LM48100Q-Q1 Boomer™ Mono, 1.3-W Audio Power Amplifier With Output Fault Detection and Volume Control

1 Features

- Output Fault Detection
- I^2C Volume and Mode Control
- Input Mixer and Multiplexer
- High PSRR
- Individual 32-Step Volume Control
- Short Circuit and Thermal Protection
- Advanced Click-and-Pop Suppression
- Low-Power Shutdown Mode
- Available in 14-Pin HTSSOP Package
- Key Specifications:
  - Output Power at V_{DD} = 5 V, R_L = 8 Ω, THD+N ≤ 1% 1.3 W (Typical)
  - Quiescent Power Supply Current at 5 V, 6 mA (Typical)
  - PSRR at 1 kHz 74 dB (Typical)
  - Shutdown current 0.01 µA (Typical)

2 Applications

- Automotive Instrument Clusters
- Hands-Free Car Kits
- Medical

3 Description

The LM48100Q-Q1 is a single supply, mono, bridge-tied load amplifier with I^2C volume control, ideal for automotive applications. A comprehensive output fault detection system senses the load conditions, protecting the device during short circuit events, as well as detecting open circuit conditions.

Operating from a single 5-V supply, the LM48100Q-Q1 delivers 1.3 W of continuous output power to an 8 Ω load with < 1% THD+N. Flexible power supply requirements allow operation from 3 V to 5.5 V. High power supply rejection ratio (PSRR), 74 dB at 1 kHz, allows the device to operate in noisy environments without additional power supply conditioning.

The LM48100Q-Q1 features dual audio inputs that can be mixed/multiplexed to the device output. Each input path has its own independent, 32-step volume control. The mixer, volume control and device mode select are controlled through an I^2C compatible interface. An open drain $\overline{FAULT}$ output indicates when a fault has occurred. Comprehensive output short circuit and thermal overload protection prevent the device from being damaged during a fault condition.

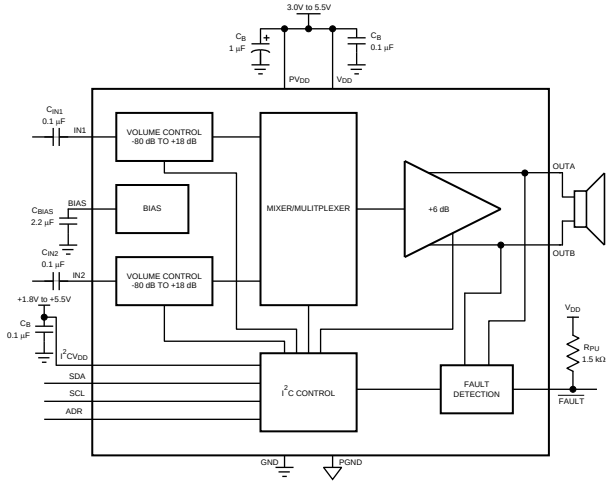
A low power shutdown mode reduces supply current consumption to 0.01 µA. Superior click and pop suppression eliminates audible transients on power-up/down and during shutdown. The LM48100Q-Q1 is available in an 14-pin HTSSOP PowerPAD™ IC package.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM48100Q-Q1	HTSSOP (14)	5.00 mm × 4.40 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Typical Audio Amplifier Application Circuit



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Revision History

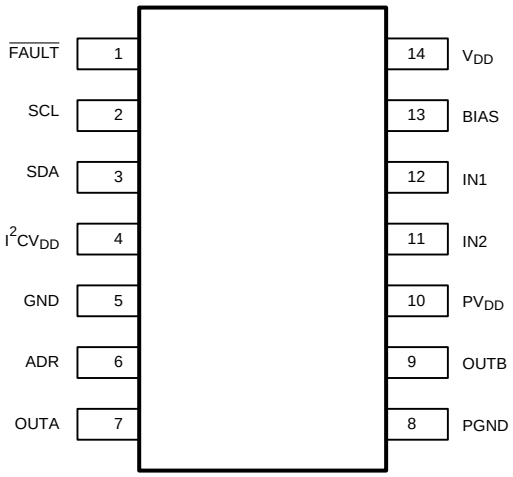
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
10/14/08	1.0	Initial release.
10/20/08	1.01	Text edits.
11/07/08	1.02	Added a column (Limits) in the Electrical tables.
11/12/08	1.03	Text edits.
03/21/2013	D	Changed layout of the National Data Sheet to TI format
11/2015	E	Added *Pin Configuration and Functions* section, *ESD Ratings* table, *Feature Description*section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout*section, *Device and Documentation Support*section, and *Mechanical, Packaging, and Orderable Information* section
		Removed LM48100Q-Q1TL Demo board Bill of Materials table.

