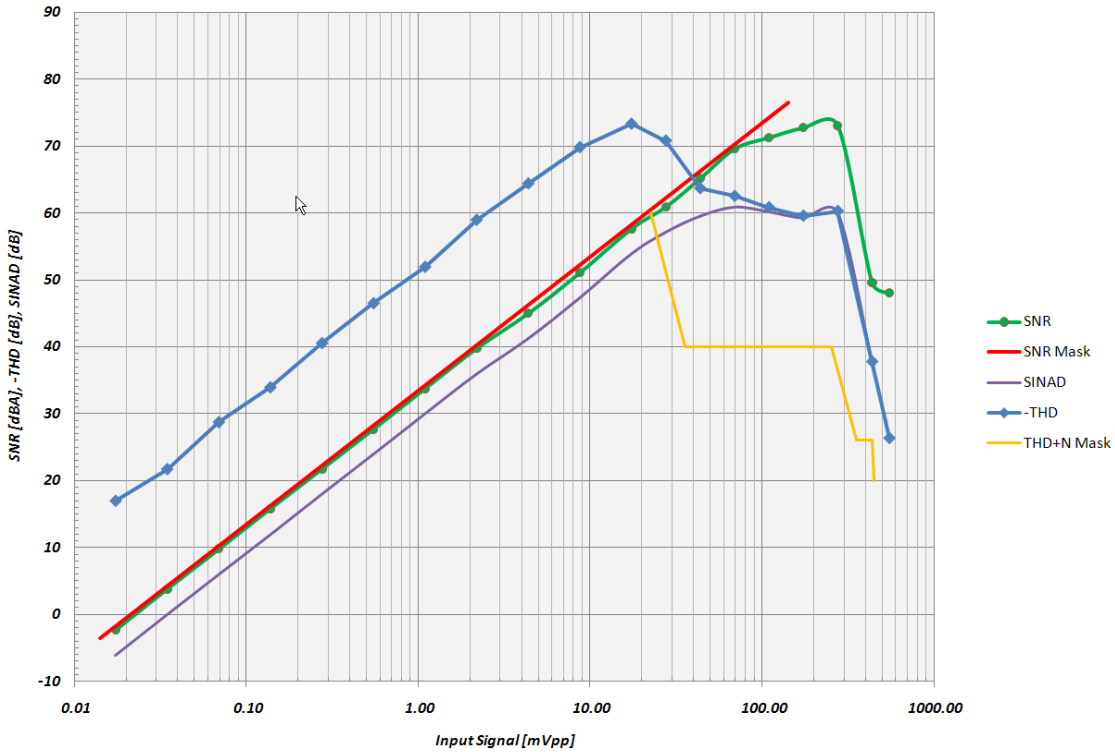



**Figure 4. THD, SINDA, and SNR vs. Input Amplitude**

## Typical Performance Characteristics

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

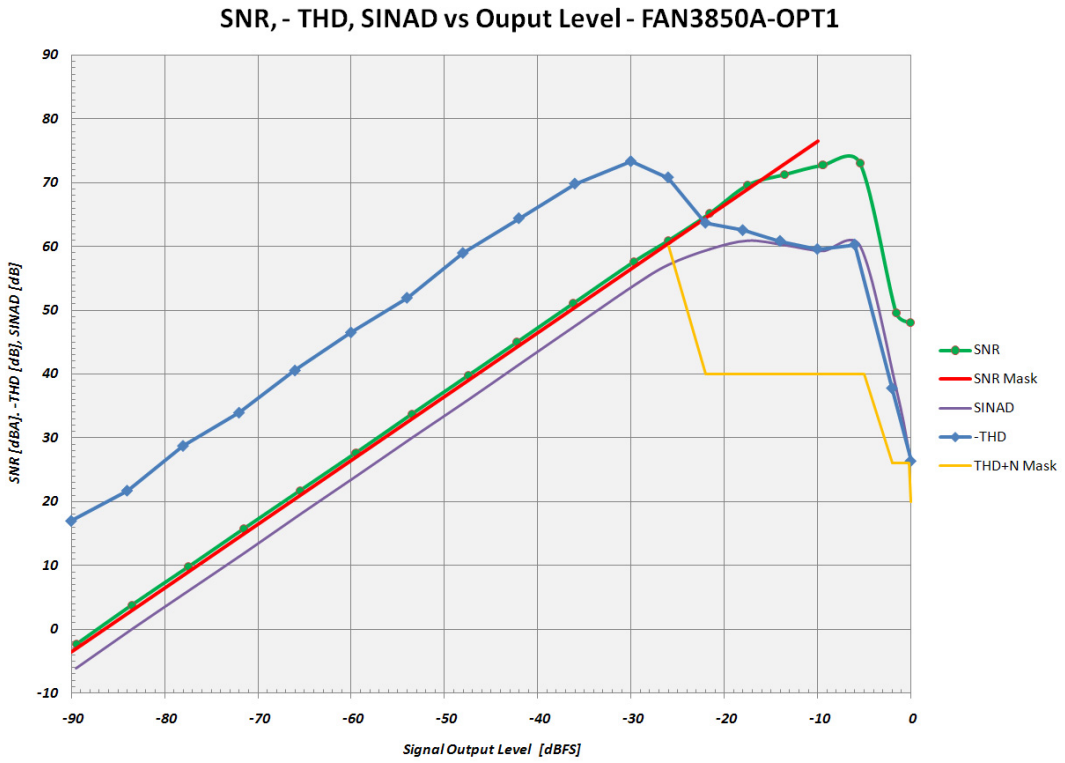



**Figure 5. THD, SINAD and SNR vs. Output Level**

| Temp (˚C) | Delta(dB) |
|---|---|
| -40 | 0.1971 |
| -30 | 0.1644 |
| -20 | 0.1260 |
| -10 | 0.0954 |
| 0 | 0.0657 |
| 10 | 0.0359 |
| 20 | 0.0139 |
| 25 | 0.0000 |
| 30 | -0.0097 |
| 40 | -0.0344 |
| 50 | -0.0514 |
| 60 | -0.0739 |
| 70 | -0.0998 |
| 80 | -0.1183 |
| 85 | -0.1271 |

