

## Capless 3Vrms Line Driver with Adjustable Gain

### FEATURES

- Capless Structure
- Eliminates Pop/Clicks
- Eliminates Output DC-Blocking Capacitors
- Provides Flat Frequency Response from DC to 20kHz
- Low Noise and THD
- Typical SNR=90dB
- Typical THD+N=0.01%(f=1kHz)
- 3Vrms Output Voltage into 2.5kΩ Load with 5V Supply Voltage
- Differential Input

### APPLICATIONS

- Set-Top Box
- LCD TV
- Blue-Ray DVD-Players
- Home Theater in a Box

### GENERAL DESCRIPTION

The TMI8320C is a 3Vrms pop/click-free stereo line driver designed to allow the removal of the output DC-blocking capacitors for reduced component count and cost. The device is ideal for single supply electronics when size and cost are critical design parameters.

The TMI8320C is capable of driving 3Vrms into a 2.5kΩ load with 5V supply voltage. The device has differential inputs and uses external gain setting resistors that supports a gain range of  $\pm 1V/V$  to  $\pm 10V/V$ . The TMI8320C has built-in shutdown control for pop/click-free on/off control.

Using the TMI8320C in audio products can reduce component count compared to traditional methods of generating a 3Vrms output. The TMI8320C doesn't require a power supply greater than 5V to generate an 8.5V<sub>pp</sub> output, nor does the device require a split rail power supply. The TMI8320C integrates a charge pump to generate a negative supply rail that provides a clean, pop/click-free ground-biased 3Vrms output.

The TMI8320C is available in Green MSOP10 package. It operates over an ambient temperature range of -40°C to 85°C.

## TYPICAL APPILCATION

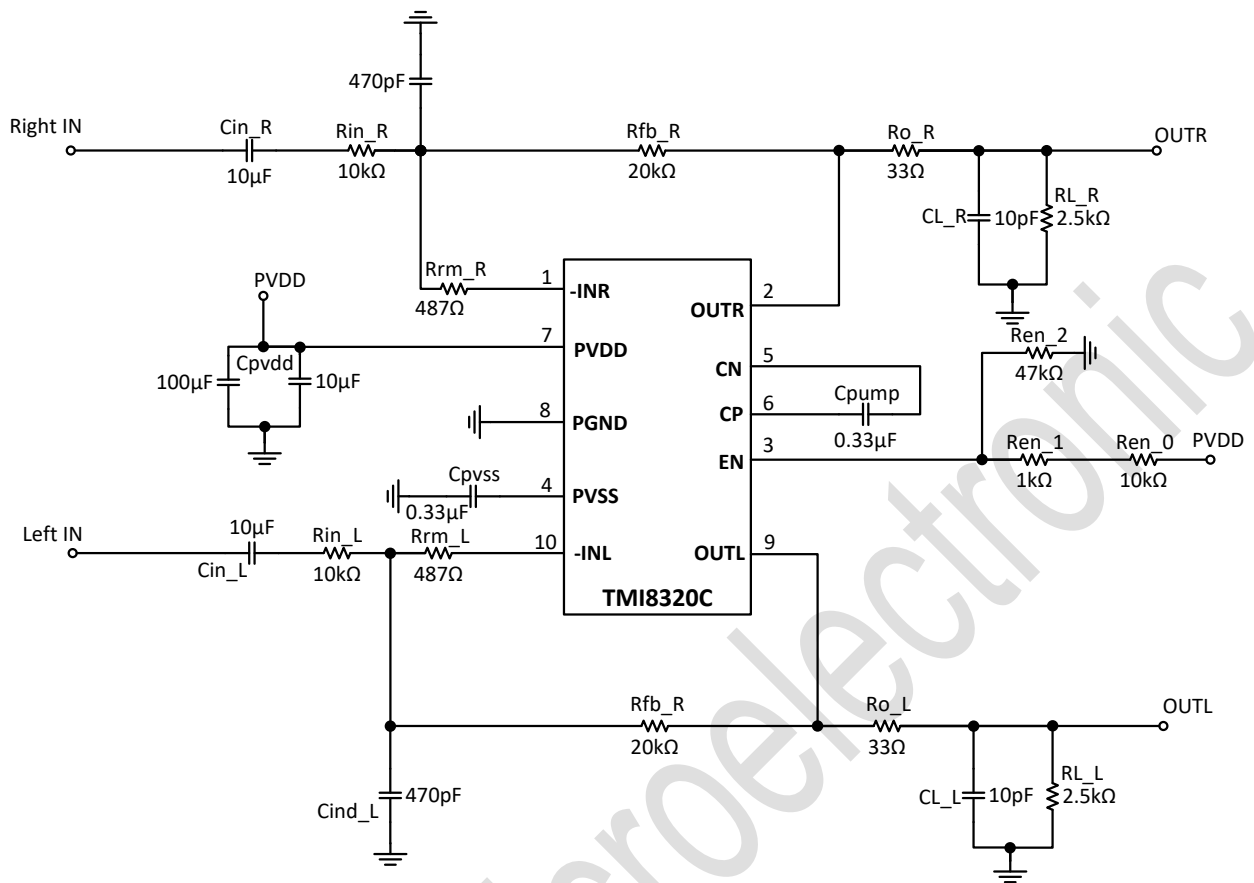
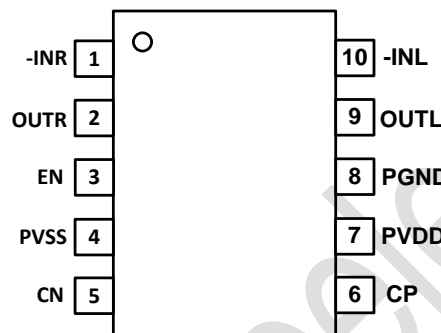