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5 Pin Configuration and Functions

PWP Package
14-Pin HTSSOP with PowerPAD
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	$\overline{\text{FAULT}}$	O	Open-Drain output fault flag. $\overline{\text{FAULT}}$ = 0 indicates that a fault condition has occurred.
2	SCL	I	I^2C Clock Input
3	SDA	I/O	I^2C Serial Data Input
4	I^2CV_{DD}	—	I^2C Interface Power Supply
5	GND	—	Ground
6	ADR	I	I^2C Address Bit. Connect to I^2CV_{DD} to set address bit, B1 = 1. Connect to GND to set address bit B1 = 0
7	OUTA	O	Non-Inverting Audio Output
8	PGND	—	Power Ground
9	OUTB	O	Inverting Audio Output
10	PV_{DD}	—	Output Amplifier Power Supply
11	IN2	I	Audio Input 2
12	IN1	I	Audio Input 1
13	BIAS	—	Bias Bypass
14	V_{DD}	—	Power Supply
—	Exposed Pad	—	Exposed paddle. Connect to GND.

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6 Specifications

6.1 Absolute Maximum Ratings

See (1)(2)(3)

	MIN	MAX	UNIT
Supply voltage, continuous		6	V
Input voltage	−0.3	V_{DD} + 0.3	°C
Power dissipation(4)	Internally Limited		
Junction temperature		150	°C
Lead temperature (soldering 4 sec)(5)		260	°C
Storage temperature	−65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The *Electrical Characteristics* tables found in *Specifications* list ensured specifications under the listed *Recommended Operating Conditions* except as otherwise modified or specified by the *Electrical Characteristics* Test Conditions, Notes, or both. Typical specifications are estimations only and are not ensured.
(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
(4) θ_{JA} measured with a 4 layer JEDEC board.
(5) For detailed information on soldering plastic HTSSOP and LLP packages go to the TI Packaging site, ti.com/packaging.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002(1)	2500	V
		Charged-device model (CDM), per AEC Q100-011	300	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

		MIN	MAX	UNIT
Temperature	$T_{MIN} \le T_A \le T_{MAX}$	−40	105	°C
Supply voltage	$V_{DD}$and PV_{DD}	3	5.5	V
I^2C Supply voltage	I^2CV_{DD}	1.8	5.5	V
		I^2CV_{DD}	V_{DD}	V

6.4 Thermal Information

THERMAL METRIC(1)		LM48100Q-Q1 PWP (HTSSOP) 14 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	37.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	5.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	—	°C/W
ψ_{JT}	Junction-to-top characterization parameter	—	°C/W
ψ_{JB}	Junction-to-board characterization parameter	—	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

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6.5 Electrical Characteristics for V_{DD} = 5 V

Programmable Gain = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = 25°C, unless otherwise specified.

PARAMETER		TEST CONDITIONS		MIN(1)	TYP(2)	MAX	UNIT
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0 V, Both channels active	R_L = 8 Ω		4.4	9	mA
			R_L = ∞		4.2	6	
I_{DD}	Diagnostic Mode Quiescent Power Supply Current	Diagnostic Mode Enabled, R_L = ∞			12.5	14.5	mA
I_{SD}	Shutdown Current	Shutdown Enabled			0.01	1	µA
V_{OS}	Differential Output Offset Voltage	V_{IN} = 0 V, R_L = 8 Ω			8.8	50	mV
T_{WU}	Wake-Up Time	Time from shutdown to audio available			11.6	50	ms
A_V	Gain	Minimum Gain Setting		–55	–54	–53	dB
		Maximum Gain Setting		17	18	19	
Mute	Mute Attenuation				–80	–77	dB
R_{IN}	Input Resistance	A_V = 18 dB		11.5	12.5	13.5	kΩ
		A_V = –54 dB		98	110	120	
P_O	Output Power	R_L = 8 Ω, f = 1 kHz	THD+N = 10%		1.6		W
			THD+N = 1%	1.05	1.3		
THD+N	Total Harmonic Distortion + Noise	P_O = 850 mW, f = 1 kHz, R_L = 8 Ω			0.04%		
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200 mV_{P-P} Sine, Inputs AC GND, $C_{IN_}$ = 1 µF, Input Referred, C_{BIAS} = 2.2 µF	f = 217 Hz	66	79		dB
			f = 1 kHz		74		
SNR	Signal-to-Noise-Ratio	P_{OUT} = 450 mW, f = 1 kHz			104		dB
ϵ_{OS}	Output Noise	A_V = 0 dB, A-weighted Filter			12		µV
$I_{OUT(\overline{FAULT})}$	$\overline{FAULT}$ Output Current	$\overline{FAULT}$ = 0, $V_{OUT(\overline{FAULT})}$= 0.4 V			3		mA
R_{FAULT}	Output to Supply Short Circuit Detection Threshold	Short between either OUTA to V_{DD} or GND, or OUTB to V_{DD} or GND	Short Circuit	3			kΩ
			Open Circuit			7.5	
R_{FAULT}	Output to Supply Short Circuit Detection Threshold	Short between both OUTA and OUTB to V_{DD} or GND	Short Circuit	6			kΩ
			Open Circuit			15	
R_{OPEN}	Open Circuit Detection Threshold	Open circuit between OUTA and OUTB		100		200	Ω
R_{SHT}	Output to Output Short Circuit Detection Threshold	Short circuit between OUTA and OUTB		2		6	Ω
I_{SHTCKT}	Short Circuit Current Limit				1.47	1.67	A
T_{SD}	Thermal Shutdown Threshold				170		°C
t_{DIAG}	Diagnostic Time				58		ms

(1) Datasheet min/max specification limits are specified by test or statistical analysis.
(2) Typical Values are given for T_A = 25°C.