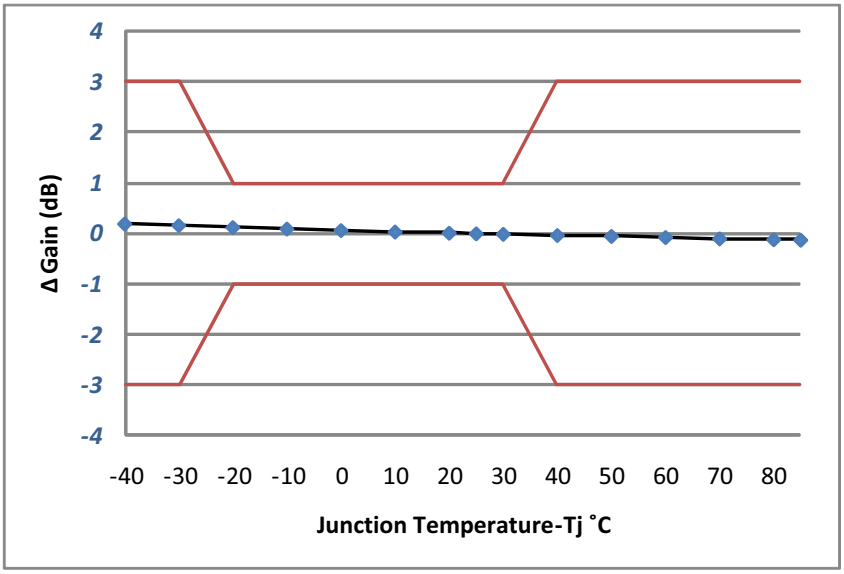



**Figure 6. Δ Gain vs. Temperature (Nominal Temperature = 25°C)**

## Applications Information

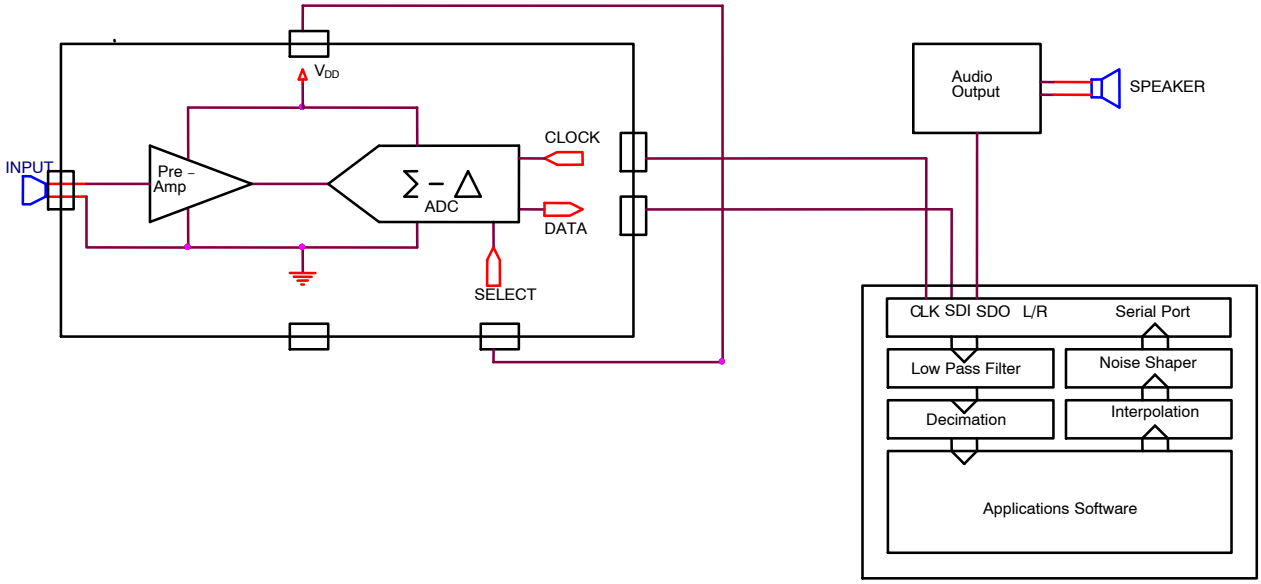



**Figure 7. Mono Microphone Application Circuit**

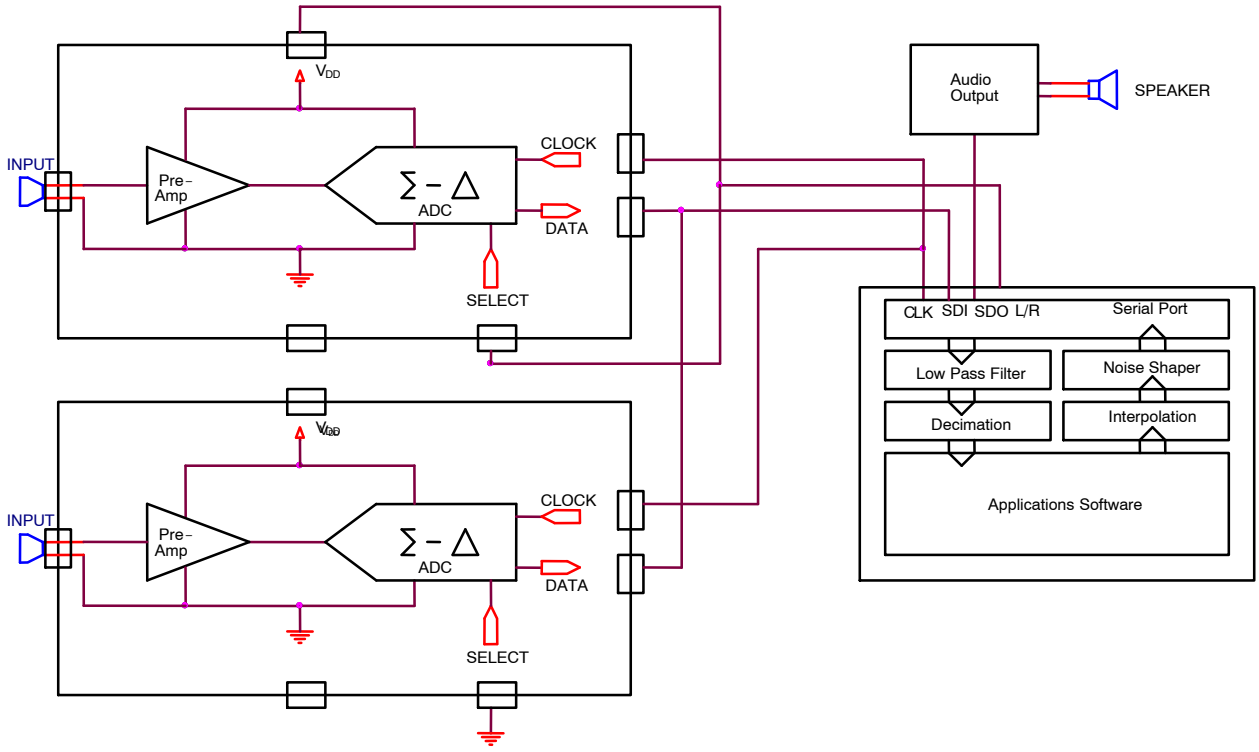



**Figure 8. Stereo Microphone Application Circuit**

## Applications Information (continued)

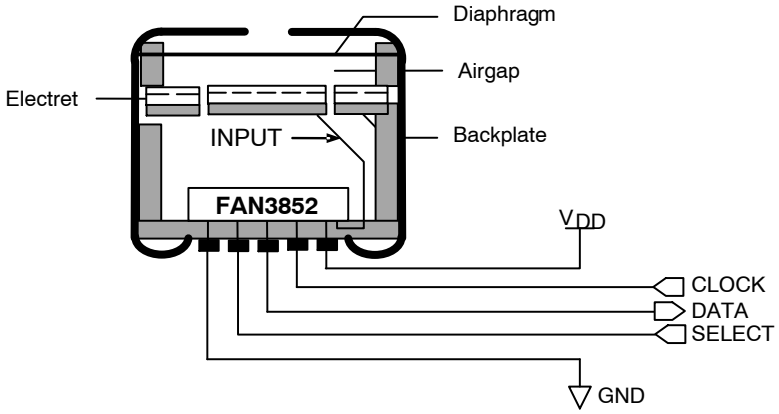



**Figure 9. MIC Element Drawing**

A 0.1 μF decoupling capacitor is required for VDD. It can be located inside the microphone or on the PCB very close to the VDD pin.

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

A 100 Ω resistance is recommended on the clock output of the device driving the FAN3852 to minimize ringing and improve signal integrity.

For optimal PSR, route a trace to the VDD pin. Do not place a VDD plane under the device.