Figure 1. TMI8320C Application Circuit

**ABSOLUTE MAXIMUM RATINGS** (Note 1)

| Parameter                        | Value  | Unit |
|----------------------------------|--|------|
| Supply Voltage                   | -0.3~6                                       | V    |
| Input Voltage                    | V <sub>ss</sub> -0.3 to V <sub>dd</sub> +0.3 | V    |
| Minimum Load Impedance (RL)      | 600  | Ω    |
| EN to GND                        | -0.3 to V <sub>dd</sub> +0.3                 | V    |
| Junction Temperature (Note2)     | 150  | °C   |
| Storage Temperature Range        | -65~150                                      | °C   |
| Lead Temperature (Soldering,10s) | 260  | °C   |

**PIN CONFIGURATION**



**MSOP10**

**Top Mark: T8320C/YYXXX (T8320C: Device Code, YYXXX: Inside code)**

| Part Number | Package | Top mark     | Quantity/ Reel |
|-------------|---------|--------------|----------------|
| TMI8320C    | MSOP10  | T8320C/YYXXX | 3000           |

TMI8320C devices are Pb-free and RoHS compliant.

## PIN FUNCTIONS

| Pin No. | Name | Function  |
|---------|------|---|
| 1       | -INR | Right Channel OPAMP Positive input (connected to GND) |
| 2       | OUTR | Right Channel OPAMP Output                            |
| 3       | EN   | Enable Input. Active high                             |
| 4       | PVSS | Negative Supply Voltage Output                        |
| 5       | CN   | Charge Pump Flying Capacitor Negative Terminal        |
| 6       | CP   | Charge Pump Flying Capacitor Positive Terminal        |
| 7       | PVDD | Positive Supply                                       |
| 8       | PGND | Power Ground  |
| 9       | OUTL | Left Channel OPAMP Output                             |
| 10      | -INL | Left Channel OPAMP Negative Input                     |

## ESD RATINGS

| Items            | Description                   | Value | Unit |
|------------------|-------------------------------|-------|------|
| V <sub>ESD</sub> | Human Body Model for all pins | 3000  | V    |

JEDEC specification JS-001

## RECOMMENDED OPERATING CONDITIONS

| Items          | Description                          | Min | Max | Unit |
|----------------|--------------------------------------|-----|-----|------|
| Voltage Range  | IN                                   | 3   | 5.5 | V    |
| T <sub>j</sub> | Operating Junction Temperature Range | -40 | 125 | °C   |

**ELECTRICAL CHARACTERISTICS**
**(V<sub>DD</sub> = 5V, T<sub>A</sub> = 25°C, unless otherwise noted.)**

| Symbol                | Parameter                            | Conditions  | Min  | Typ  | Max  | Unit              |
|-----------------------|--------------------------------------|---|------|------|------|-------------------|
| V <sub>OS</sub>       | Output Offset Voltage                | V <sub>DD</sub> =3V to 5V   |      | 1.5  | 5    | mV                |
| PSRR                  | Power Supply Rejection Ratio         | V <sub>DD</sub> =3V to 5V   |      | 90   |      | dB                |
| V <sub>CH</sub>       | High-Level Output Voltage            | V <sub>DD</sub> =3.3V, R <sub>L</sub> =2.5kΩ                            | 3.18 |      |      | V                 |
| V <sub>OL</sub>       | Low-Level Output Voltage             | V <sub>DD</sub> =3.3V, R <sub>L</sub> =2.5kΩ                            |      |      | -3.1 | V                 |
| I <sub>IH</sub>       | High-Level Input Current (EN)        | V <sub>DD</sub> =5V, V <sub>I</sub> =V <sub>DD</sub>                    |      |      | 1    | μA                |
| I <sub>IH</sub>       | Low-Level Input Current (EN)         | V <sub>DD</sub> =5V, V <sub>I</sub> =0V                                 |      |      | 1    | μA                |
| I <sub>DD</sub>       | Supply Current                       | V <sub>DD</sub> =3.3V, No load, EN=V <sub>DD</sub>                      | 8    | 11.3 |      | mA                |
|                       |                                      | V <sub>DD</sub> =5V, No load, EN=V <sub>DD</sub>                        |      | 11.7 | 18   |                   |
|                       |                                      | Shutdown mode,<br>V <sub>DD</sub> =3V to 5V                             |      | 0.1  | 0.2  |                   |
| V <sub>O</sub>        | Output Voltage (Outputs in Phase)    | THD+N=1%, V <sub>DD</sub> =3.3V,<br>f=1kHz, R <sub>L</sub> =2.5kΩ       |      | 2.28 |      | V <sub>rms</sub>  |
|                       |                                      | THD+N=1%, V <sub>DD</sub> =5V,<br>f=1kHz, R <sub>L</sub> =2.5kΩ         |      | 3.50 |      |                   |
|                       |                                      | THD+N=1%, V <sub>DD</sub> =5V,<br>f=1kHz, R <sub>L</sub> =100kΩ         |      | 3.57 |      |                   |
| THD+N                 | Total Harmonic Distortion Plus Noise | V <sub>O</sub> =2V <sub>rms</sub> , f=1kHz,<br>R <sub>L</sub> =2.5kΩ    |      | 0.01 |      | %                 |
|                       |                                      | V <sub>O</sub> =3V <sub>rms</sub> , f=1kHz,<br>R <sub>L</sub> =2.5kΩ    |      | 0.01 |      | %                 |
| X <sub>TALK</sub>     | Crosstalk                            | V <sub>O</sub> =2V <sub>rms</sub> , f=1kHz,<br>R <sub>L</sub> =2.5kΩ    |      | -90  |      | dB                |
|                       |                                      | V <sub>O</sub> =3V <sub>rms</sub> , f=1kHz,<br>R <sub>L</sub> =2.5kΩ    |      | -88  |      | dB                |
| I <sub>O</sub>        | Output Current Limit                 | V <sub>DD</sub> = 3.3V  |      | 20   |      | mA                |
| R <sub>IN</sub>       | Input Resistor Range                 |   | 1    | 10   | 47   | kΩ                |
| R <sub>FB</sub>       | Feedback Resistor Range              |   | 4.7  | 20   | 100  | kΩ                |
| SR                    | Slew Rate                            |   |      | 8    |      | V/μs              |
| C <sub>LOAD_Max</sub> | Maximum Capacitive Load              |   |      | 220  |      | pF                |
| V <sub>N</sub>        | Noise Output Voltage                 | A-weighted, BW = 20kHz  |      | 30   |      | μV <sub>rms</sub> |
| SNR                   | Signal to Noise Ratio                | V <sub>O</sub> =3V <sub>rms</sub> , THD+N=0.1%,<br>BW=20kHz, A-Weighted |      | 90   |      | dB                |
| G <sub>BW</sub>       | Unity Gain Bandwidth                 |   |      | 5.4  |      | MHz               |
| A <sub>VO</sub>       | Open-Loop Voltage Gain               |   |      | 110  |      | dB                |