6.6 Electrical Characteristics for V_{DD} = 5 V at Extended Temperature Limits

Programmable Gain = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = –40°C to 105°C, unless otherwise specified.

PARAMETER		TEST CONDITIONS		MIN(1)	TYP(2)	MAX	UNIT
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0 V, Both channels active	R_L = 8 Ω		4.4	10.8	mA
			R_L = ∞		4.2	7.9	
I_{DD}	Diagnostic Mode Quiescent Power Supply Current	Diagnostic Mode Enabled, R_L = ∞			12.5		mA
I_{SD}	Shutdown Current	Shutdown Enabled			0.01		µA
V_{OS}	Differential Output Offset Voltage	V_{IN} = 0 V, R_L = 8 Ω			8.8	75	mV
T_{WU}	Wake-Up Time	Time from shutdown to audio available			11.6		ms
A_V	Gain	Minimum Gain Setting		–56	–54	–52	dB
		Maximum Gain Setting		17	18	19	
Mute	Mute Attenuation				–80	–74	dB

(1) Datasheet min/max specification limits are specified by test or statistical analysis.
(2) Typical Values are given for T_A = 25°C.

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Electrical Characteristics for V_{DD} = 5 V at Extended Temperature Limits (continued)

Programmable Gain = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = –40°C to 105°C, unless otherwise specified.

PARAMETER		TEST CONDITIONS		MIN(1)	TYP(2)	MAX	UNIT
R_{IN}	Input Resistance	A_V = 18 dB			12.5		kΩ
		A_V = –54 dB		89	110	130	
P_O	Output Power	R_L = 8 Ω, f = 1 kHz	THD+N = 10%		1.6		W
			THD+N = 1%	0.96	1.3		
THD+N	Total Harmonic Distortion + Noise	P_O = 850 mW, f = 1 kHz, R_L = 8 Ω			0.04%		
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200 mV_{P-P} Sine, Inputs AC GND, $C_{IN_}$ = 1 µF, Input Referred, C_{BIAS} = 2.2 µF	f = 217 Hz	63	79		dB
			f = 1 kHz		74		
SNR	Signal-to-Noise-Ratio	P_{OUT} = 450 mW, f = 1 kHz			104		dB
ϵ_{OS}	Output Noise	A_V = 0 dB, A-weighted Filter			12		µV
$I_{OUT(\overline{FAULT})}$	$\overline{FAULT}$ Output Current	$\overline{FAULT}$ = 0, $V_{OUT(\overline{FAULT})}$= 0.4 V			3		mA
R_{FAULT}	Output to Supply Short Circuit Detection Threshold	Short between either OUTA to V_{DD} or GND, or OUTB to V_{DD} or GND	Short Circuit	3			kΩ
			Open Circuit			7.5	
I_{SHTCKT}	Short Circuit Current Limit				1.47	2	A
T_{SD}	Thermal Shutdown Threshold				170		°C
t_{DIAG}	Diagnostic Time				58		ms

6.7 Electrical Characteristics for V_{DD} = 3.6 V

Programmable Gain = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = 25°C, unless otherwise specified.

PARAMETER		TEST CONDITIONS		MIN(1)	TYP(2)	MAX	UNIT
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0 V, Both channels active	R_L = 8 Ω		3.8	8.5	mA
			R_L = ∞		3.6	5	
I_{DD}	Diagnostic Mode Quiescent Power Supply Current	Diagnostic Mode Enabled, R_L = ∞			11.7	14.5	mA
I_{SD}	Shutdown Current	Shutdown Enabled			0.01	1	µA
V_{OS}	Differential Output Offset Voltage	V_{IN} = 0 V, R_L = 8 Ω			8.8	50	mV
T_{WU}	Wake-Up Time	Time from shutdown to audio available			11.5	50	ms
A_V	Gain	Minimum Gain Setting		–55	–54	–53	dB
		Maximum Gain Setting		17	18	19	
Mute	Mute Attenuation				–79	–77	dB
R_{IN}	Input Resistance	A_V = 18 dB		11.5	12.5	13.5	kΩ
		A_V = –54 dB		98	110	120	
P_O	Output Power	R_L = 8 Ω, f = 1 kHz	THD+N = 10%		820		mW
			THD+N = 1%	480	660		
THD+N	Total Harmonic Distortion + Noise	P_O = 400 mW, f = 1 kHz, R_L = 8 Ω			0.04%		
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200 mV_{P-P} Sine, Inputs AC GND, $C_{IN_}$ = 1 µF, Input Referred, C_{BIAS} = 2.2 µF	f = 217 Hz	66	78		dB
			f = 1 kHz		75		
SNR	Signal-to-Noise-Ratio	P_{OUT} = 780 mW, f = 1 kHz			106		dB
ϵ_{OS}	Output Noise	A_V = 0 dB, A-weighted Filter			12.5		µV
$I_{OUT(\overline{FAULT})}$	$\overline{FAULT}$ Output Current	$\overline{FAULT}$ = 0, $V_{OUT(\overline{FAULT})}$= 0.4 V			3		mA
R_{FAULT}	Output to Supply Short Circuit Detection Threshold	Short between either OUTA to V_{DD} or GND, or OUTB to V_{DD} or GND	Short Circuit	3			kΩ
			Open Circuit			7.5	
R_{FAULT}	Output to Supply Short Circuit Detection Threshold	Short between both OUTA and OUTB to V_{DD} or GND	Short Circuit	6			kΩ
			Open Circuit			15	
R_{OPEN}	Open Circuit Detection Threshold	Open circuit between OUTA and OUTB		100		200	Ω
R_{SHT}	Output to Output Short Circuit Detection Threshold	Short circuit between OUTA and OUTB		2		6	Ω
I_{SHTCKT}	Short Circuit Current Limit				1.43		A

(1) Datasheet min/max specification limits are specified by test or statistical analysis.
(2) Typical Values are given for T_A = 25°C.