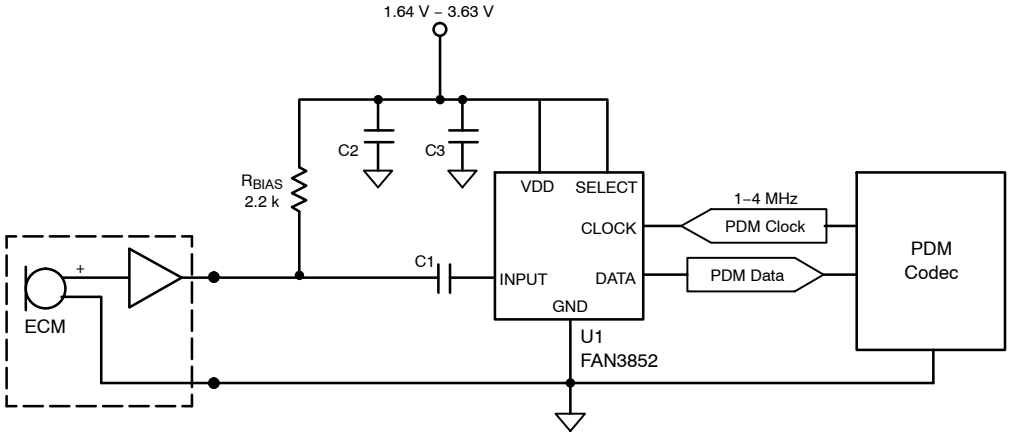


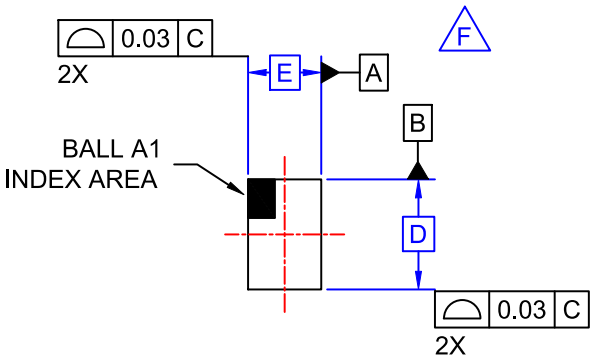

**Figure 10. Example Hardware Implementation**

**Table 7. RECOMMENDED COMPONENTS**

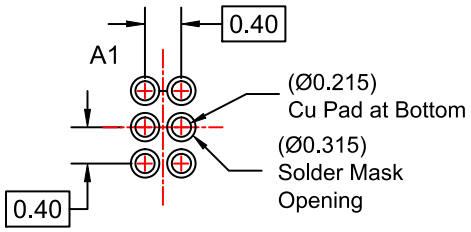
| Ref Des | Qty | Description of Options | Package | Manufacturer | Mfg PIN |
|---|---|---|---|---|---|
| U1 | 1 | FAN3852 Microphone Pre−Amplifier with Digital Output | WLCSP6 | ON Semiconductor | FAN3852UC16X |
| C1 | 1 | Input AC Coupling Capacitor; 1 nF/1000 pF, ≥ 6.3 V, low−leakage | 0402 | Johansen Dielectrics | 500R07W102KV4T |
| | | | 0402 | Murata | GCM155R71H102KA37D |
| | | | 0603 | Taiyo Yuden | UMK107SD102KA−T |
| C2 | 1 | Primary VDD Decoupling Capacitor; 0.1 μF, MLCC, ≥ 6.3 V | 0402 | Samsung | CL05B104KO5NNNC |
| | | | 0402 | Yageo | CC0402KRX7R7BB104 |
| | | | 0603 | AVX | 06033C104KAT4A |
| C3 | 1 | Optional VDD Decoupling Capacitor; 0.01 μF, MLCC, ≥ 6.3 V | 0402 | Samsung | CL05B103KB5VPNC |
| | | | 0402 | Murata | GCM155R71H103KA55J |
| | | | 0603 | Yageo | CC0603KRX7R7BB103 |

## PACKAGE DIMENSIONS

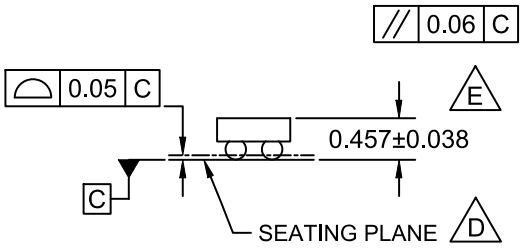