**ELECTRICAL CHARACTERISTICS** (Continued)

| Symbol            | Parameter  | Conditions          | Min  | Typ  | Max  | Unit |
|-------------------|--|---------------------|------|------|------|------|
| F <sub>CP</sub>   | Charge Pump Frequency                                  |                     | 300  | 417  | 540  | kHz  |
| V <sub>UVP</sub>  | External Under Voltage Detection                       |                     | 1.05 | 1.15 | 1.25 | V    |
| I <sub>HYS</sub>  | External Under Voltage Detection<br>Hysteresis Current |                     |      | 4.6  |      | μA   |
| V <sub>EN_H</sub> | Input High Voltage Threshold                           | V <sub>DD</sub> =5V |      | 1.65 |      | V    |
| V <sub>EN_L</sub> | Input Low Voltage Threshold                            | V <sub>DD</sub> =5V |      | 0.6  |      | V    |

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** T<sub>J</sub> is calculated from the ambient temperature T<sub>A</sub> and power dissipation PD according to the following formula: T<sub>J</sub> = T<sub>A</sub> + (P<sub>D</sub>) × θ<sub>JA</sub>.

**FUNCTIONAL BLOCK DIAGRAM**

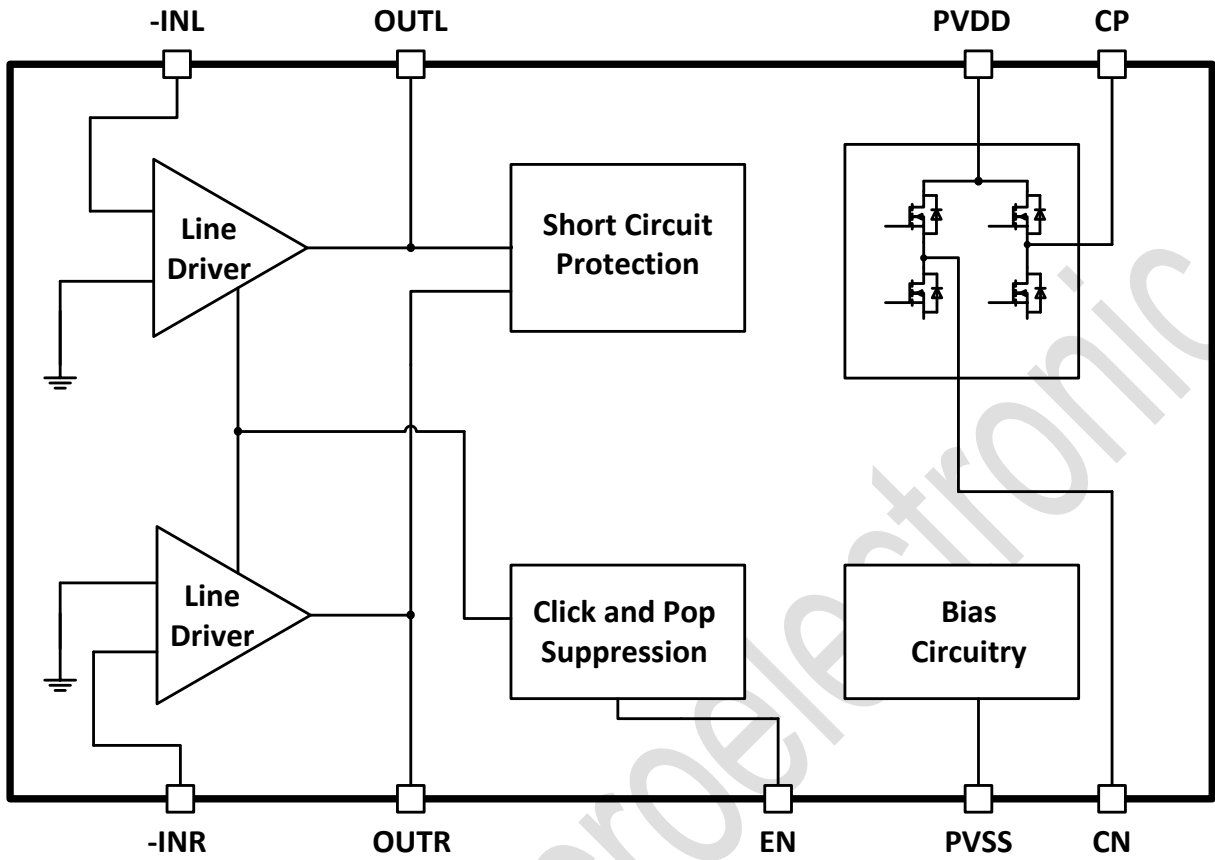
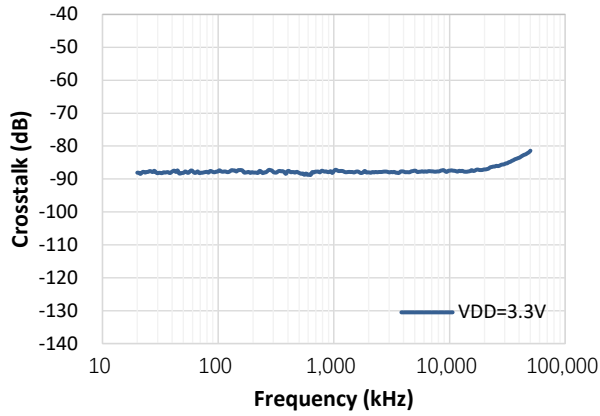