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Electrical Characteristics for V_{DD} = 3.6 V (continued)

Programmable Gain = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = 25°C, unless otherwise specified.

PARAMETER		TEST CONDITIONS	MIN(1)	TYP(2)	MAX	UNIT
T_{SD}	Thermal Shutdown Threshold			170		°C
t_{DIAG}	Diagnostic Time			63		ms

6.8 Electrical Characteristics for V_{DD} = 3.6 V at Extended Temperature Limits

Programmable Gain = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = –40°C to 105°C, unless otherwise specified.

PARAMETER		TEST CONDITIONS		MIN(1)	TYP(2)	MAX	UNIT
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0 V, Both channels active	R_L = 8 Ω		3.8	10.8	mA
			R_L = ∞		3.6	7	
I_{DD}	Diagnostic Mode Quiescent Power Supply Current	Diagnostic Mode Enabled, R_L = ∞			11.7		mA
I_{SD}	Shutdown Current	Shutdown Enabled			0.01		µA
V_{OS}	Differential Output Offset Voltage	V_{IN} = 0 V, R_L = 8 Ω			8.8	76	mV
T_{WU}	Wake-Up Time	Time from shutdown to audio available			11.5		ms
A_V	Gain	Minimum Gain Setting			–54		dB
		Maximum Gain Setting			18		
Mute	Mute Attenuation				–79		dB
R_{IN}	Input Resistance	A_V = 18 dB			12.5		kΩ
		A_V = –54 dB		89	110	135	
P_O	Output Power	R_L = 8 Ω, f = 1 kHz	THD+N = 10%		820		mW
			THD+N = 1%		660		
THD+N	Total Harmonic Distortion + Noise	P_O = 400 mW, f = 1 kHz, R_L = 8 Ω			0.04%		
PSRR	Power Supply Rejection Ratio	V_{RIPPLE} = 200 mV_{P-P} Sine, Inputs AC GND, $C_{IN_}$ = 1 µF, Input Referred, C_{BIAS} = 2.2 µF	f = 217 Hz	60	78		dB
			f = 1 kHz		75		
SNR	Signal-to-Noise-Ratio	P_{OUT} = 780 mW, f = 1 kHz			106		dB
$\in_{OS}$	Output Noise	A_V = 0 dB, A-weighted Filter			12.5		µV
$I_{OUT(\overline{FAULT})}$	$\overline{FAULT}$ Output Current	$\overline{FAULT}$ = 0, $V_{OUT(\overline{FAULT})}$ = 0.4 V			3		mA
I_{SHTCKT}	Short Circuit Current Limit				1.43		A
T_{SD}	Thermal Shutdown Threshold				170		°C
t_{DIAG}	Diagnostic Time				63		ms

(1) Datasheet min/max specification limits are specified by test or statistical analysis.
(2) Typical Values are given for T_A = 25°C.

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6.9 I^2C Interface Characteristics for V_{DD} = 5 V, 2.2 V ≤ I^2C V_{DD} ≤ 5.5 V

A_V = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = 25 °C, unless otherwise specified.

PARAMETER		TEST CONDITIONS	MIN(1)	MAX	UNIT
t_1	SCL Period		2.5		µs
t_2	SDA Setup Time		100		ns
t_3	SDA Stable Time		0		ns
t_4	Start Condition Time		100		ns
t_5	Stop Condition Time		100		ns
t_6	SDA Data Hold Time		100		ns
V_{IH}	Logic High Input Threshold		0.7 x I^2CV_{DD}		V
V_{IL}	Logic Low Input Threshold			0.3 x I^2CV_{DD}	V

(1) Datasheet min/max specification limits are specified by test or statistical analysis.

6.10 I^2C Interface Characteristics for V_{DD} = 5 V, 1.8 V ≤ I^2C V_{DD} ≤ 2.2 V

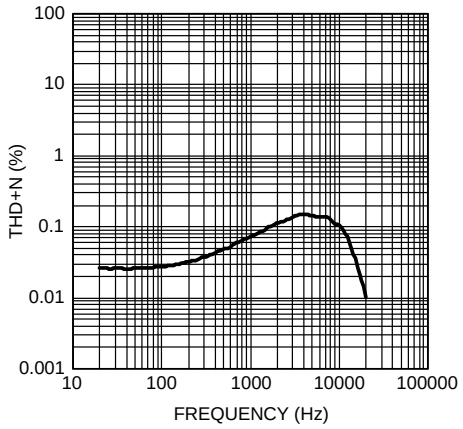
A_V = 0 dB, R_L = 8 Ω, f = 1 kHz, unless otherwise specified. Limits apply for T_A = 25 °C, unless otherwise specified.