**WLCSP6 1.242x0.842x0.495**
CASE 567TS
ISSUE O

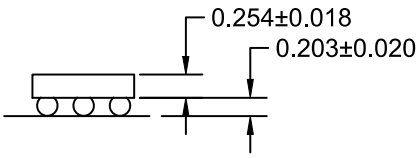



TOP VIEW

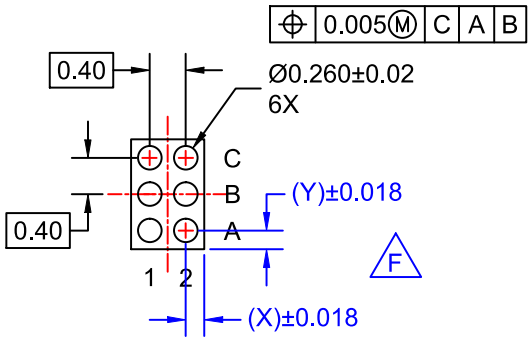



RECOMMENDED LAND PATTERN
(NSMD PAD TYPE)




SIDE VIEWS




BOTTOM VIEW

NOTES:

A. NO JEDEC REGISTRATION APPLIES.

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES PER ASMEY14.5M, 2009.

D. DATUM C, THE SEATING PLANE IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.

E. PACKAGE TYPICAL HEIGHT IS 457 MICRONS ±38 MICRONS (419-495 MICRONS).

F. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.

## PUBLICATION ORDERING INFORMATION

**LITERATURE FULFILLMENT**:
Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
**Phone**: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
**Fax**: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
**Email**: orderlit@onsemi.com

**N. American Technical Support**: 800−282−9855 Toll Free USA/Canada
**Europe, Middle East and Africa Technical Support:**
Phone: 421 33 790 2910

**ON Semiconductor Website**: **www.onsemi.com**

**Order Literature**: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative