

AUTONOMOUS AUDIO HEADSET SWITCH

 Check for Samples: [TS3A225E](#)

FEATURES

- V_{DD} Range = 2.7 V to 4.5 V
- Break Before Make Stereo Jack Switches
- R_{on} for Ground FET Switches
 - WCSP Package: 70 m Ω
 - QFN Package: 100 m Ω
- Autonomous Detection of GND and MIC Connections
- Detection Triggered by I²C or External Trigger Pin
- HDA Compatible MIC Present Indicator
- 1.8V Compatible I²C Switch Control
- ESD Performance Tested Per JESD 22:
 - 2000-V Human-Body Model (A114-B, Class II)
 - 500-V Charged-Device Model (C101)
- ESD Performance (SLEEVE, RING2, TIP)
 - ± 8 -kV Contact Discharge (IEC 61000-4-2)

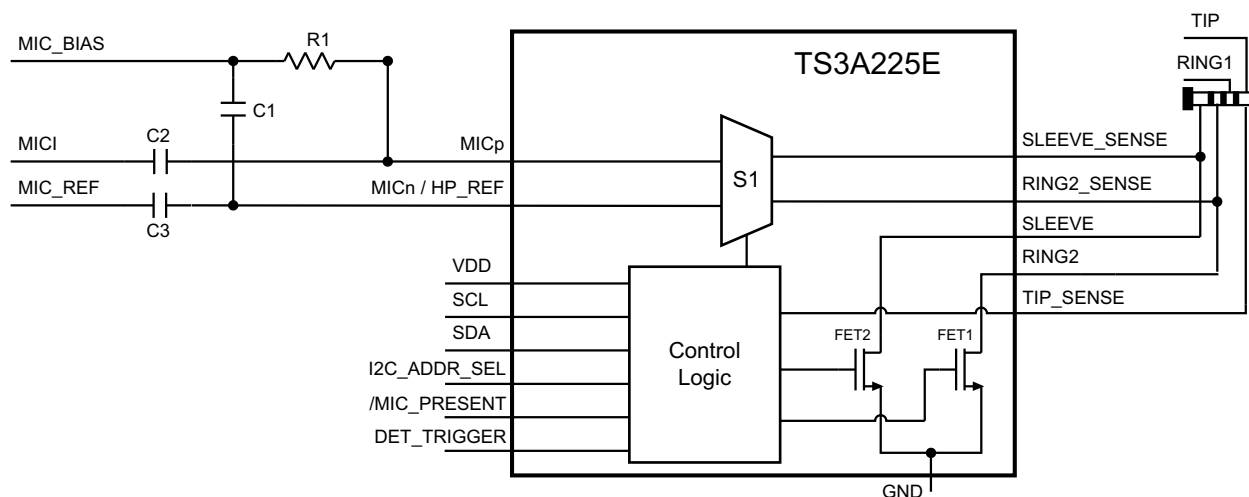
APPLICATIONS

- Mobile Phones/ Tablet PCs
- Notebook Computers

DESCRIPTION

The TS3A225E is an audio headset switch device. The device detects the presence of an analog microphone and switches a system analog microphone pin between different connectors in an audio stereo jack. The microphone connection in a stereo connector can be swapped with the ground connection depending on manufacturer. When the TS3A225E detects a certain configuration, the device automatically connects the microphone line to the appropriate pin. The device also reports the presence of an analog microphone on an audio stereo jack.

In some systems, it is desirable to connect the stereo jack pin to ground. The TS3A225E provides two internal low resistance (<100m Ω) FET switches for ground shorting.



ORDERING INFORMATION

| T _A | PACKAGE ⁽¹⁾⁽²⁾ | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|----------------|---------------------------|---------------|-----------------------|------------------|
| | -40°C to 85°C | RTE - QFN | | |
| YFF - WCSP | | Tape and reel | TS3A225EYFFR | YP225E |

(1) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

(2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI Web site at www.ti.com.

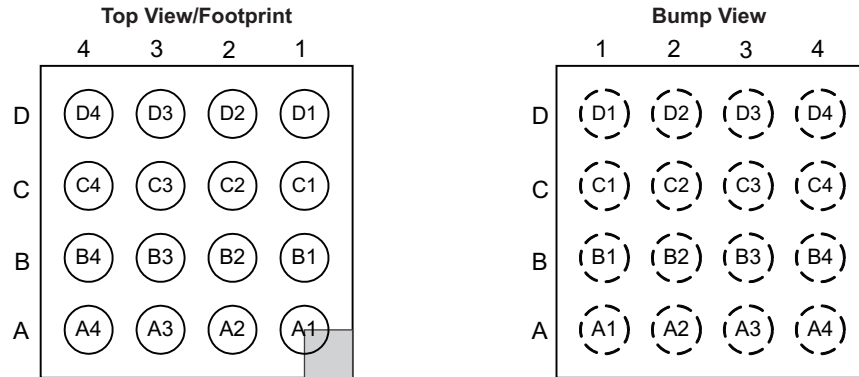


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

PACKAGE OPTION #1: YFF- WCSP



Die Size: 1.56mm x 1.56mm (± 0.03mm)
 Bump Size: 0.25mm
 Bump Pitch: 0.4mm

Table 1. TS3A225E Pin Mapping (Top View)

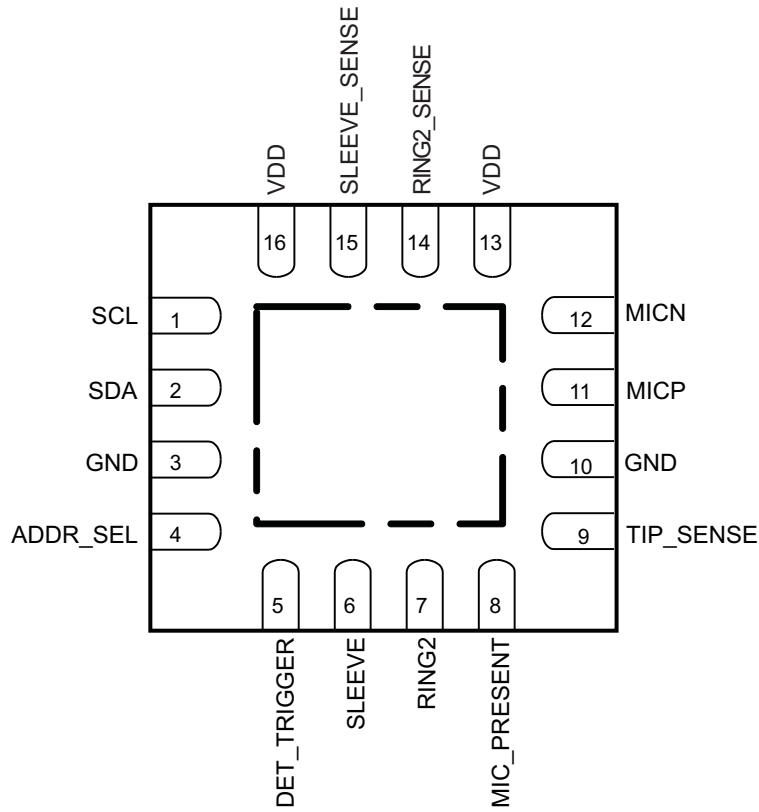
| | 4 | 3 | 2 | 1 |
|---|--------------|--------------------|--------------------|--------------|
| D | /MIC_PRESENT | TIP_SENSE | MICp | MICn |
| C | RING2 | GND ⁽¹⁾ | VDD ⁽¹⁾ | RING2_SENSE |
| B | SLEEVE | GND ⁽¹⁾ | VDD ⁽¹⁾ | SLEEVE_SENSE |
| A | DET_TRIGGER | ADDR_SEL | SDA | SCL |

(1) To ensure proper operation at least 1 of the VDD balls and at least 1 of the GND balls must be pad-connected.

PIN DESCRIPTION – WCSP

| PIN # | PIN | | DESCRIPTION |
|-------|--------------|--------|--|
| | WCSP | NAME | |
| A1 | SCL | I/O | Clock from I ² C bus. This can be connected to VDD if I ² C is not used. |
| A2 | SDA | I/O | Bidirectional data from/to I ² C bus. This can be connected to VDD if I ² C is not used. |
| A3 | ADDR_SEL | I/O | This pin is used to change the device I2C address in an I ² C system to avoid address conflict. Please see the External Pin Connection section for more details. This pin can be grounded if not needed. |
| A4 | DET_TRIGGER | I/O | A rising edge from low to high on this pin triggers the detection. This pin can be connected to the headset jack to allow automatic pull-up to supply after headset insertion to initialize detection sequence. The detection trigger can be disabled or activated in I ² C |
| B1 | SLEEVE_SENSE | I/O | Connected to the SLEEVE segment of the jack. If SLEEVE segment on plug is MIC signal, this is connected to MICp. If not, this is connected to MICn and becomes the remote sensing feedback for the headphone. |
| B2 | VDD | Supply | Power supply |
| B3 | GND | Ground | Headphone ground connection (Current return path to headphone amplifier), switch ground reference. |
| B4 | SLEEVE | I/O | Headphone current return path if SLEEVE is GND for headset. Connect to SLEEVE with low DCR trace. |
| C1 | RING2_SENSE | I/O | Connected to the RING2 segment of the jack. If RING2 segment on plug is MIC signal, this is connected to MICp. If not, this is connected to MICn and becomes the remote sensing feedback for the headphone. |
| C2 | VDD | Supply | Power supply |
| C3 | GND | Ground | Headphone ground connection (Current return path to headphone amplifier), switch ground reference. |
| C4 | RING2 | I/O | Headphone current return path if RING2 is GND for headset. Connect to RING2 with low DCR trace. |
| D1 | MICn | I/O | Microphone signal reference connection to codec. |
| D2 | MICp | I/O | Microphone signal connection to codec. Microphone bias should be fed into this pin. |
| D3 | TIP_SENSE | I/O | Connected to the TIP segment of the headphone jack |
| D4 | /MIC_PRESENT | Output | Open Drain output. When pulled-low, it indicate that a mic is detected on the headset (switch for HDA sense resistor or INT output in an I2S based system. Default behavior is a hardware pulldown for HDA resistor. Programmable through I2C into an interrupt.) |

PACKAGE OPTION #2: RTE- QFN



Top View
 Package Size: 3 mm x 3 mm
 Pitch: 0.5 mm

PIN DESCRIPTION – QFN

| PIN # | PIN | | DESCRIPTION |
|-------|--------------|--------|--|
| | NAME | TYPE | |
| 1 | SCL | I/O | Clock from I ² C bus. This can be connected to VDD if I ² C is not used. |
| 2 | SDA | I/O | Bidirectional data from/to I ² C bus. This can be connected to VDD if I ² C is not used. |
| 3 | GND | Ground | Headphone ground connection (Current return path to headphone amplifier), switch ground reference. |
| 4 | ADDR_SEL | I/O | This pin is used to change the device I2C address in an I ² C system to avoid address conflict. Please see the External Pin Connection section for more details. This pin can be grounded if not needed. |
| 5 | DET_TRIGGER | I/O | A rising edge from low to high on this pin triggers the detection. This pin can be connected to the headset jack to allow automatic pull-up to supply after headset insertion to initialize detection sequence. The detection trigger can be disabled or activated in I ² C |
| 6 | SLEEVE | I/O | Headphone current return path if SLEEVE is GND for headset. Connect to SLEEVE with low DCR trace. |
| 7 | RING2 | I/O | Headphone current return path if RING2 is GND for headset. Connect to RING2 with low DCR trace. |
| 8 | /MIC_PRESENT | Output | Open Drain output. When pulled-low, it indicate that a mic is detected on the headset (switch for HDA sense resistor or INT output in an I2S based system. Default behavior is a hardware pulldown for HDA resistor. Programmable through I2C into an interrupt.) |
| 9 | TIP_SENSE | I/O | Connected to the TIP segment of the headphone jack |
| 10 | GND | Ground | Headphone ground connection (Current return path to headphone amplifier), switch ground reference. |
| 11 | MICp | I/O | Microphone signal connection to codec. Microphone bias should be fed into this pin. |
| 12 | MICn | I/O | Microphone signal reference connection to codec. |
| 13 | VDD | Supply | Power supply |
| 14 | RING2_SENSE | I/O | Connected to the RING2 segment of the jack. If RING2 segment on plug is MIC signal, this is connected to MICp. If not, this is connected to MICn and becomes the remote sensing feedback for the headphone. |
| 15 | SLEEVE_SENSE | I/O | Connected to the SLEEVE segment of the jack. If SLEEVE segment on plug is MIC signal, this is connected to MICp. If not, this is connected to MICn and becomes the remote sensing feedback for the headphone. |
| 16 | VDD | Supply | Power supply |

FUNCTIONAL BLOCK DIAGRAM

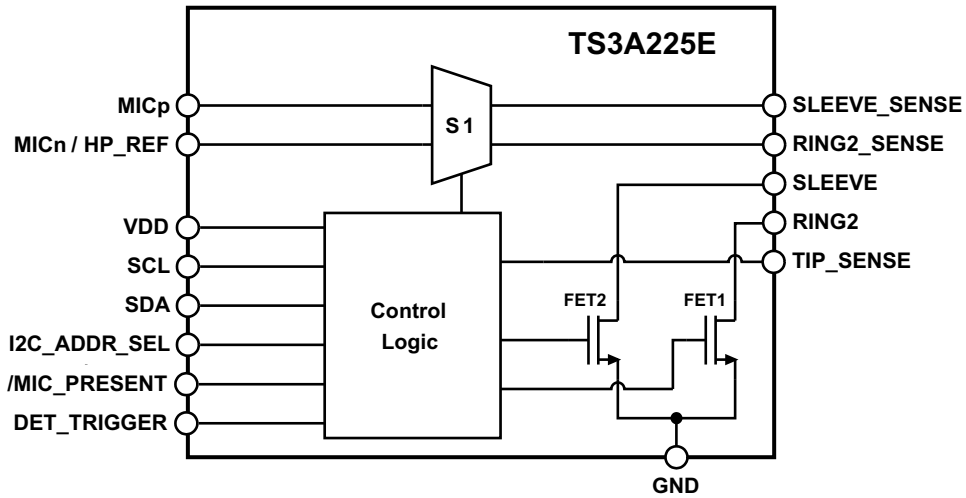


Figure 1. Functional Block Diagram

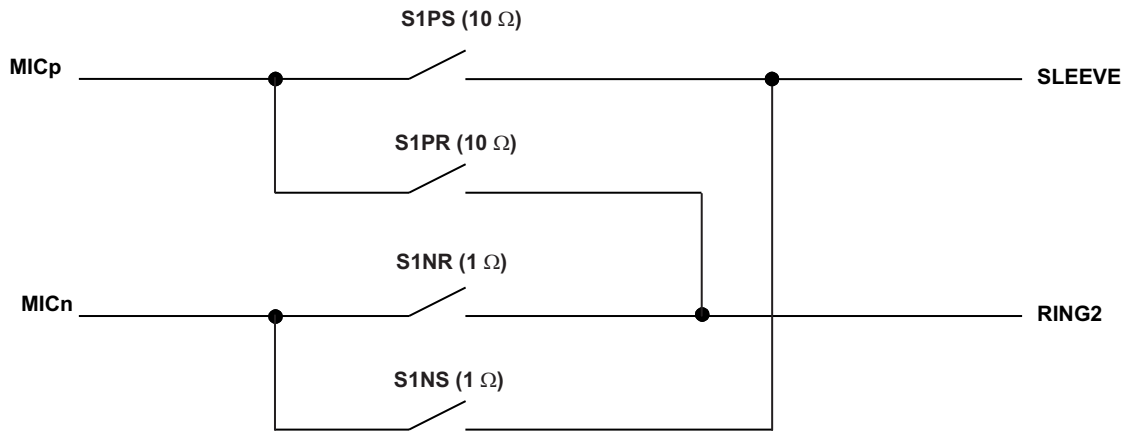


Figure 2. S1 Mux Details

ABSOLUTE MAXIMUM RATINGS⁽¹⁾⁽²⁾

over operating free-air temperature range (unless otherwise noted)

| | | VALUE | UNIT |
|----------------------|---|------------------------------|------|
| V _I | Voltage range on V _{DD} ⁽³⁾ | -0.3 to 5 | V |
| | Voltage range on SCL, SDA, ADDR_SEL, DET_TRIGGER, MICP, MICN, SLEEVE_SENSE, RING2_SENSE, RING2, SLEEVE ⁽³⁾ | -0.3 to V _{DD} +0.5 | V |
| T _A | Operating ambient temperature range | -40 to 85 | °C |
| T _{J (MAX)} | Maximum operating junction temperature | 125 | °C |
| T _{stg} | Storage temperature range | -65 to 150 | °C |
| ESD rating | Machine model (JESD 22 A115) | 100 | V |
| | Charge device model (JESD 22 C101) | 500 | V |
| | Human body model (JESD 22 A114) | 2 | kV |
| | Contact discharge on SLEEVE_SENSE, RING2_SENSE, RING2, SLEEVE, TIP_SENSE (IEC 61000-4-2) | 8 | kV |

- 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 under recommended operating conditions is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.
- In applications where high power dissipation and/or poor package thermal resistance is present, the maximum ambient temperature may have to be derated. Maximum ambient temperature [T_{A(max)}] is dependent on the maximum operating junction temperature [T_{J(max)}], the maximum power dissipation of the device in the application [P_{D(max)}], and the junction-to-ambient thermal resistance of the part/package in the application (Q_{JA}), as given by the following equation: T_{A(max)} = T_{J(max)} – (θ_{JA} × P_{D(max)})
- All voltage values are with respect to network ground terminal.

RECOMMENDED OPERATING CONDITIONS

| | | MIN | MAX | UNIT | |
|----------------------|---|--------------------|------------------------|------------------------|---|
| V _{DD} | Supply voltage range | 2.7 | 4.5 | V | |
| V _{IN} | Digital input voltage range (SDA, SCL, ADDR_SEL, DET_TRIGGER) | 0 | V _{DD} | V | |
| V _{IO} | Input/Output voltage range (SLEEVE, SLEEVE_SENSE, RING2, RING2_SENSE, MICP, MICN) | 0 | V _{DD} | V | |
| V _{IO(TIP)} | Input/Output voltage range for TIP | -2 | V _{DD} | V | |
| V _{IH} | Input logic high | SDA, SCL, ADDR_SEL | 1.2 | 4.5 | V |
| | | DET_TRIGGER | V _{DD} × 0.65 | V _{DD} | V |
| V _{IL} | Input logic low | SDA, SCL, ADDR_SEL | 0 | 0.4 | V |
| | | DET_TRIGGER | 0 | V _{DD} × 0.40 | V |
| T _A | Operating temperature range | -40 | 85 | °C | |

ELECTRICAL CHARACTERISTICS

Unless otherwise noted the specification applies over the V_{DD} range and operating junction temp $-40^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$. Typical values are for $V_{DD} = 3.3\text{V}$ and $T_J = 25^{\circ}\text{C}$.

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------------------------|---|--|-----|-------|-----|------------------|
| V_{DD} | Input voltage range | | 2.7 | 3.3 | 4.5 | V |
| I_{DD} | Quiescent current | $V_{MIC} = 1.8\text{ V to }V_{DD}$ | | 8 | 10 | μA |
| V_{OL} | SDA output high voltage | $I_{OL} = 3\text{ mA}$ | | | 0.3 | V |
| I_{IN-I2C} | SCL, SDA input leakage | $V_{MIC} = 1.8\text{ V to }V_{DD}$ | | 0.1 | 1 | μA |
| $I_{IN-ADDR}$ | ADDR input leakage | $V_{MIC} = 0\text{ V}$ | | 0.1 | 1 | μA |
| SWITCH RESISTANCE | | | | | | |
| R_{F1} (WCSP) | FET1 on resistance (WCSP Package) | $V_{DD} = 2.7\text{ V}, V_{GND} = 0\text{ V}, I_{GND} = 10\text{ mA}$ (see Figure 3) | | 70 | | $\text{m}\Omega$ |
| R_{F1} (QFN) | FET1 on resistance (QFN Package) | | | 100 | | $\text{m}\Omega$ |
| R_{F2} (WCSP) | FET2 on resistance (WCSP Package) | | | 70 | | $\text{m}\Omega$ |
| R_{F2} (QFN) | FET2 on resistance (QFN Package) | | | 100 | | $\text{m}\Omega$ |
| R_{S1PS} | S1PS on resistance | $V_{DD} = 2.7\text{ V},$ $V_{SLEEVE_SENSE/RING2_SENSE} = 0\text{ V to }2.7\text{ V},$ $I_{MIC} = \pm 10\text{ mA}$ (see Figure 4) | | | 10 | Ω |
| R_{S1PR} | S1PR on resistance | | | | 10 | Ω |
| R_{S1NS} | S1NS on resistance | | | | 1 | Ω |
| R_{S1NR} | S1NR on resistance | | | | 1 | Ω |
| $R_{MIC_PRESENT}$ | /MIC_PRESENT pin output resistance | $V_{DD} = 2.7\text{ V}$ | | | 25 | Ω |
| SWITCH LEAKAGE CURRENT | | | | | | |
| $I_{OFF-0.1}$ | FET1 and FET2 off leakage | $V_{IN} = 0\text{ V to }2.7\text{ V}, V_{OUT} = 0\text{ V},$ $V_{DD} = 4.5\text{V}$ (see Figure 5) | | | 1 | μA |
| I_{OFF-1} | S1NS, S1NR off leakage | | | | 1 | μA |
| I_{OFF-10} | S1PS, S1PR off leakage | | | | 1 | μA |
| I_{ON-1} | S1NS, S1NR on leakage | $V_{IN} = 0\text{ V to }2.7\text{ V}, V_{OUT} = 0\text{ V},$ $V_{DD} = 4.5\text{ V}$ (see Figure 6) | | | 1 | μA |
| I_{ON-10} | S1PS, S1PR on leakage | | | | 1 | μA |
| SWITCH DYNAMIC CHARACTERISTICS | | | | | | |
| PSR_{217} | Power supply rejection, $R_L = 5\ \Omega$ (see Figure 7) | $V = 200\text{ mV}_{PP}, f = 217\text{ Hz}$ | | -100 | | dB |
| PSR_{1k} | | $V = 200\text{ mV}_{PP}, f = 1\text{ kHz}$ | | -80 | | dB |
| PSR_{20k} | | $V = 200\text{ mV}_{PP}, f = 20\text{ kHz}$ | | -50 | | dB |
| ISO_{S1} | SLEEVE_SENSE or RING2_SENSE to MICP Isolation (see Figure 8) | $V = 200\text{ mV}_{PP}, f = 20\text{ kHz}, R_L = 50\ \Omega$ | | -100 | | dB |
| SEP_{S1} | SLEEVE_SENSE to RING2_SENSE Separation | $V = 200\text{ mV}_{PP}, f = 20\text{ kHz}, R_L = 50\ \Omega$ (see Figure 9) | | -60 | | dB |
| THD_{200} | Total Harmonic Distortion (see Figure 10) | $V = 200\text{mV}_{PP}, f = 20\text{-}20\text{ kHz}, R_S = 600\ \Omega$ | | 0.003 | | % |
| THD_{500} | | $V = 500\text{mV}_{PP}, f = 20\text{-}20\text{kHz}, R_S = 600\ \Omega$ | | 0.002 | | % |
| t_{BBM} | Break-Before-Make Off Time | Default | | 30 | | μs |
| | | BBM register bit = 1'b1 | | 60 | | μs |
| t_{DETC} | Detection sequence duration | | | 360 | 500 | ms |

I²C INTERFACE TIMING REQUIREMENTS

Unless otherwise noted the specification applies over the V_{DD} range and operating junction temp $-40^{\circ}\text{C} \leq T_J \leq 70^{\circ}\text{C}$.

| PARAMETER | STANDARD MODE I ² C BUS | | FAST MODE I ² C BUS | | UNIT |
|---|---------------------------------------|------|-----------------------------------|-----|---------------|
| | MIN | MAX | MIN | MAX | |
| f_{scl} I ² C clock frequency | 0 | 100 | 0 | 400 | kHz |
| t_{sch} I ² C clock high time | 4 | | 0.6 | | μs |
| t_{scl} I ² C clock low time | 4.7 | | 1.3 | | μs |
| t_{sp} I ² C spike time | | 50 | | 50 | ns |
| t_{sds} I ² C serial-data setup time | 250 | | 100 | | ns |
| t_{sdh} I ² C serial-data hold time | 0 | | 0 | | ns |
| t_{icr} I ² C input rise time | | 1000 | 21 | 300 | ns |
| t_{icf} I ² C input fall time | | 300 | 21 | 300 | ns |
| t_{ocf} I ² C output fall time ($C_L = 10 \text{ pF}$ to 400 pF) | | 300 | $20+0.1C_b^{(1)}$ | 300 | ns |
| t_{bus} I ² C bus free time between Start and Stop conditions | 4.7 | | 1.3 | | μs |
| t_{sts} I ² C Start or repeat Start condition setup | 4.7 | | 0.6 | | μs |
| t_{sth} I ² C Start or repeat Start condition hold | 4 | | 0.6 | | μs |
| t_{sps} I ² C Stop condition setup | 4 | | 0.6 | | μs |
| $t_{vd(data)}$ SCL low to SDA output valid | | 1 | | 1 | μs |
| $t_{vd(ack)}$ Valid-data time, ACK from SCL low to SDA low | | 1 | | 1 | μs |
| C_b I ² C bus load | 0 | 400 | 0 | 400 | pF |

(1) C_b = total capacitance of one bus line in pF.

PARAMETER MEASUREMENT INFORMATION

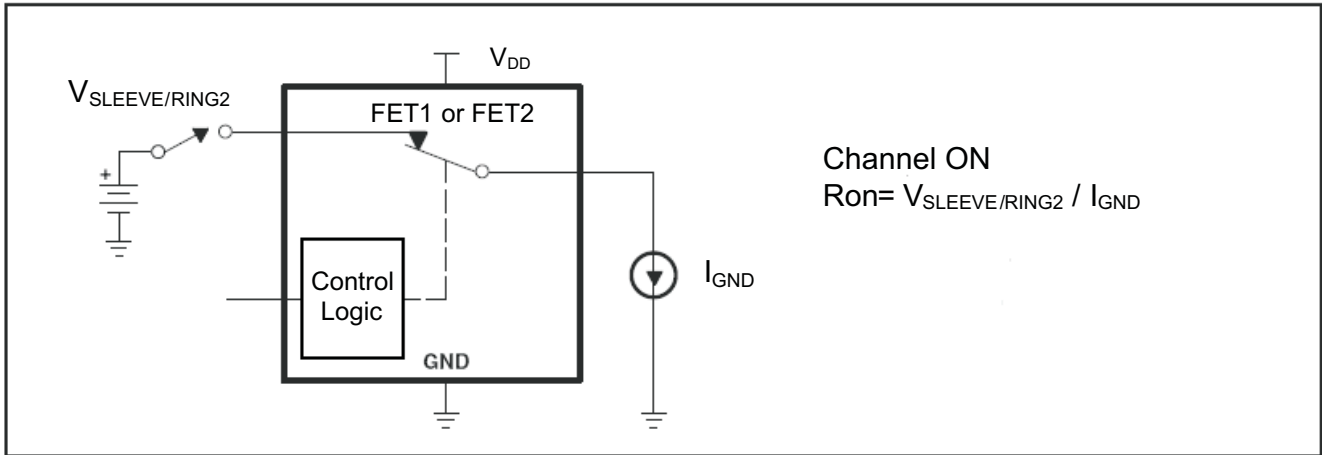


Figure 3. FET1/FET2 On Resistance Measurement

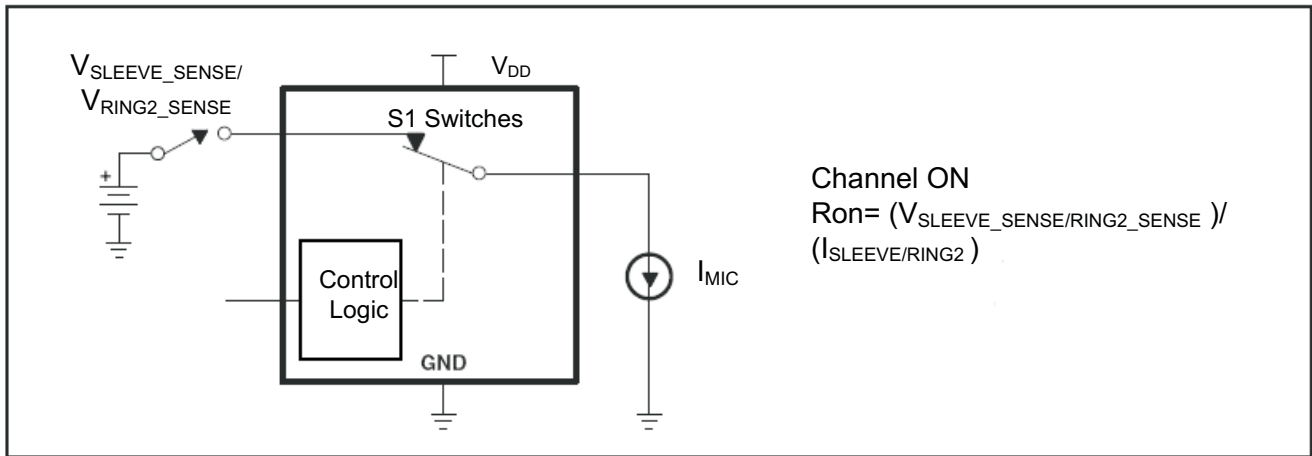


Figure 4. S1 Switch On Resistance Measurement

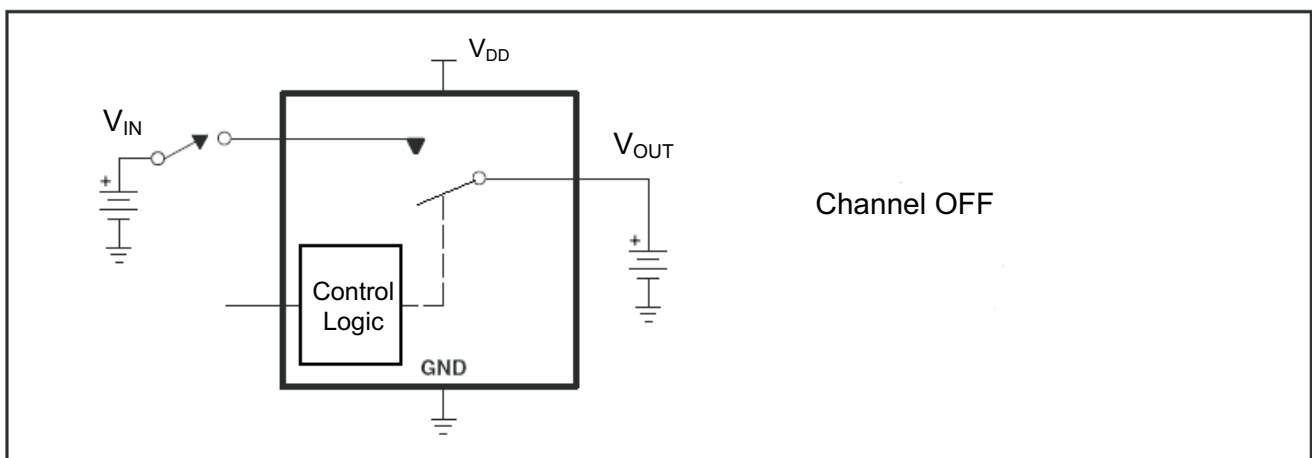


Figure 5. Switch Off Leakage Current Measurement

PARAMETER MEASUREMENT INFORMATION (continued)

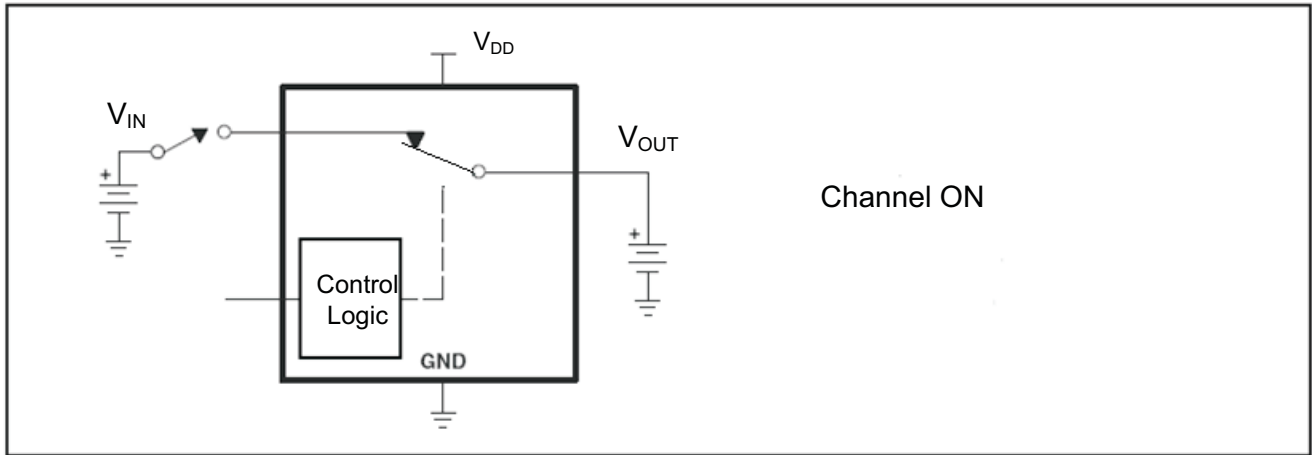


Figure 6. Switch On Leakage Current Measurement

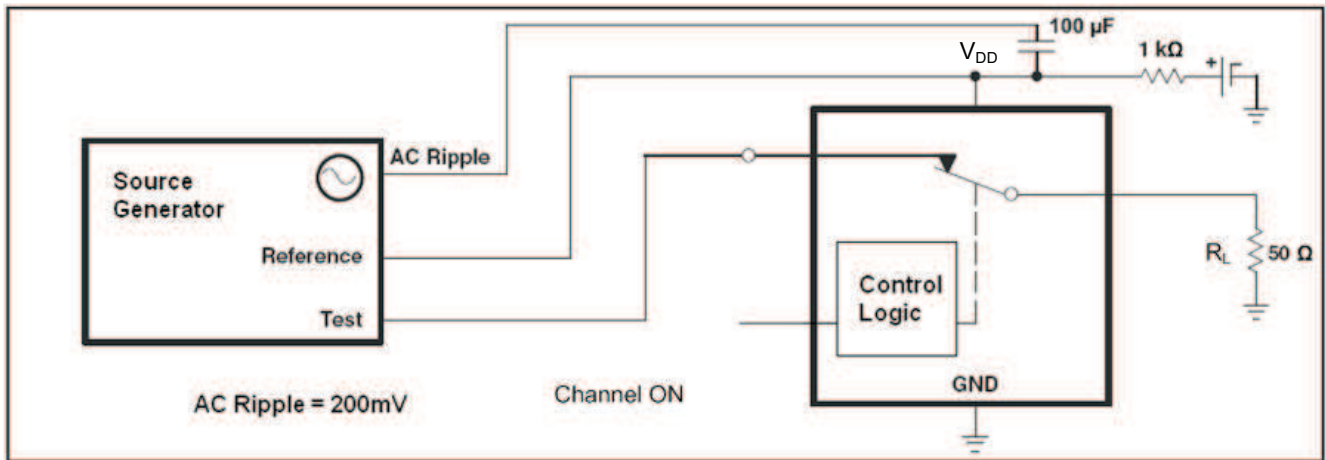


Figure 7. Power Supply Rejection Ratio (PSRR)

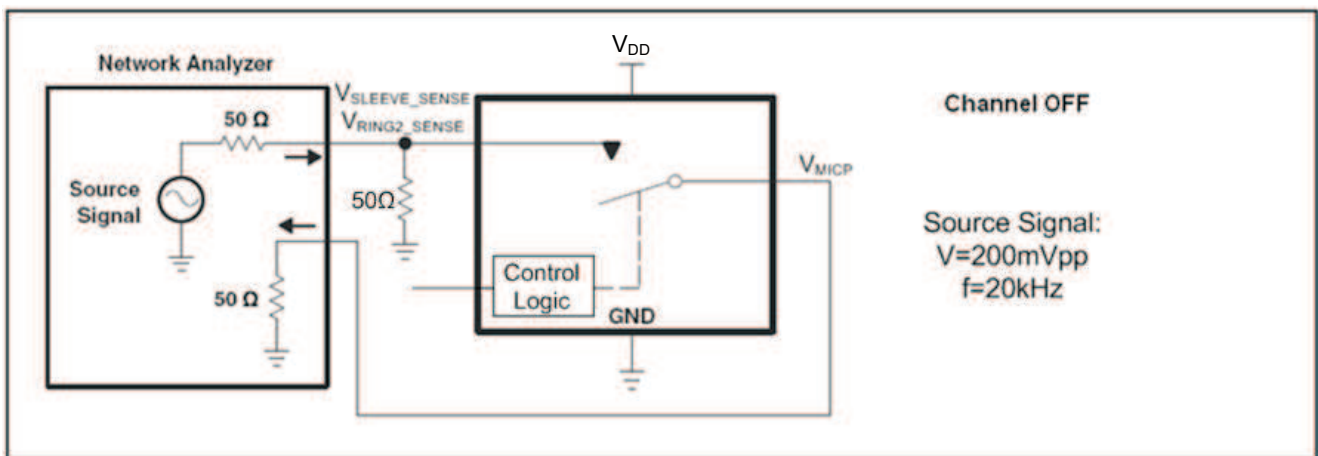


Figure 8. OFF-Isolation

PARAMETER MEASUREMENT INFORMATION (continued)

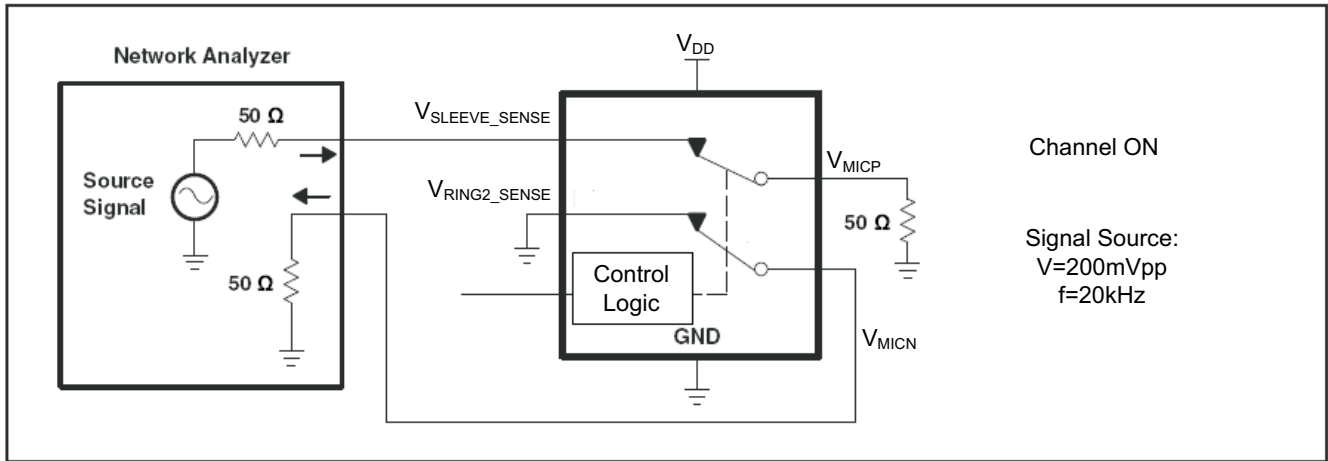
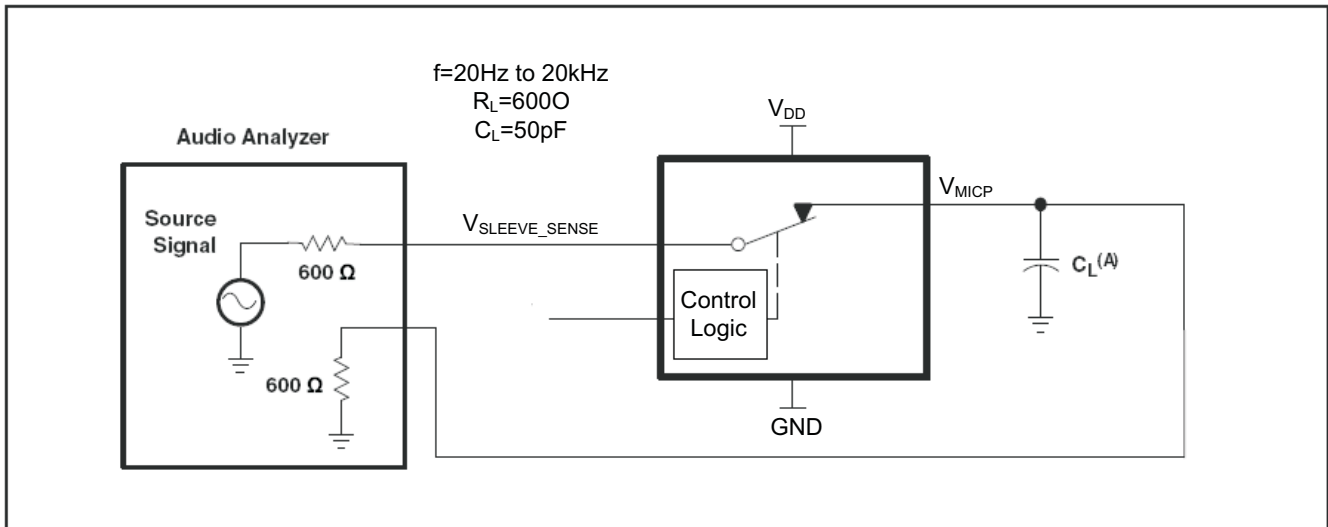


Figure 9. Channel Separation



A. C_L includes probe and jig capacitance.

Figure 10. Total Harmonic Distortion (THD)

PARAMETER MEASUREMENT INFORMATION (continued)

GND FET On Resistance

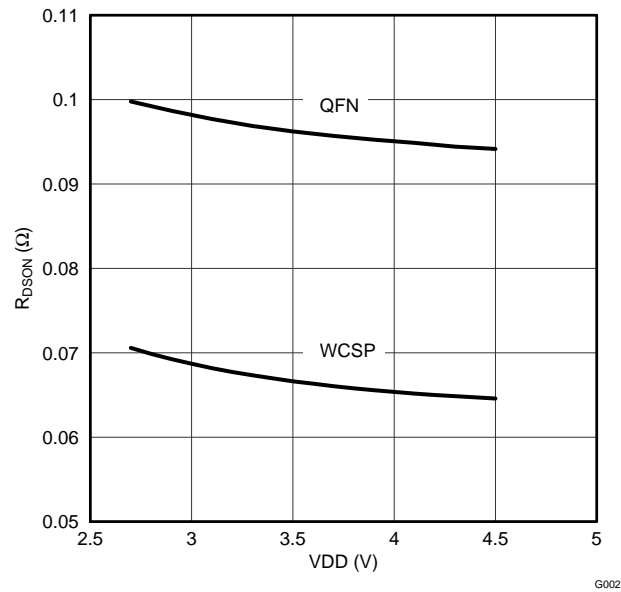


Figure 11. GND FET On Resistance

DESCRIPTION OF OPERATION

GENERAL OPERATION

The TS3A225E is an audio headset switch device that detects the existence and polarity of a microphone connected to a headset. Upon detection of a microphone the TS3A225E automatically connects a system analog microphone pin to the appropriate audio jack connection. The device also routes the system microphone GND to the proper jack connection.

The detection sequence is initiated via I²C command or the external trigger detection (DET_TRIGGER) pin. The automatic routing feature can be disabled by I²C command. Additionally, all the switches of TS3A225E can be manually controlled by I²C register. See the I²C register usage section for details.

EXTERNAL PIN CONNECTION

(1) HARDWARE MODE

The TS3A225E can be used in a non- I²C system in which the controls are performed via external pins. The following table summarizes how the external pins should be connected in a non- I²C system:

| PIN | CONNECT TO | DETAILED DESCRIPTION |
|--------------|---------------------------------|--|
| SCL/SDA | V _{DD} | In a non- I ² C system, these two pins should be tied directly to V _{DD} to emulate the default state in an I ² C commutation protocol. |
| I2C_ADDR_SEL | V _{DD} or GND | In a non- I ² C system this pin has no use and should be grounded. |
| /MIC_Present | None | This is an output pin and can be read to check whether microphone is detected. This pin will be driven low upon microphone detection. |
| DET_TRIGGER | Rising edge initiates detection | In a non- I ² C system, this pin needs to be manually asserted to initiate a headset detection sequence. A rising edge on this pin triggers the detection. |

(2) I²C Mode

In an I²C system, the external pins should be connected as follows:

| PIN | CONNECT TO | NOTE | | | | | | | | | | | | | |
|------------------|---------------------------------|--|------------------|---------|------------|----|-------|-------|-------|------|---|-------|-------|-------|------|
| SCL/SDA | I ² C buses | SCL/SDA pins should be connected to the corresponding I2C buses in an I2C system | | | | | | | | | | | | | |
| I2C_ADDR_SEL | V _{DD} or GND | This pin is used to modify the device I2C address in an I2C system to avoid address conflict. The address can be changed as follows: <table border="1" data-bbox="701 1268 1279 1470" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>I2C_ADDR_SEL Pin</th> <th>Address</th> <th>Read/Write</th> </tr> </thead> <tbody> <tr> <td rowspan="2">0*</td> <td>8'h76</td> <td>Write</td> </tr> <tr> <td>8'h77</td> <td>Read</td> </tr> <tr> <td rowspan="2">1</td> <td>8'h78</td> <td>Write</td> </tr> <tr> <td>8'h79</td> <td>Read</td> </tr> </tbody> </table> <p style="text-align: center;">*This is the factory programmed value</p> | I2C_ADDR_SEL Pin | Address | Read/Write | 0* | 8'h76 | Write | 8'h77 | Read | 1 | 8'h78 | Write | 8'h79 | Read |
| I2C_ADDR_SEL Pin | Address | Read/Write | | | | | | | | | | | | | |
| 0* | 8'h76 | Write | | | | | | | | | | | | | |
| | 8'h77 | Read | | | | | | | | | | | | | |
| 1 | 8'h78 | Write | | | | | | | | | | | | | |
| | 8'h79 | Read | | | | | | | | | | | | | |
| /MIC_Present | None | By default, this is an output pin. This pin will be driven low upon microphone detection and will remain low until another detection event. In an I ² S system, this pin can also serve as interrupt for I2C register update. See the I ² C register usage section for more details. | | | | | | | | | | | | | |
| DET_TRIGGER | Rising edge initiates detection | In an I ² C system, detection sequence can be initiated via the I2C DET_TRIGGER register or this DET_TRIGGER external pin. A rising edge on this pin triggers the detection. | | | | | | | | | | | | | |

MICROPHONE PRESENT INDICATOR

The TS3A225E detects whether or not a microphone is present on an inserted audio stereo jack. If a microphone is detected, the TS3A225E pulls the /MIC_PRESENT pin low and also indicates the presence of the microphone in an I²C register. The /MIC_PRESENT connection is an open-drain output with a maximum on resistance of 25 Ω. This makes the /MIC_PRESENT pin compatible with HDA standards (if /MIC_PRESENT is asserted low when connected to an external 5.1 kΩ pull-up resistor, the effective series resistance of the MIC_PRESENT transistor + pull-up resistor will be changed by less than 0.5%).

The /MIC_PRESENT pin can also be used as an interrupt flag in I²S based systems. The pin can be programmed via I²C to pull low when a microphone is present (the pin's default function), to act as an I²C interrupt when a microphone is detected, or it can be completely disabled.

MICROPHONE POLARITY DETECTION

Microphone polarity is automatically detected by the TS3A225E when running the diagnostic sequence. Microphone polarity is accurately detected under all common connection scenarios for the TIP_SENSE pin including a GND centered amplifier, a non-GND centered (AC-coupled) amplifier, or an amplifier with a tri-stated output.

Microphone detection is not guaranteed if either TIP or RING1 are transmitting audio signals during the detection sequence. To assure proper detection, do not output audio from the headphone amplifier until detection sequence is complete (500 ms after insertion).

It should also be noted that this device is backward compatible with headsets that include send/end functions. However, it should be specified that the user not to hold down the send/end button while the headset is being plugged since it may cause inaccurate microphone detection and the headset may need to be re-plugged.

Microphone polarity is defined by impedance to system GND as noted in the table below in a 4-prong headset:

| Connection | Impedance to GND (Ω) |
|-----------------------|-------------------------------|
| R (Ring1) | 16 ~ 1500 |
| L (Tip) | 16 ~ 1500 |
| Mic (Ring2 or Sleeve) | 600 ~ 3000 |

SWITCH MANUAL CONTROL

In addition to fully automatic switching (the default mode), the TS3A225E's switches can also be manually controlled for increased flexibility. All switches are open by default, and each switch can be controlled individually via the CTRL2 register setting or based on one of the preset modes used in the CTRL1 register. The following outline the proper steps to perform manual switching:

Step 1: Disable auto switching by setting AUTO_SW_DIS in CTRL3 to 1.

Step 2: Change /Mic_present bit to I²C interrupt by setting I2C_INT register in CTRL3 to 1.

Step 3: Initialize detection by asserting the DET_TRIGGER register or the DET_TRIGGER external pin. After detection, the DAT1 registers store the detection result and they can be read to get the headset information. CTRL1 will stay in isolation mode '000' after detection since auto switching has been disabled.

Step 4: Manually control the switches by using one of the preset modes in CTRL1 ('010' to '110') or change the mode of CTRL1 to '111' to control each switch individually based on CTRL2 register settings. The /MIC_PRESENT pin can be manually pulled down by setting **b4** of the CTRL3 register to '1'.

STANDARD I2C INTERFACE DETAILS

The bidirectional I²C bus consists of the serial clock (SCL) and serial data (SDA) lines. Both lines must be connected to a positive supply via a pull-up resistor when connected to the output stages of a device. Data transfer may be initiated only when the bus is not busy.

I²C communication with this device is initiated by the master sending a START condition, a high-to-low transition on the SDA input/output while the SCL input is high (see). After the start condition, the device address byte is sent, MSB first, including the data direction bit (R/W). This device does not respond to the general call address. After receiving the valid address byte, this device responds with an ACK, a low on the SDA input/output during the high of the ACK-related clock pulse.

The data byte follows the address ACK. The R/W bit is kept low for transfer from the master to the slave. The data byte is followed by an ACK sent from this device. Data are output only if complete bytes are received and acknowledged. The output data is valid at time (tpv) after the low-to-high transition of SCL, during the clock cycle for the ACK.

On the I²C bus, only one data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the high pulse of the clock period, as changes in the data line at this time are interpreted as control commands (START or STOP) (see).

A Stop condition, a low-to-high transition on the SDA input/output while the SCL input is high, is sent by the master (see Figure). The number of data bytes transferred between the start and the stop conditions from transmitter to receiver is not limited. Each byte of eight bits is followed by one ACK bit. The transmitter must release the SDA line before the receiver can send an ACK bit.

A slave receiver that is addressed must generate an ACK after the reception of each byte. The device that acknowledges has to pull down the SDA line during the ACK clock pulse so that the SDA line is stable low during the high pulse of the ACK-related clock period (see Figure 12). Setup and hold times must be taken into account.