PARAMETER		TEST CONDITIONS	MIN(1)	MAX	UNIT
t_1	SCL Period		2.5		µs
t_2	SDA Setup Time		250		ns
t_3	SDA Stable Time		0		ns
t_4	Start Condition Time		250		ns
t_5	Stop Condition Time		250		ns
t_6	SDA Data Hold Time		250		ns
V_{IH}	Logic High Input Threshold		0.7 x I^2CV_{DD}		V
V_{IL}	Logic Low Input Threshold			0.3 x I^2CV_{DD}	V

(1) Datasheet min/max specification limits are specified by test or statistical analysis.

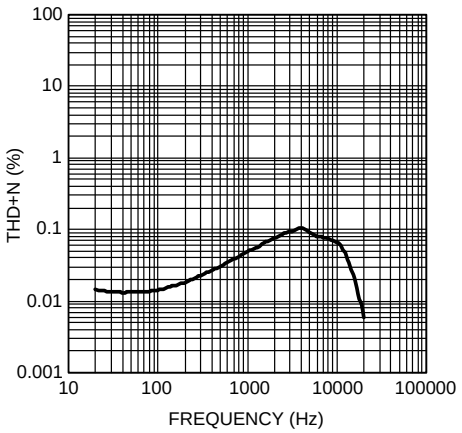
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6.11 Typical Characteristics



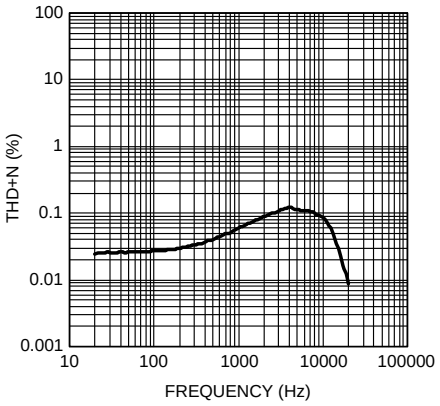
V_{DD} = 3.6 V P_{OUT} = 600 mW R_L = 4 Ω

Figure 1. THD+N vs Frequency



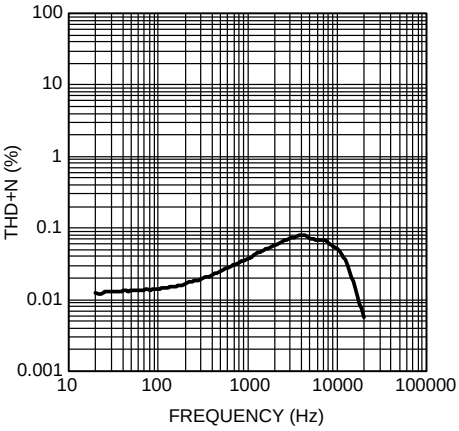
V_{DD} = 3.6 V P_{OUT} = 400 mW R_L = 8 Ω