Figure 2. TMI8320C Block Diagram

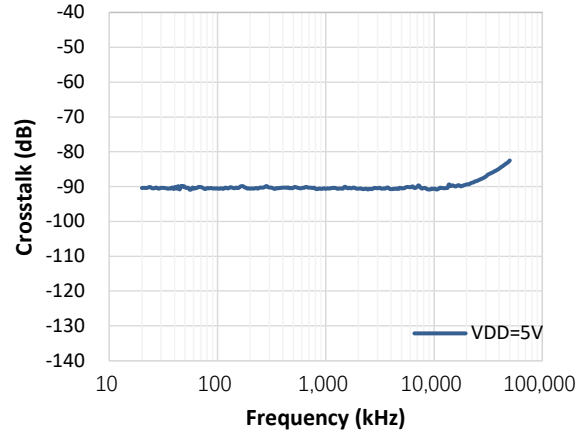
## TYPICAL PERFORMANCE CHARACTERISTICS

( $V_{DD} = 3.3V$ ,  $R_L = 2.5k\Omega$ ,  $C_{PUMP} = 0.33\mu F$ ,  $C_{PVSS} = 0.33\mu F$ ,  $C_{IN} = 10\mu F$ ,  $R_{IN} = 10k\Omega$ ,  $R_{FB} = 20k\Omega$ ,  $T_A = 25^\circ C$ , unless otherwise noted.)