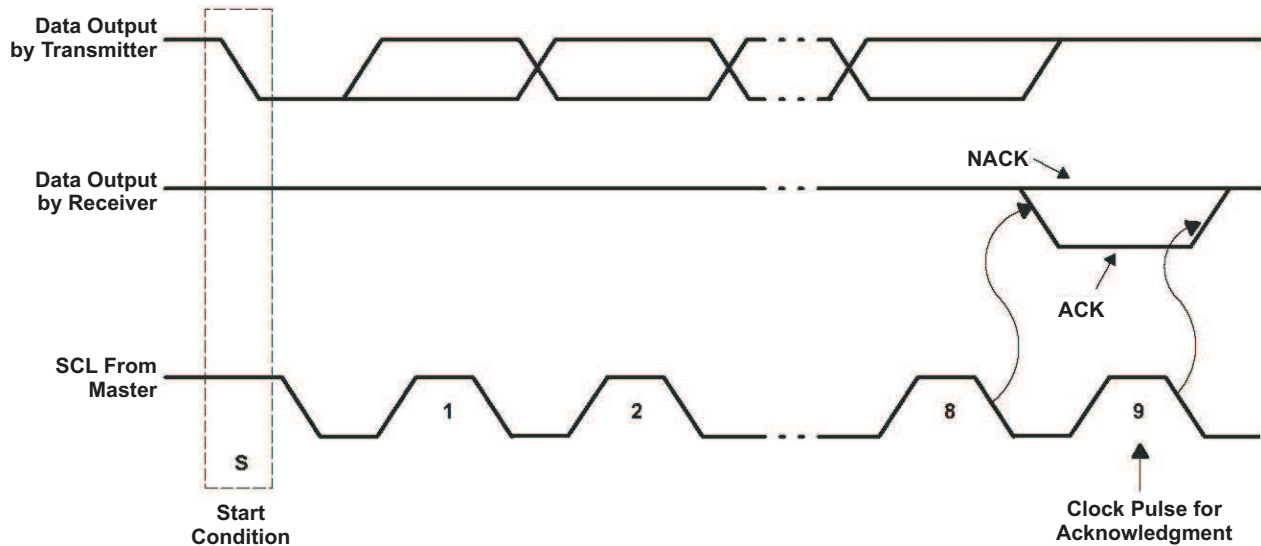


Figure 12. Acknowledgment on I²C Bus

WRITES OPERATION

Data is transmitted to the TS3A225E by sending the device slave address and setting the LSB to a logic 0. The command byte is sent after the address and determines which register receives the data that follows the command byte. The next byte is written to the specified register on the rising edge of the ACK clock pulse. See Figure 13 and Figure 14 for the two modes of Write operations.

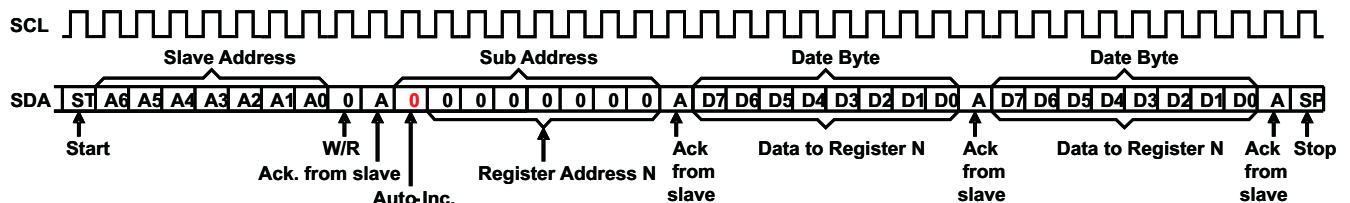


Figure 13. Repeated Data Write to a Single Register

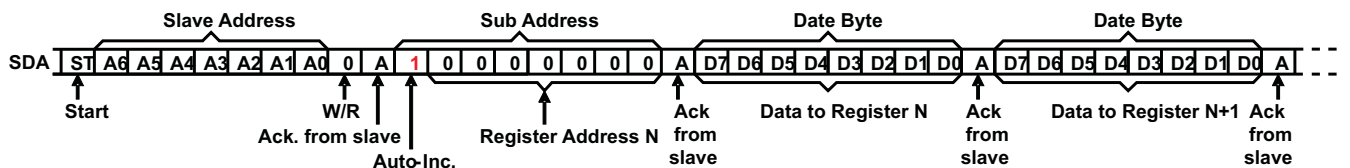


Figure 14. Burst Data Write to Multiple Registers

READS OPERATION

The bus master first send the TS3A225E slave address with the LSB set to logic 0. The command byte is sent after the address and determines which register is accessed. After a restart, the device slave address is sent again but, this time, the LSB is set to logic 1. Data from the register defined by the command byte then is sent by the TS3A225E. Data is clocked into the SDA output shift register on the rising edge of the ACK clock pulse. See Figure 15 to Figure 18 for different modes of Reads Operation.

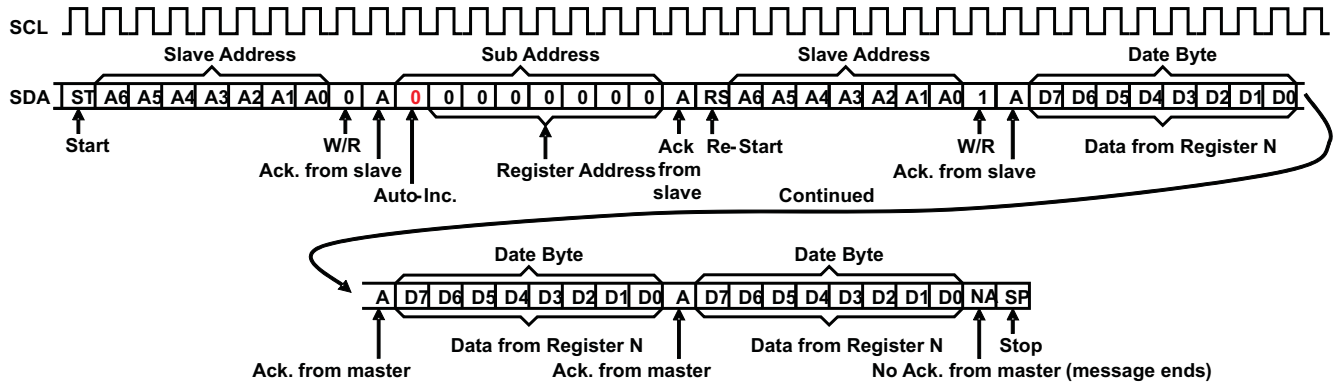


Figure 15. Repeated Data Read from a Single Register – Combined Mode

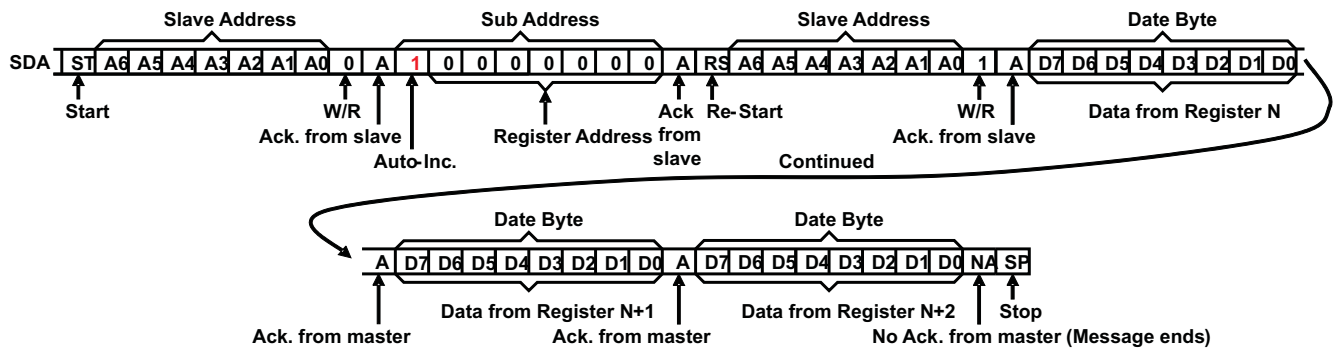


Figure 16. Burst Data Read from Multiple Registers – Combined Mode

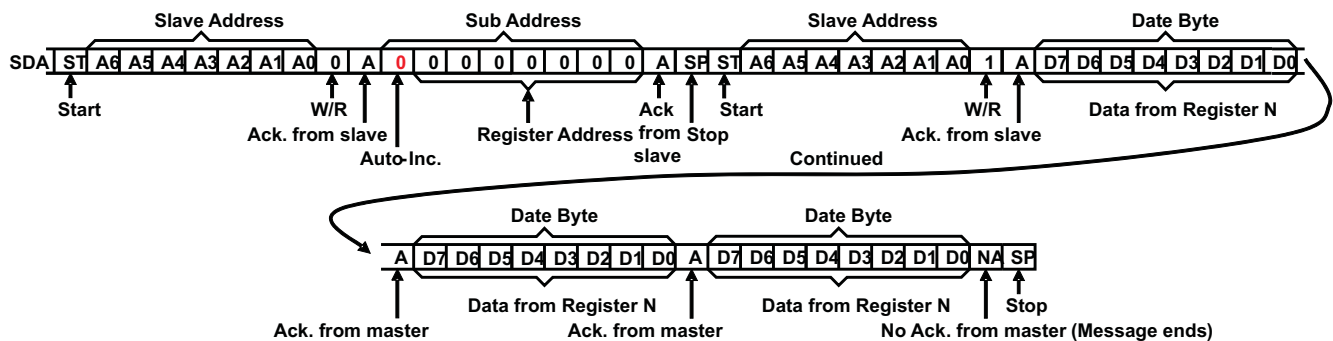


Figure 17. Repeated Data Read from a Single Register – Split Mode

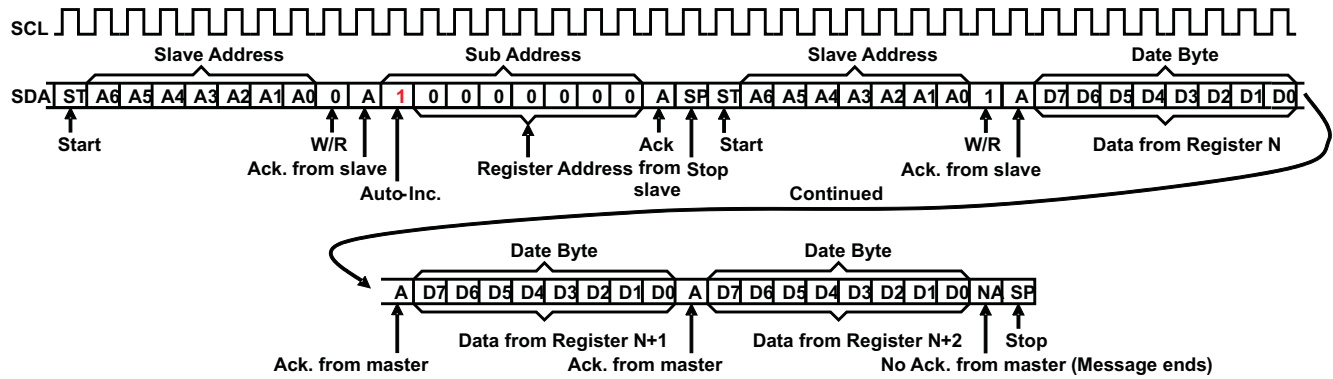


Figure 18. Burst Data Read from Multiple Registers – Split Mode

Notes:

1. SDA is pulled low on Ack. from slave or Ack. from master.
2. Register writes always require sub-address write before first data byte.
3. Repeated data writes to a single register continue indefinitely until Stop or Re-Start.
4. Repeated data reads from a single register continue indefinitely until No Ack. from master.
5. Burst data writes start at the specified register address, then advance to the next register address, even to the read-only registers and continue until Stop or Re-Start. For the read-only registers, data write appears to occur, though no data are changed by the writes.
6. Burst data reads start at the specified register address, then advance to the next register address and continues until No Ack. from master.