Figure 2. THD+N vs Frequency



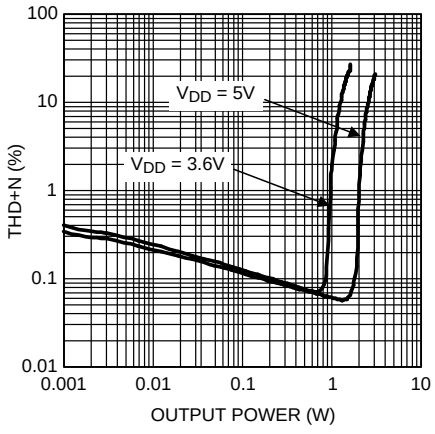
V_{DD} = 5 V P_{OUT} = 1.2 W R_L = 4 Ω

Figure 3. THD+N vs Frequency



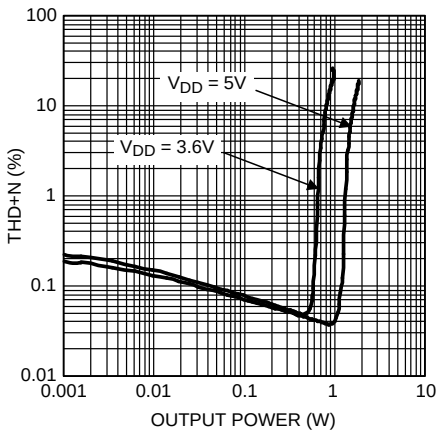
V_{DD} = 5 V P_{OUT} = 850 mW R_L = 8 Ω

Figure 4. THD+N vs Frequency



f = 1 kHz R_L = 4 Ω

Figure 5. THD+N vs Output Power

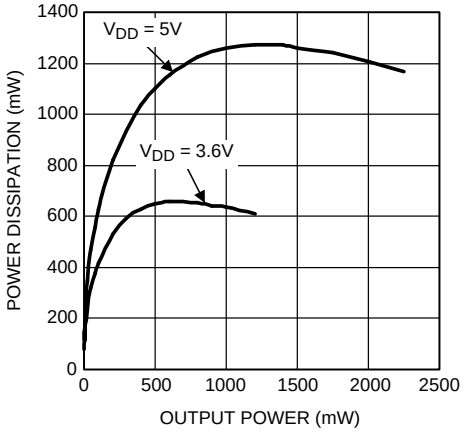


f = 1 kHz R_L = 8 Ω

Figure 6. THD+N vs Output Power

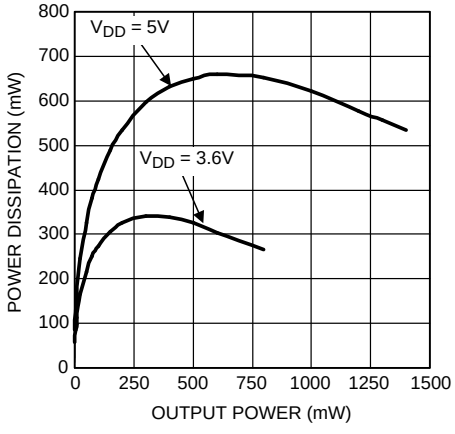
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Typical Characteristics (continued)