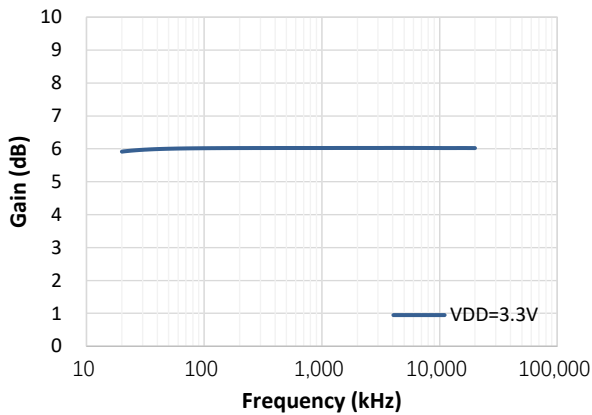
**Crosstalk at  $V_{DD}=3.3V$**



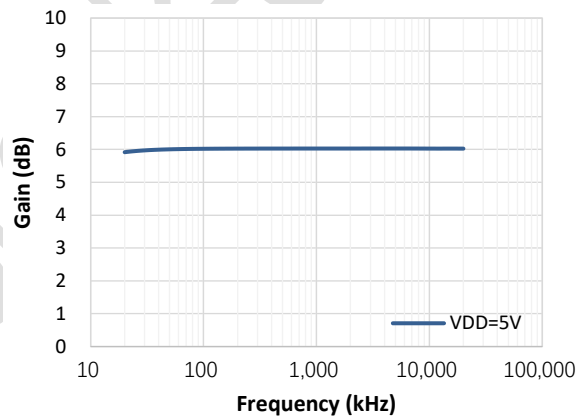
**Crosstalk at  $V_{DD}=5V$**



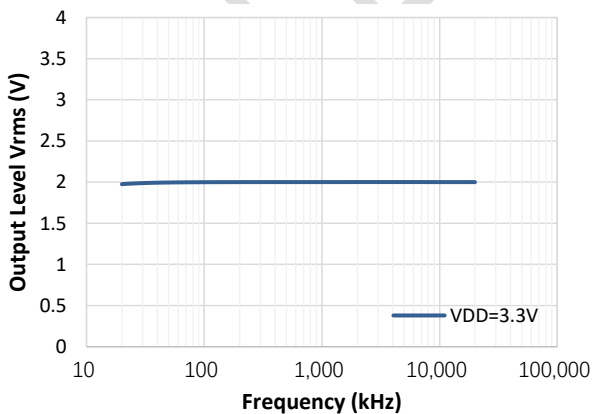
**Gain at  $V_{DD}=3.3V$**



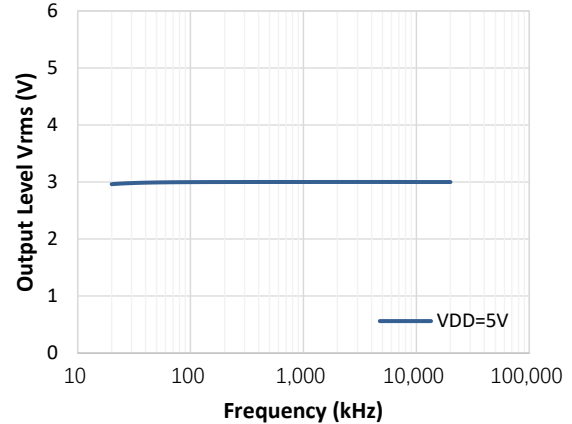
**Gain at  $V_{DD}=5V$**



**Output  $V_{rms}$  Level at  $V_{DD}=3.3V$**



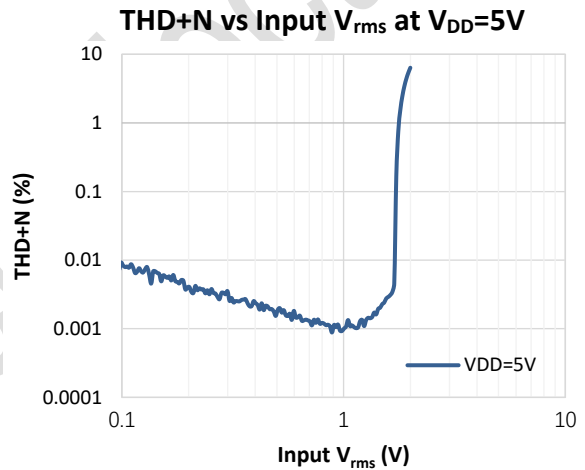
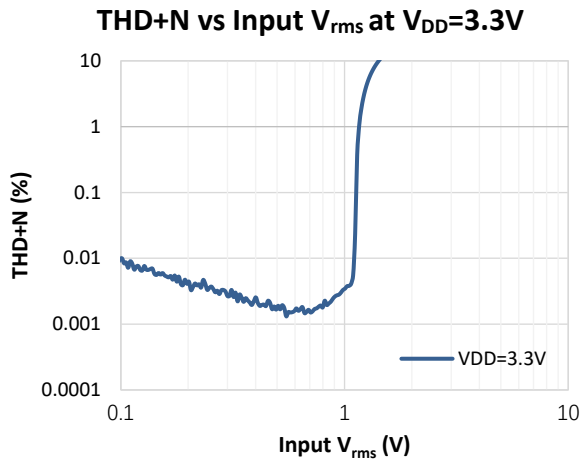
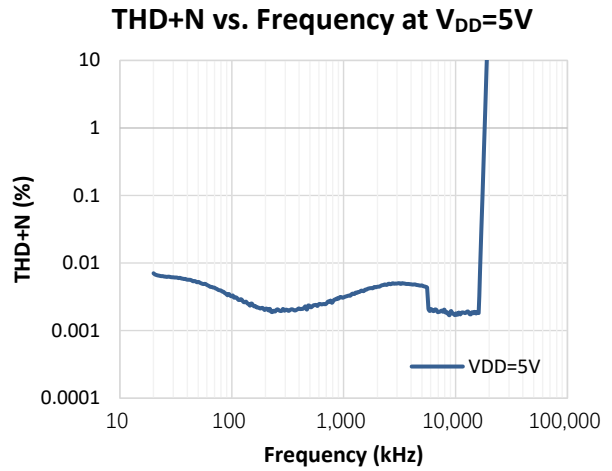
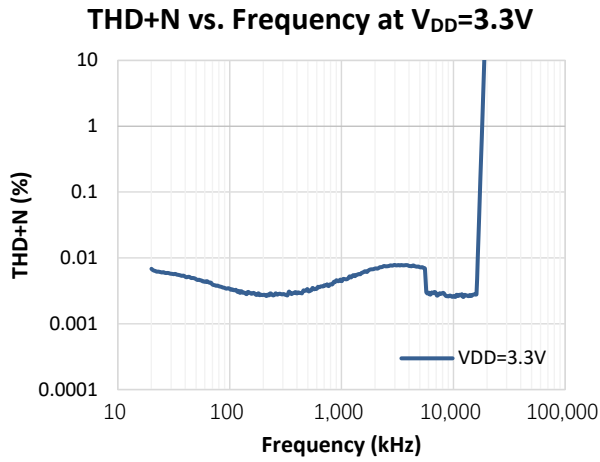
**Output  $V_{rms}$  Level at  $V_{DD}=5V$**





**TYPICAL PERFORMANCE CHARACTERISTICS** (Continuous)

( $V_{DD} = 3.3V$ ,  $R_L = 2.5k\Omega$ ,  $C_{PUMP} = 0.33\mu F$ ,  $C_{PVSS} = 0.33\mu F$ ,  $C_{IN} = 10\mu F$ ,  $R_{IN} = 10k\Omega$ ,  $R_{FB} = 20k\Omega$ ,  $T_A = 25^\circ C$ , unless otherwise noted.)