REGISTER MAP

| Addr (xxh) | Name | Type | Reset Value | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|------------|----------|------|-------------|------|---------|---------------|---------------------|----------------|--------------|------------------|--------------|
| 0x01 | ID | R | NA | | | | | | | | |
| 0x02 | CTRL1 | R/W | 0x00 | | | | | BBM | MODE[2:0] | | |
| 0x03 | CTRL2 | R/W | 0x00 | S1NR | S1NS | S1PR | S1PS | | | FET1 | FET2 |
| 0x04 | CTRL3 | R/W | 0x00 | | | | /MIC_PRESENT MANUAL | DET_TRIG_DIS | I2C_INT | AUTO_DET_DIS | DET_TRIGGER |
| 0x05 | DAT1 | R | 0x00 | | GND_LOC | SLEEVE_Z[2:0] | | | RING2_Z[2:0] | | |
| 0x06 | INT | R | 0x00 | | | | | DET_ERROR | | MIC_PRESENT | STD_TSR |
| 0x07 | INT Mask | R/W | 0x00 | | | | I2C_INT MASK | DET_ERROR MASK | | MIC_PRESENT MASK | STD_TSR MASK |

REGISTER DESCRIPTION

1. ID

Address : 0x01 Reset Value : N/A Type : Read

| NAME | SIZE(BITS) | DESCRIPTION |
|-----------|------------|------------------------|
| Device ID | 8 | Unique Revision Number |

2. CTRL1
Address : 0x02 Reset Value : 0x00 Type : Read and Write

| NAME | SIZE(BITS) | DESCRIPTION | Data [7:0] |
|----------|------------|---|------------|
| RESERVED | 4 | | |
| BBM | 1 | 0: Disable break-before-make functionality | xxxx0xxx |
| | | 1: Enable break-before-make functionality | xxxx1xxx |
| MODE | 3 | 000: Isolation. All Switch open. This is the default state. | xxxxx000 |
| | | 001: Reserved | xxxxx001 |
| | | 010: Normal Single Ended (FET1, S1NR, S1PS closed) | xxxxx010 |
| | | 011: Reverse Single Ended (FET2, S1NS, S1PR closed) | xxxxx011 |
| | | 100: Normal Differential (S1NR, S1PS closed) | xxxxx100 |
| | | 101: Reversed Differential (S1NS, S1PR closed) | xxxxx101 |
| | | 110: 3Prong (FET1, FET2, S1NS, S1NR closed) | xxxxx110 |
| | | 111: Manual (I2C mode) with all switches open. Switch position controlled via CTRL2 | xxxxx111 |

3. CTRL2
Address : 0x03 Reset Value : 0x00 Type : Read and Write

| NAME | SIZE(BITS) | DESCRIPTION | Data [7:0] |
|----------|------------|--|------------|
| S1NR | 1 | 0: S1NR Switch Disabled when MODE[2:0] = 3'b111 in CTRL1 | 0xxxxxxx |
| | | 1: S1NR Switch Enabled when MODE[2:0] = 3'b111 in CTRL1 | 1xxxxxxx |
| S1MS | 1 | 0: S1NS Switch Disabled when MODE[2:0] = 3'b111 in CTRL1 | x0xxxxxx |
| | | 1: S1NS Switch Enabled when MODE[2:0] = 3'b111 in CTRL1 | x1xxxxxx |
| S1PR | 1 | 0: S1PR Switch Disabled when MODE[2:0] = 3'b111 in CTRL1 | xx0xxxxx |
| | | 1: S1PR Switch Enabled when MODE[2:0] = 3'b111 in CTRL1 | xx1xxxxx |
| S1PS | 1 | 0: S1PS Switch Disabled when MODE[2:0] = 3'b111 in CTRL1 | xxx0xxxx |
| | | 1: S1PS Switch Enabled when MODE[2:0] = 3'b111 in CTRL1 | xxx1xxxx |
| Reserved | 2 | | |
| FET1 | 1 | 0: FET1 Disabled when MODE[2:0] = 3'b111 in CTRL1 | xxxxxx0x |
| | | 1: FET1 Enabled when MODE[2:0] = 3'b111 in CTRL1 | xxxxxx1x |
| FET2 | 1 | 0: FET2 Disabled when MODE[2:0] = 3'b111 in CTRL1 | xxxxxxx0 |
| | | 1: FET2 Enabled when MODE[2:0] = 3'b111 in CTRL1 | xxxxxxx1 |

4. CTRL3
Address : 0x041 Reset Value : 0x00 Type : Read and Write

| NAME | SIZE(BITS) | DESCRIPTION | Data [7:0] |
|------------------------|------------|---|----------------------|
| Reserved | 3 | | |
| /MIC_PRESENT MANUAL | 1 | 0: Default 1: Set this bit to 1 manually pull the /MIC_PRESENT output low | xxx0xxxx Xxx1xxxx |
| DET_TRIG_DIS | 1 | 0: Enables initiation of a detect sequence through the external DET_TRIGGER pin (default) 1: Disables initiation of a detect sequence through the external DET_TRIGGER pin | xxxx0xxx xxxx1xxx |
| I2C_INT | 1 | 0: /MIC_PRESENT pin used to indicate presence of microphone on output (default) 1: /MIC_PRESENT pin serves as interrupt for I2C register updates | xxxxx0xx xxxxx1xx |
| AUTO_SW_DIS | 1 | 0: Enables auto switching after detection (default) 1: Disables auto switching after detection | xxxxxx0x xxxxxx1x |
| DET_TRIGGER | 1 | 0: default 1: Initiates a detection through I2C control* | xxxxxxx0 xxxxxxx1 |

5. DAT1

Address : 0x05 Reset Value : 0x00 Type : Read and Write

| NAME | SIZE(BITS) | DESCRIPTION | Data [7:0] |
|----------|------------|--|------------|
| Reserved | 1 | | |
| GND_LOC | 1 | 0: GND Segment is located on Ring2 band | x0xxxxxx |
| | | 1: GND Segment is located on Sleeve band | x1xxxxxx |
| SLEEVE_Z | 3 | 000: Impedance between Tip and Sleeve is <400Ω | xx000xxx |
| | | 001: 400Ω ≤ Impedance between Tip and Sleeve <800Ω | xx001xxx |
| | | 010: 800Ω ≤ Impedance between Tip and Sleeve <1200Ω | xx010xxx |
| | | 011: 1200Ω ≤ Impedance between Tip and Sleeve <1600Ω | xx011xxx |
| | | 100: 1600Ω ≤ Impedance between Tip and Sleeve <2000Ω | xx100xxx |
| | | 101: 2000Ω ≤ Impedance between Tip and Sleeve <2400Ω | xx101xxx |
| | | 110: 2400Ω ≤ Impedance between Tip and Sleeve <2800Ω | xx110xxx |
| | | 111: Impedance between Tip and Sleeve ≥ 2800 Ω | xx111xxx |
| RING2_Z | 3 | 000: Impedance between Tip and Ring2 <400Ω | xxxxx000 |
| | | 001: 400Ω ≤ Impedance between Tip and Ring2 <800Ω | xxxxx001 |
| | | 010: 800Ω ≤ Impedance between Tip and Ring2 <1200Ω | xxxxx010 |
| | | 011: 1200Ω ≤ Impedance between Tip and Ring2 <1600Ω | xxxxx011 |
| | | 100: 1600Ω ≤ Impedance between Tip and Ring2 <2000Ω | xxxxx100 |
| | | 101: 2000Ω ≤ Impedance between Tip and Ring2 <2400Ω | xxxxx101 |
| | | 110: 2400Ω ≤ Impedance between Tip and Ring2 <2800Ω | xxxxx110 |
| | | 111: Impedance between Tip and Ring2 ≥ 2800 Ω | xxxxx111 |

6. INT

Address : 0x06 Reset Value : 0x00 Type : Read

| NAME | SIZE(BITS) | DESCRIPTION | Data [7:0] |
|-------------|------------|---|------------|
| Reserved | 4 | | |
| DET_ERROR | 1 | 0: default | xxxx0xxx |
| | | 1: Detection sequence completed without successful detection of either a standard plug or a plug with MIC | xxxx1xxx |
| Reserved | 1 | | |
| MIC_PRESENT | 1 | 0: default | xxxxxx0x |
| | | 1: A microphone detected on either RING2 or SLEEVE | xxxxxx1x |
| STD_TSR | 1 | 0: default | xxxxxxx0 |
| | | 1: A standard TSR headset detected, RING2 and SLEEVE shorted | xxxxxxx1 |

7. INT MASK

Address : 0x07 Reset Value : 0x00 Type : Read and Write


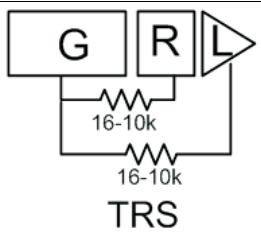
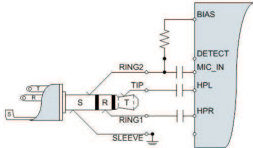

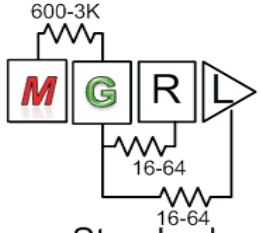
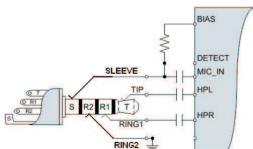
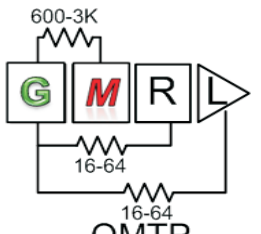
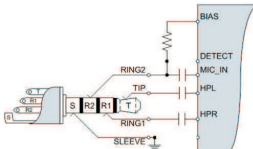
| NAME | SIZE(BITS) | DESCRIPTION | Data [7:0] |
|------------------|------------|---|------------|
| Reserved | 3 | | |
| I2C_INT_MASK | 1 | 0: default | xxx0xxxx |
| | | 1: Tri-state /MIC_PRESENT pin | xxx1xxxx |
| DET_ERROR MASK | 1 | 0: default | xxxx0xxx |
| | | 1: Mask DET_ERROR from setting an I2C interrupt | xxxx1xxx |
| Reserved | 1 | | |
| MIC_PRESENT MASK | 1 | 0: default | xxxxxx0x |
| | | 1: Mask MIC_PRESENT from setting an I2C interrupt | xxxxxx1x |
| STD_TSR MASK | 1 | 0: default | xxxxxxx0 |
| | | 1: Mask STD_TSR from setting an I2C interrupt | xxxxxxx1 |

APPLICATION INFORMATION

APPENDIX: TS3A225E APPLICATION GUIDELINE

The TS3A225E is an audio headset switch device. The device detects the presence of an analog microphone and switches a system analog microphone pin between different connectors in an audio stereo jack. There are two different headset connector configurations currently available: TRS and TRRS. The TRS is comprised of a tip, ring, and sleeve connections while the TRRS contains a tip, ring1, ring2, and sleeve connections. The additional ring connection in the TRRS provides a microphone connection to the headset. Currently, there are two configurations for the TRRS: the Standard and OMTP (Open Mobile Terminal Platform) headsets. The difference between these two configurations is that the GND and Microphone bands are switched. Table 1 below depicts the differences between the TRS and the 2 types of TRRS headsets and their range of internal impedance values between the bands.

Table 2. Headset Configuration

| Physical Connector | Internal Impedance | Pin Configuration | | Connector Structure | |
|---|--|---|---------------|---|---|
| | | Pin Name | Configuration | | |
|  <p>TRS</p> |  <p>TRS</p> | Tip | Audio Left |  | |
| | | Ring | Audio Right | | |
| | | Sleeve | Ground | | |
|  <p>TRRS</p> |  <p>Standard (Apple, HTC, RIM)</p> | Tip | Audio Left |  | |
| | | Ring 1 | Audio Right | | |
| | | Ring 2 | Ground | | |
| | |  <p>OMTP (Nokia, Motorola, SEMC)</p> | Sleeve | Microphone |  |
| | | | Tip | Audio Left | |
| | | | Ring 2 | Audio Right | |
| | | Ring 2 | Ground | | |
| | | Sleeve | Microphone | | |

The TS3A225E detects one of the configurations above by going through a series of impedance detection steps. The device automatically connects the microphone line to the appropriate pin after the detection result becomes available. The device also routes the system microphone GND to the proper jack connection to establish appropriate GND return path. Therefore, TS3A225E provides the capability to use one single universal headset jack to accept both types of microphone headsets.

Reference Schematic

The following figure (Figure 19) is the reference circuit that is recommended to be used to connect the TS3A225E between the audio combo jack and audio CODEC. Table 2 below listed the suggested passive components to be used in the system.