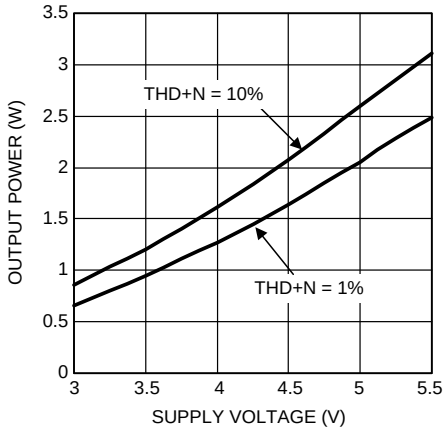
f = 1 kHz R_L = 4 Ω

Figure 7. Power Dissipation vs Output Power



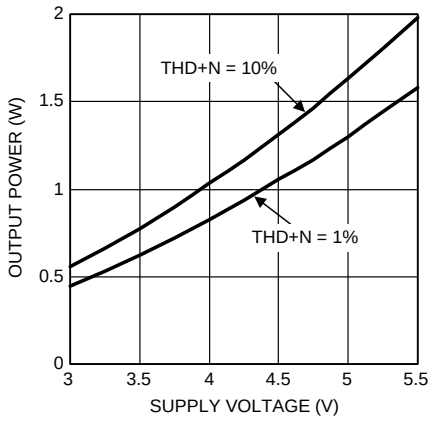
f = 1 kHz R_L = 8 Ω

Figure 8. Power Dissipation vs Output Power



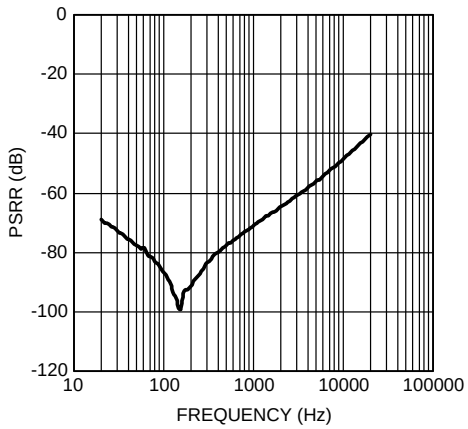
f = 1 kHz R_L = 4 Ω

Figure 9. Output Power vs Supply Voltage



f = 1 kHz R_L = 8 Ω

Figure 10. Output Power vs Supply Voltage



V_{DD} = 3.6 V V_{RIPPLE} = 200 mV_{P-P} R_L = 8 Ω

Figure 11. PSRR vs Frequency

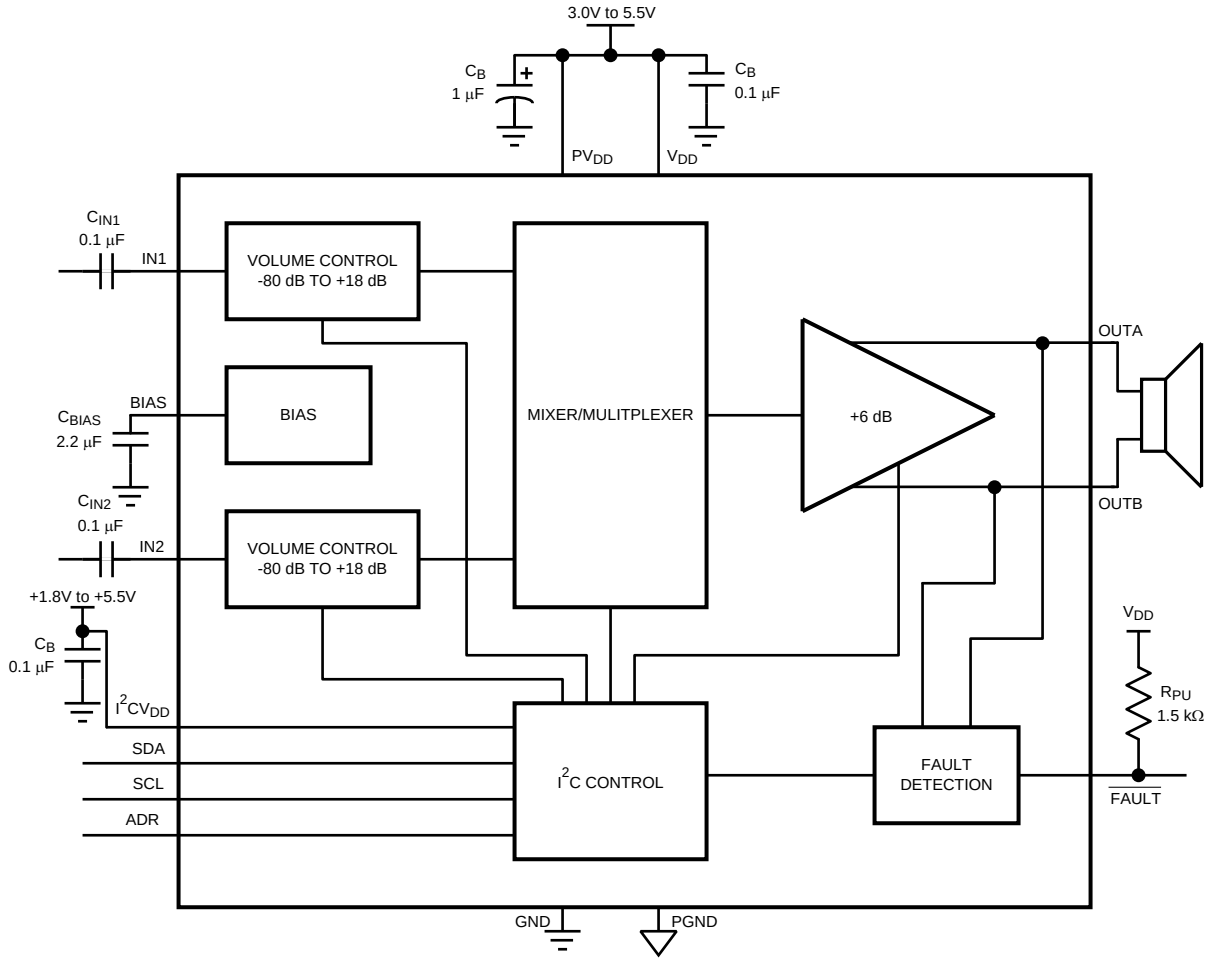
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7 Detailed Description

7.1 Overview

The LM48100Q-Q1 integrates a comprehensive output fault detection system, which can sense the load conditions, protecting the device during short circuit events and detecting open circuit conditions. High power supply rejection ratio allows the device to operate in noisy environments without additional power supply conditioning. Dual audio inputs can be mixed or multiplexed to the device output. Each input path has its own independent, 32-step volume control. The mixer, volume control and device mode select are controlled through an I^2C compatible interface. An open drain FAULT output indicates when a fault has occurred. Comprehensive output short circuit and thermal overload protection prevent the device from damage during fault conditions. Superior click and pop suppression eliminates audible transients on power-up, power-down, and during shutdown.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Diagnostic Control

The LM48100Q-Q1 output fault diagnostics are controlled through the I^2C interface. When power is initially applied to the device, the LM48100Q-Q1 initializes, performing the full diagnostic sequence; output short to V_{DD} and GND, outputs shorted together, and no load condition, is performed. The device remains in shutdown while the initial diagnostic check is performed. Any I^2C commands written to the device during this time are stored and implemented once the diagnostic check is complete. The initial diagnostic sequence can be terminated by setting DG_RESET = 1.

The Diagnostic Control register, register 1, controls the LM48100Q-Q1 diagnostic process. Bit B4, DG_EN, enables the output fault detection. Set DG_EN = 1 to enable the output diagnostic test sequence. The LM48100Q-Q1 treats the DG_EN bit as rising-edge-sensitive; once DG_EN = 1 is clocked into the device, the diagnostic test is performed. If the LM48100Q-Q1 is in one-shot mode, once the test sequence is performed, the DG_EN bit is ignored and the test sequence will not be run again. Cycle DG_EN from high-to-low-to-high to re-enable the one-shot diagnostic test sequence.

In continuous diagnostic mode, the test sequence is repeated until either a fault condition occurs, DG_RESET is cycled, or the device is taken out of continuous diagnostic mode. Set DG_CONT = 1 before setting DG_EN = 1 to initiate a continuous diagnostic. Set DG-CONT = 0 to disable continuous diagnostic mode. When the device is active and DG_EN = 0, the LM48100Q-Q1 does not perform the output short, or no load diagnostics, however, the thermal overload and output over current protection circuitry remains active, and disables the device should a thermal or over-current fault occur. The initial diagnostic operation when power is applied to the device occurs regardless of the state of DG_EN. The LM48100Q-Q1 output fault detection can be set to either continuous mode where the output diagnostic occurs every 60ms, or a one-shot mode. Set bit B3 (DG_CONT) to 1 for continuous mode, set B3 = 0 for one-shot mode.

Bit B2, DG_RESET, restores the LM48100Q-Q1 to normal operation after an output fault is detected. Toggle DG_RESET to re-enable the device outputs and set $\overline{\text{FAULT}}$ high.