## APPLICATION INFORMATION

### Decoupling Capacitors

The TMI8320C is a capless line driver amplifier that requires adequate power supply decoupling to ensure that the noise and total harmonic distortion (THD) are low. A good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1 $\mu$ F, placed as close as possible to the device PVDD lead, works best. Placing this decoupling capacitor close to the TMI8320C is important for the performance of the amplifier. For filtering lower frequency noise signals, a 10 $\mu$ F or larger capacitor placed near the audio power amplifier would also help, but it is not required in most applications because of the high PSRR of this device.

### Gain Setting Resistors Ranges

The gain setting resistors,  $R_{IN}$  and  $R_{FB}$ , must be chosen so that noise, stability and input capacitor size of the TMI8320C are kept within acceptable limits. Voltage gain is defined as  $R_{FB}$  divided by  $R_{IN}$ .

Selecting values that are too low demands a large input AC coupling capacitor,  $C_{IN}$ . Selecting values that are too high increases the noise of the amplifier. Table 1 lists the recommended resistor values for different gain settings.

| Input Resistor Value, $R_{IN}$ | Feedback Resistor Value, $R_{FB}$ | Inverting Input Gain |
|--------------------------------|-----------------------------------|----------------------|
| 22k $\Omega$                   | 22k $\Omega$                      | 1.0V/V               |
| 20k $\Omega$                   | 30k $\Omega$                      | 1.5V/V               |
| 33k $\Omega$                   | 68k $\Omega$                      | 2.1V/V               |
| 10k $\Omega$                   | 100k $\Omega$                     | 10.0V/V              |

Table 1. Recommended Resistor Values

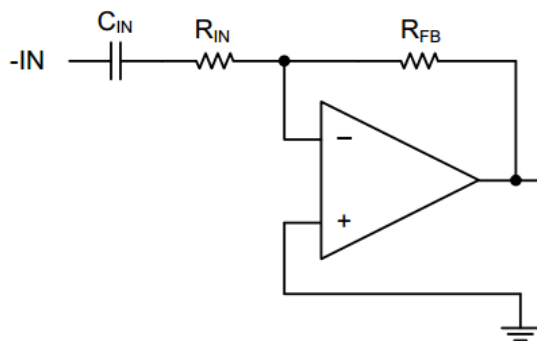


Figure 3.  $R_{IN}$   $R_{FB}$  resistor

### Input-Blocking Capacitors

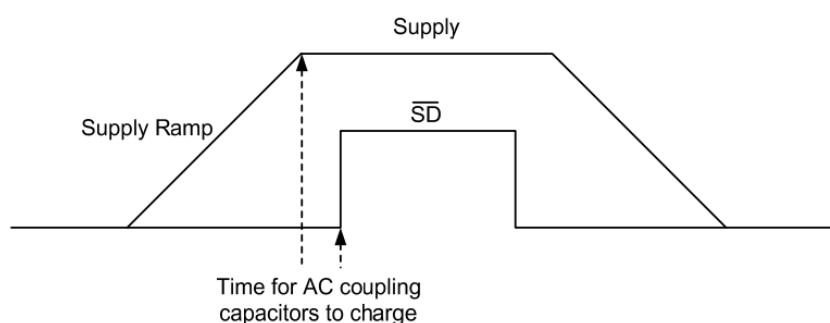
DC input-blocking capacitors are required to be added in series with the audio signal into the input pins of the TMI8320C. These capacitors block the DC portion of the audio source and allow the TMI8320C inputs to be properly biased to provide maximum performance. The input blocking capacitors also limit the DC-gain to one, limiting the DC-offset voltage at the output.

These capacitors form a high-pass filter with the input resistor,  $R_{IN}$ . The cutoff frequency is calculated using Equation 1. For this calculation, the capacitance used is the input-blocking capacitor and the resistance is the input resistor chosen from Table 1, then the frequency and/or capacitance can be determined when one of the two values are given.

$$f_{CIN} = 1 / (2\pi \times R_{IN} \times C_{IN}) \text{ or } C_{IN} = 1 / (2\pi \times f_{CIN} \times R_{IN}) \quad (\text{Equation 1})$$

### Pop-Free Power Up

Pop-free power up is ensured by keeping the SD (EN) (shutdown pin) low during power supply ramp up and down. The EN pin should be kept low until the input AC coupling capacitors are fully charged before asserting the EN pin high. This way proper pre-charge of the AC coupling is performed, and pop-free power-up is achieved. Figure below illustrates the preferred sequence.



**Figure 4. Power-Up Sequence**

### External Under Voltage Detection

External under voltage detection can be used to mute/shut down the TMI8320C before an input device can generate a pop.