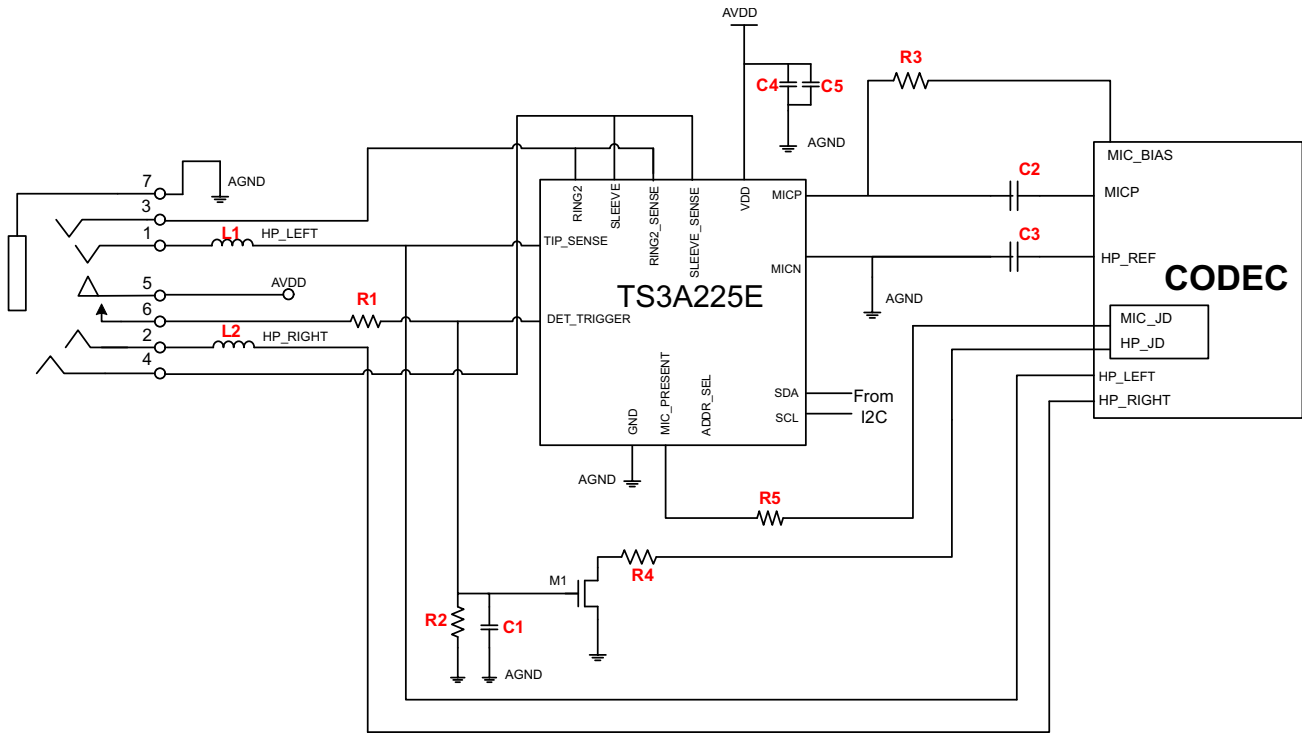


Figure 19. TS3A225E Reference Schematic

Table 3. Components Description

| Capacitor | Value | Resistor | Value | Ferrite Bead | Value |
|-----------|-------|----------|--------|--------------|-------|
| C1 | 1 µF | R1 | 1 kΩ | L1, L2 | N/A |
| C2 | 1 µF | R2 | 100 kΩ | | |
| C3 | 1 µF | R3 | 2.2 kΩ | | |
| C4 | 10 µF | R4 | 39.2 Ω | | |
| C5 | 1 µF | R5 | 20 kΩ | | |

Detailed Application Recommendation

The followings are the recommended usages for TS3A225E.

- To properly initiate the detection sequence of TS3A225E, the DET_TRIGGER pin needs to be configured correctly. The detection is triggered with a low to high transition on the DET_TRIGGER pin. To configure this function automatically through hardware, consider using an audio jack similar to the one shown in Figure 1 and connect pin 5 to VDD and pin 6 to GND through a 100k resistor. With this setup, the DET_TRIGGER pin is normally pulled low without a headset plugged-in and goes high when jack is inserted. To smooth out the low-to-high transition and to mitigate “slow plug-in” issue (discussed in the next section), R and C are recommended to be added to the DET_TRIGGER pin (R1 and C1). It’s recommended to have $C1 > 1\mu\text{F}$. The value of R1 can be adjusted depending on the audio jack used. A good default value to start with is $1\text{k}\Omega$.
- The DET_TRIGGER signal can also be utilized to implement the headphone sense (HP_JD) feature of the audio CODEC. When used together with a MOSFET (M1), this pin can be connected to the HP_JD pin (or any other relevant pin) of the audio CODEC to indicate a headset has been plugged-in. The CODEC can then turn on the left and right channel audios after a specific amount of delay ($>$ detection period of TS3A225E = 360ms). The value of R4 may change depending on CODEC used.
- The MIC_PRESENT pin is an open-drain output and will be pulled low when a microphone is detected by TS3A225E. This pin can be connected directly to the MIC_JD pin on the CODEC to indicate the system a microphone is connected. The value of R5 may change depending on the CODEC used.
- The SLEEVE and RING2 pins should be routed to the actual headset jack connections with low impedance traces (wide, short traces). SLEEVE_SENSE and RING2_SENSE should not use the same traces and they can be much narrower and higher in impedance as they will be fed into high impedance inputs looking into the CODEC. On the CODEC side of the switch, the MICn / HP_REF connection should be fed into the HP_REF input of the CODEC. Utilizing the HP_REF input on CODECs typically improves cross talk by 10-15 dB. Not all CODECs have these inputs, but almost all newly released CODECs have this feature.
- The TIP_SENSE pin goes to the left channel of the audio headphone (HP_LEFT). The right channel does not go through the TS3A225E. Ferrite Beads (L1 and L2) are recommended on these 2 paths to filter out high frequency noises on the audio channels.
- Parallel 10uF and 1uF standard decoupling capacitor are recommended for the supply to decouple noises on the power rail.
- The SDA/SCL pins are connected to the I2C interfaces of the MCU. They maybe pulled up to VDD via resistors if no I2C control is needed. The ADDR_SEL pin is a GPIO-controlled pin for changing TS3A225E’s slave address to avoid system address conflict. If this feature is not needed, ADDR_SEL can be grounded.

Special Note on Slow Headset Plug-In Issue

In real-world scenario a user might plug in the headset to the audio jack very slowly. This creates a challenging case for TS3A225E's detection mechanism and detection error might occur if care is not taken when designing the components around the TS3A225E. The main concern for slow plug-in is the detection process might have already begun before the headset gets fully inserted into the jack. If the detection is running with headset's plug out of position, the TS3A225E might retrieve false impedance information from the test and give incorrect detection result. To mitigate the slow plug-in issue, the following 3 steps can be implemented:

Jack Selection

Usage of proper audio jack in conjunction with TS3A225E is the most effective technique to alleviate the slow plug-in issue. One type of popular audio combo jack on the market has the pin composition similar to the one shown in Figure 20 below, where the DET_TRIGGER mechanism has to be designed around the RING1 pin. While headset is being inserted, the tip of the headset touches the RING1 pin first, pushing out pin 5 to pin 6 and connect them together, generating a low-to-high transition on the DET_TRIGGER pin and triggers the detection sequence of TS3A225E. However, the headset is not yet fully inserted at this moment (tip has not touched pin 1) and if the insertion is relatively slow the impedance detection of TS3A225E may complete before the tip of the headset touches pin 1. This may result in false impedance values read by TS3A225E and affects its proper switching mechanism.

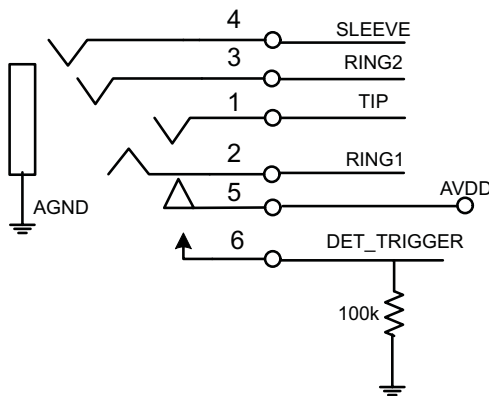


Figure 20. Poor Jack Usage

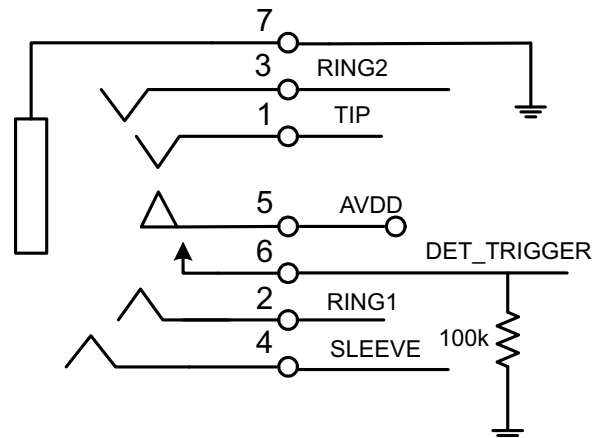


Figure 21. Recommended Audio Jack Selection

A more suitable audio jack to be used with TS3A225E is the one shown in Figure 21 above. This type of jack has the push-out mechanical structure located on the inner-most part of the jack. It thus allows the transition on DET_TRIGGER pin to occur only after the headset has been fully inserted with the tip touching pin 1 and 5, which reduces the risk of early-triggering on TS3A225E's detection sequence.

RC Delay on DET_TRIGGER

Another possible method to alleviate the slow-plug in issue is to introduce RC delay on the DET_TRIGGER pin. As specified in the Reference Schematic (Figure 1) in the previous section, the combination of R1 and C1 produces a low-pass effect on the DET_TRIGGER pin to slow down its transition from low to high. This delay provides more time for the headset to be fully inserted into the jack before the detection sequence of TS3A225E is triggered.

For effective delay implementation, it is recommended to use $C1 > 1\mu\text{F}$. The board layout space can be reserved for R1 and the value of R1 can be adjusted based on the actual measurement data. A good default value to start with is $1\text{k}\Omega$.

Internal Delay

The TS3A225E has built-in 120ms delay to address the slow plug-in issue. After the low-to-high transition on the DET_TRIGGER pin, the TS3A225E does not start impedance detection sequence until 120ms later. This delay period gives some time buffer for the headset to be fully plugged-in.

Special Note On Power Of Noise Issue

In computing, the Advanced Configuration and Power Interface (ACPI) specification provides an open standard for device configuration and power management by the operating system. The ACPI specification defines a number of different power states for an ACPI-compliant computer-system, ranging from G0 (system working) to G3 (system mechanical off with close to zero power consumption).

When TS3A225E is used in the ACPI-compliant computer-system, and if the user has a speaker (with amplifier) plugged into the audio jack when the system enters low-power state, audible noise interference may be heard during G1, G2, and G3 states. The G1, G2, and G3 states are defined as:

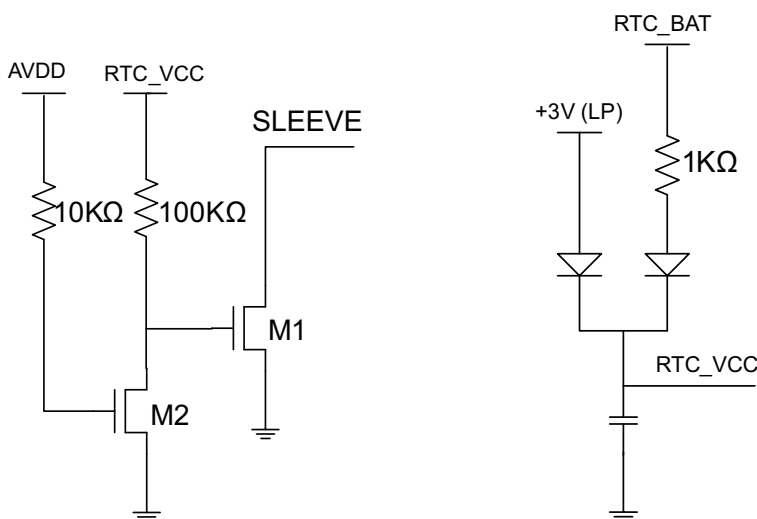
G1: Sleeping mode

G2 (or S5) Soft Off: G2 is almost the same as G3 Mechanical Off, but some components remain powered so the computer can "wake" from input from the keyboard, clock, modem, LAN, or USB device.

G3: Mechanical Off: The computer's power consumption approaches zero, to the point that the power cord can be removed and the system is safe for dis-assembly.

The root cause of this noise interference comes from the fact that the TS3A225E's VDD supply is disconnected during mode G1 to G3. The two Ground FET switches (FET1 and FET2) become open by default when no power is supplied to the device, and the ground return path lines become floating under this circumstance. With no established ground return path, the long speaker wire acts as an antenna and picks up random signals from the air and outputs the noise to the amplified speaker, creating undesirable buzzing noises.

To levitate this problem, the following circuitry is recommended:



With the use of this circuitry, the SLEEVE pin will be pulled down to GND by the RTC_VCC power source. The RTC_VCC power source is generated by the Real Time Clock source running off a small on-board battery (RTC_BAT) that is kept running even in G3 mode. With SLEEVE pin pulled down to GND, ground return path is established for the speaker and noises will be eliminated. Diodes are added from RTC_BAT to +3V (LP) to prevent leakage when system is turning on.

During normal system operation, AVDD becomes available to turn on M2 and in turn shut off M1. The SLEEVE to GND path will then be controlled solely by the internal FET switches of TS3A225E.