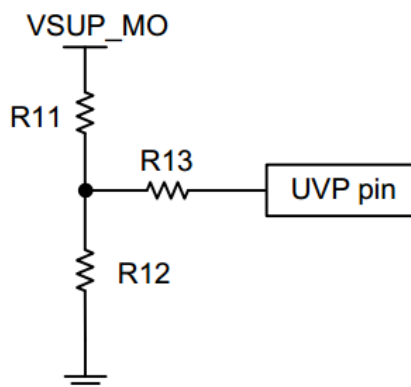
The threshold seen at the UVP pin is 1.15V. A hysteresis is introduced with a resistive divider, where thresholds for startup and shutdown are determined respectively as follows:

Startup Threshold:  $V_{UDPR} = 1.15 \times (R_{11} + R_{12}) / R_{12}$

Shutdown Threshold:  $V_{UDPF} = 1.15 \times (R_{11} + R_{12}) / R_{12} - I_{uvp} \times (R_{13} + R_{11} \parallel R_{12}) \times (R_{11} + R_{12}) / R_{12}$

Hysteresis:  $I_{uvp} \times (R_{13} + R_{11} \parallel R_{12}) \times (R_{11} + R_{12}) / R_{12}$

The R13 is optional. If the R13 is not used, the UVP pin connects to the divider center tap directly.



**Figure 5. UVP Resistors**

## Capacitive Load

The TMI8320C has the ability to drive large capacitive load up to 220pF directly, and larger capacitive loads can be accepted by adding a series resistor of 47 $\Omega$  or larger.

## Gain-Setting Resistors

The gain setting resistors,  $R_{IN}$  and  $R_{FB}$ , must be placed close to the input pins to minimize the capacitive loading on these pins and to ensure maximum stability of the TMI8320C.

## Layout Consideration

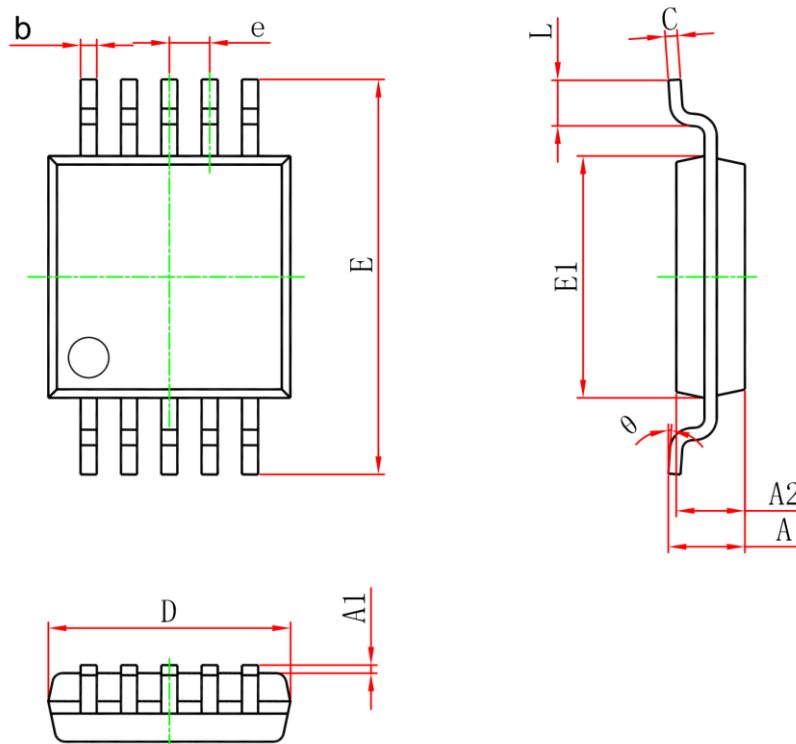
For best performance of the TMI8320C, the following guidelines must be strictly followed.

- 1) 0.1 $\mu$ F decoupling capacitor must be close to PGND and PVDD pins.
- 2) Capacitor can be connected between PVDD and PGND pins directly and then connect PGND pin to GND layer.