REVISION HISTORY

| Changes from Original (August 2012) to Revision A | Page |
|---|------|
| • Added V_{IO} and $V_{IO(TIP)}$ parameters to the RECOMMENDED OPERATING CONDITIONS. | 7 |
| • Deleted DETECTION SEQUENCE AND RESET section. | 15 |

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| HPA02141ERTER | ACTIVE | WQFN | RTE | 16 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 85 | ZTL | Samples |
| HPA02141EYFFR | ACTIVE | DSBGA | YFF | 16 | 3000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | YP225E | Samples |
| TS3A225ERTER | ACTIVE | WQFN | RTE | 16 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | -40 to 85 | ZTL | Samples |
| TS3A225EYFFR | ACTIVE | DSBGA | YFF | 16 | 3000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | YP225E | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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TAPE AND REEL INFORMATION



QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TS3A225ERTER | WQFN | RTE | 16 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| TS3A225EYFFR | DSBGA | YFF | 16 | 3000 | 180.0 | 8.4 | 1.65 | 1.65 | 0.81 | 4.0 | 8.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TS3A225ERTER | WQFN | RTE | 16 | 3000 | 367.0 | 367.0 | 35.0 |
| TS3A225EYFFR | DSBGA | YFF | 16 | 3000 | 182.0 | 182.0 | 20.0 |

MECHANICAL DATA

RTE (S-PWQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



4205254/D 01/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Quad Flatpack, No-leads (QFN) package configuration.
 -  The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
 - E. Falls within JEDEC MO-220.

THERMAL PAD MECHANICAL DATA

RTE (S-PWQFN-N16)

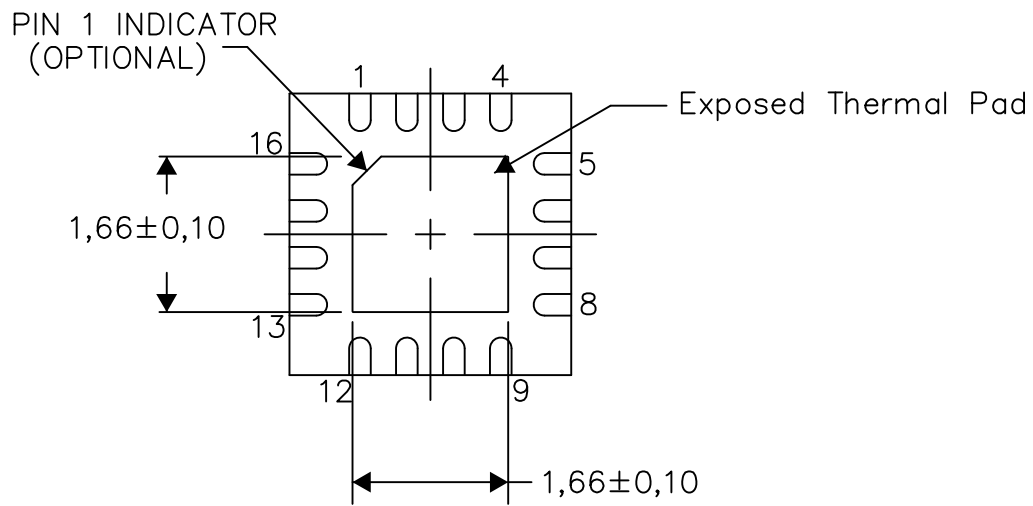
PLASTIC QUAD FLATPACK NO-LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

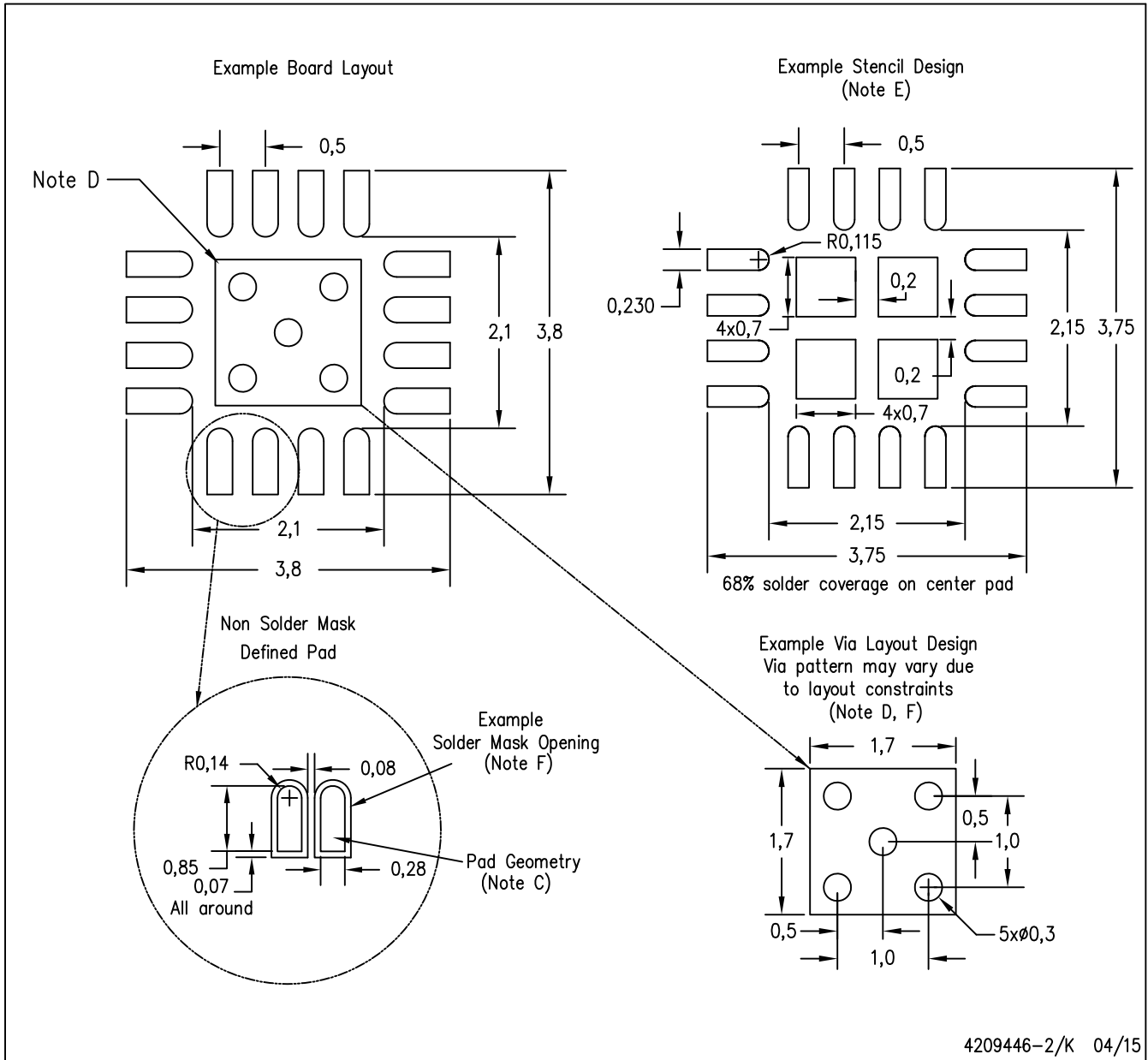
Exposed Thermal Pad Dimensions

4206446-8/U 08/15

NOTE: A. All linear dimensions are in millimeters

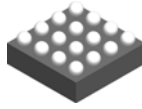
RTE (S-PWQFN-N16)

PLASTIC QUAD FLATPACK NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
 - Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

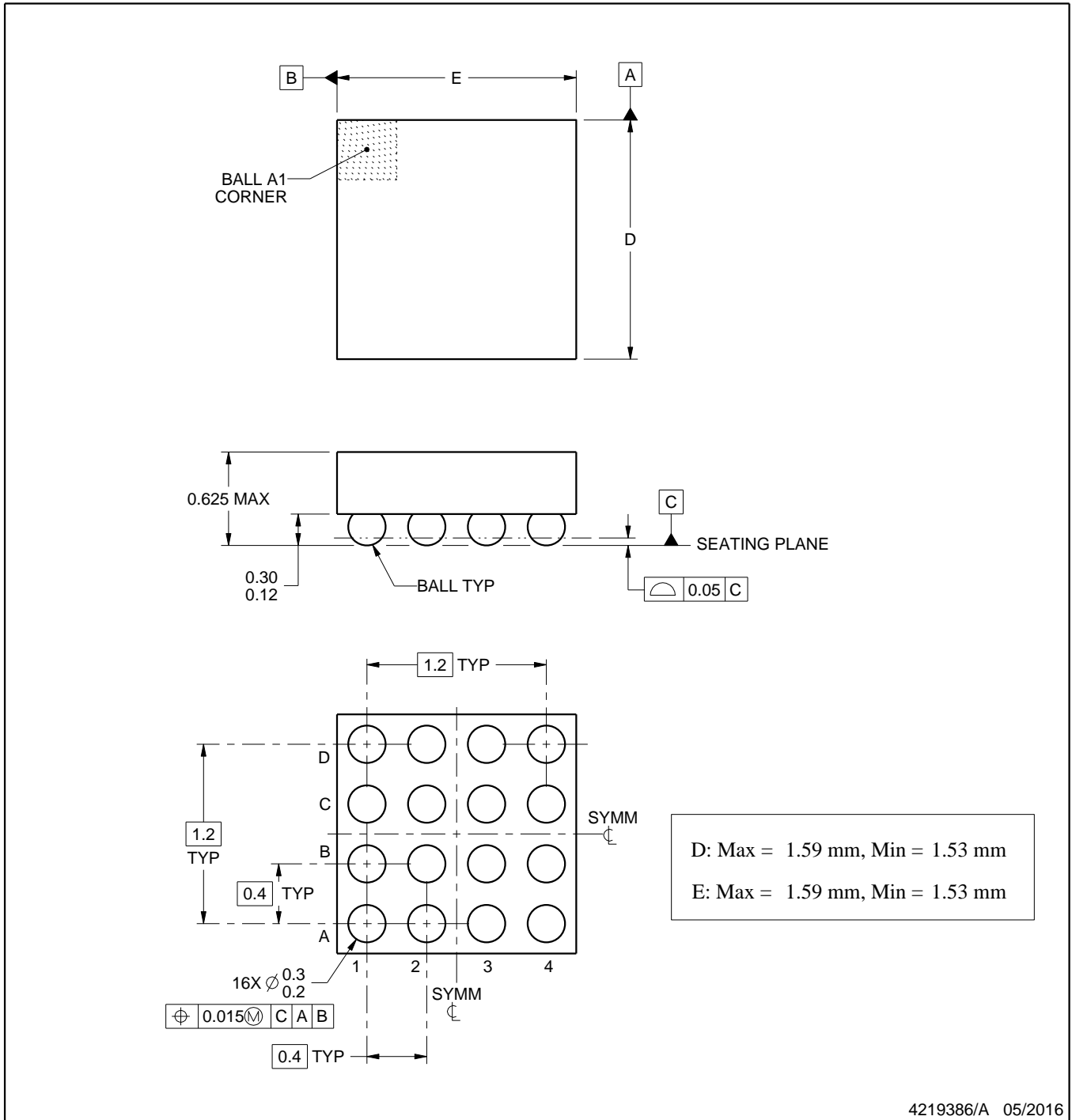
YFF0016



PACKAGE OUTLINE

DSBGA - 0.625 mm max height

DIE SIZE BALL GRID ARRAY



NOTES:

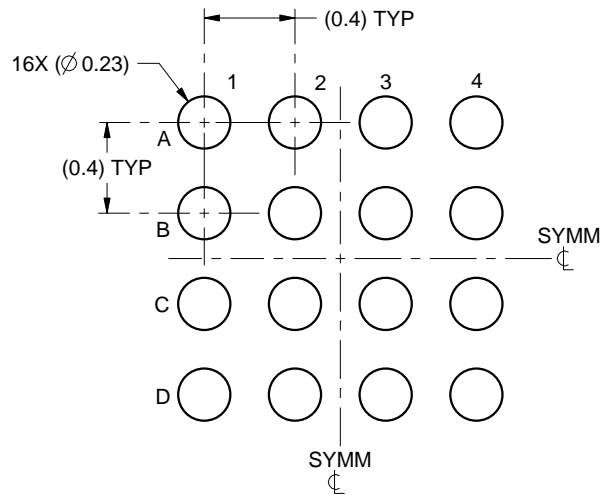
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

YFF0016

DSBGA - 0.625 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
SCALE:30X



SOLDER MASK DETAILS
NOT TO SCALE

4219386/A 05/2016

NOTES: (continued)

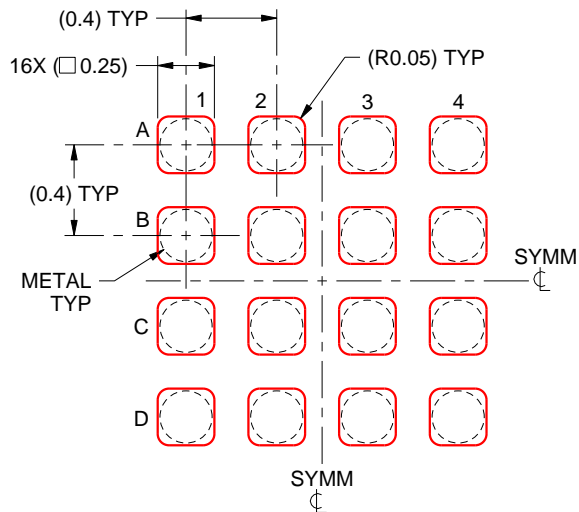
3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints. For more information, see Texas Instruments literature number SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YFF0016

DSBGA - 0.625 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE:30X

4219386/A 05/2016

NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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