TOLL Microelectronic

**PACKAGE INFORMATION**

**MSOP10**



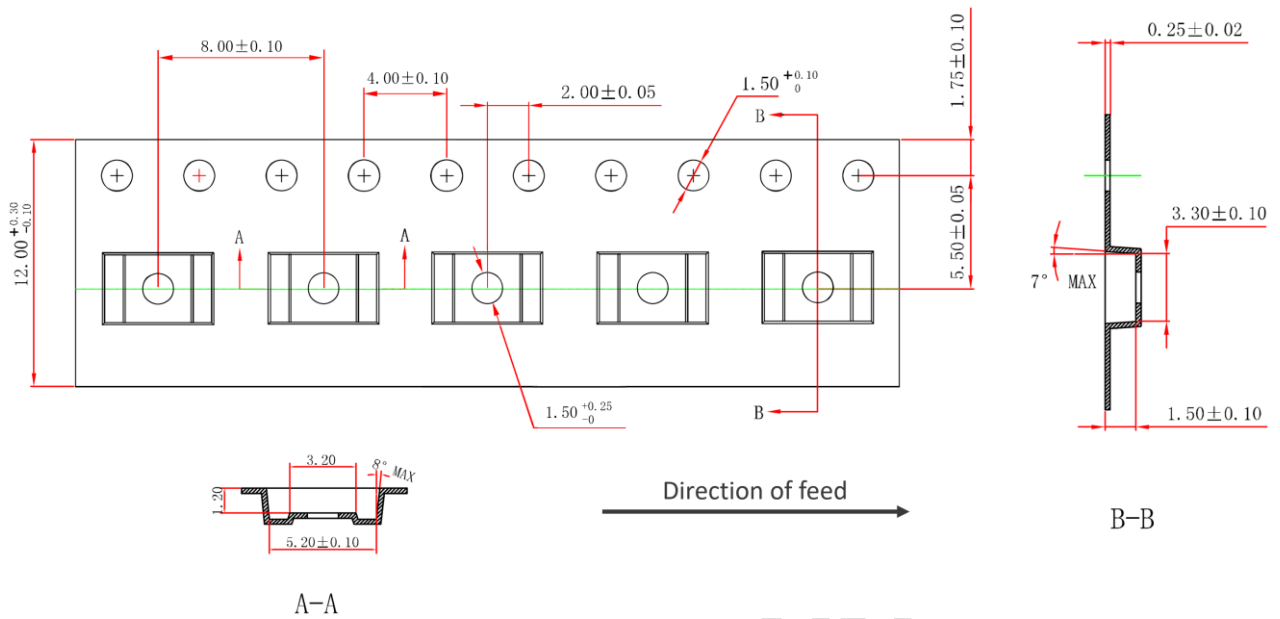
| Symbol   | Dimensions In Millimeters |       |       | Dimensions In Inches |        |       |
|----------|---------------------------|-------|-------|----------------------|--------|-------|
|          | Min                       | Typ   | Max   | Min                  | Typ    | Max   |
| A        | 0.820                     | 0.960 | 1.100 | 0.032                | 0.0375 | 0.043 |
| A1       | 0.020                     | 0.585 | 1.150 | 0.001                | 0.0035 | 0.006 |
| A2       | 0.750                     | 0.850 | 0.950 | 0.030                | 0.0335 | 0.037 |
| b        | 0.180                     | 0.255 | 0.330 | 0.007                | 0.010  | 0.013 |
| c        | 0.090                     | 0.160 | 0.230 | 0.004                | 0.0065 | 0.009 |
| D        | 2.900                     | 3.000 | 3.100 | 0.114                | 0.118  | 0.122 |
| E        | 2.900                     | 3.000 | 3.100 | 0.114                | 0.118  | 0.122 |
| E1       | 4.750                     | 4.900 | 5.050 | 0.187                | 0.193  | 0.199 |
| e        | 0.500 BSC                 |       |       | 0.020 BSC            |        |       |
| L        | 0.400                     | 0.600 | 0.800 | 0.016                | 0.0235 | 0.031 |
| $\theta$ | 0°                        | 3°    | 6°    | 0°                   | 3°     | 6°    |

**Note:**

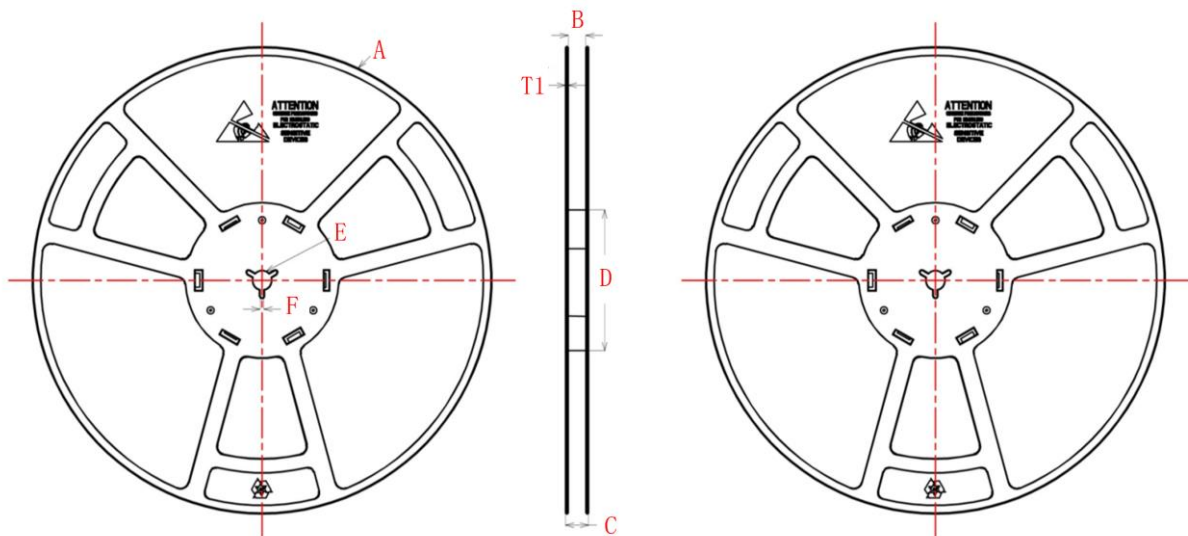
1) All dimensions are in millimeters.

## TAPE AND REEL INFORMATION

### TAPE DIMENSIONS:



### REEL DIMENSIONS:



Unit: mm

| A         | B                                    | C                                    | D           | E          | F       | T1      |
|-----------|--------------------------------------|--------------------------------------|-------------|------------|---------|---------|
| Ø 330±1.0 | 12.4 <sup>+1.0</sup> <sub>-0.0</sub> | 17.6 <sup>+1.0</sup> <sub>-0.0</sub> | Ø 100.0±0.5 | Ø 13.0±0.2 | 1.9±0.4 | 1.9±0.2 |

#### Note:

- 1) All Dimensions are in Millimeter
- 2) Quantity of Units per Reel is 3000
- 3) MSL level is level 3.

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