Table 1. Diagnostic Control Register

BIT	NAME	VALUE	DESCRIPTION
B0	RESERVED	0	Unused
B1	ILIMIT	0	Fixed output current limit
		1	Supply dependent output current limit
B2	DG _RESET	0	Normal operation. $\overline{\text{FAULT}}$ remains low and device is disabled once a fault occurs.
		1	Reset $\overline{\text{FAULT}}$ output. Device returns to pre-fault operation.
B3	DG _CONT	0	One shot diagnostic
		1	Continuous diagnostic
B4	DG_EN	0	Disable diagnostic
		1	Enable diagnostic

7.3.2 Fault Detection Control Register

The LM48100Q-Q1 output fault tests are individually controlled through the Fault Detection Control register, register 2. Setting any of the bits in the Fault Detection Control register to 1 causes the $\overline{\text{FAULT}}$ circuitry to ignore the associated test. For example, if B2 (RAIL_SHT) = 1 and the output is shorted to V_{DD}, the $\overline{\text{FAULT}}$ output remains high. Although the $\overline{\text{FAULT}}$ circuitry ignores the selected test, the LM48100Q-Q1 protection circuitry remains active, and disables the device. This feature is useful for diagnosing which fault caused a $\overline{\text{FAULT}}$ condition.

If DG_EN = 1, and a diagnostic sequence is initiated, all the tests are performed regardless of their state in the Fault Detection Control register. If DG_EN = 0, the RAIL_SHT, OUTPUT_OPEN and OUTPUT_SHT tests are not performed, however, the thermal overload and output over-current detection circuitry remains active.

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Table 2. Fault Detection Control Register

BIT	NAME	VALUE	DESCRIPTION
B0	OUTPUT_SHT	0	Normal operation
		1	Ignore output short circuit fault (outputs shorted together)
B1	OUTPUT_OPEN	0	Normal operation
		1	Ignore output short circuit fault
B2	RAIL _SHT	0	Normal operation
		1	Ignore output short to V_{DD} or GND fault
B3	OVF	0	Normal operation
		1	Ignore output over-current fault
B4	TSD	0	Normal operation
		1	Ignore thermal overload fault

7.3.3 General Amplifier Function

7.3.3.1 Bridge Configuration Explained

The LM48100Q-Q1 is designed to drive a load differentially, a configuration commonly referred to as a bridge-tied load (BTL). The BTL configuration differs from the single-ended configuration, where one side of the load is connected to ground. A BTL amplifier offers advantages over a single-ended device. By driving the load differentially, the output voltage is doubled, compared to a single-ended amplifier under similar conditions. This doubling of the output voltage leads to a quadrupling of the output power. For example, the theoretical maximum output power for a single-ended amplifier driving 8 Ω and operating from a 5 V supply is 158 mW, while the theoretical maximum output power for a BTL amplifier operating under the same conditions is 633 mW. Since the amplifier outputs are both biased about $V_{DD}/2$, there is no net DC voltage across the load, eliminating the DC blocking capacitors required by single-ended, single-supply amplifiers.

7.3.3.2 Input Mixer/Multiplexer

The LM48100Q-Q1 features an input mixer/multiplexer controlled through the I^2C interface. The mixer/multiplexer allows either input, or the combination of both inputs to appear at the device output. Bits B2 (INPUT_1) and B3 (INPUT_2) of the Mode Control Register select the individual input channels. Set INPUT_1 = 1 to select the audio signal on IN1. Set INPUT_2 = 1 to select the audio signal on IN2. Setting both INPUT_1 and INPUT_2 = 1 mixes V_{IN1} and V_{IN2}, and the LM48100Q-Q1 outputs the result as a mono signal (Table 3).

Table 3. Input Multiplexer Control

INPUT_1	INPUT_2	LM48100Q-Q1 OUTPUT
0	0	MUTE. No input selected
1	0	IN1 ONLY
0	1	IN2 ONLY
1	1	IN1 + IN2

7.3.4 Output Fault Detection

7.3.4.1 Output Short to Supplies (V_{DD} or GND)

With a standard speaker load (6 Ω to 100 Ω) connected between OUTA and OUTB, the LM48100Q-Q1 can detect a short between the outputs and either V_{DD} or GND. A short is detected if the impedance between either OUTA or OUTB and V_{DD} or GND is less than 3 kΩ. A short is also detected if the impedance between BOTH OUTA and OUTB and either V_{DD} or GND is less than 6 kΩ. Under either of these conditions, the amplifier outputs are disabled and $\overline{\text{FAULT}}$ is driven low. No short is detected if the impedance between either output and V_{DD} or GND is greater than 7.5 kΩ. Likewise, no short is detected if the impedance between BOTH outputs and V_{DD} or GND is greater than 15 kΩ.

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7.3.4.2 Output Short Circuit and Open Circuit Detection

The LM48100Q-Q1 can detect whether the amplifier outputs have been shorted together or, an output open circuit condition has occurred. An output short circuit is detected if the impedance between OUTA and OUTB is less than 2 Ω. An open circuit is detected if the impedance between OUTA and OUTB is greater than 200 Ω. Under either of these conditions, the amplifier outputs are disabled and $\overline{\text{FAULT}}$ is driven low. The device remains in normal operation if the impedance between OUTA and OUTB is in the range of 6 Ω to 100 Ω. The output open circuit test is only performed during the initial diagnostic sequence during power up, or when DG_ENABLE is set to 1.

7.3.4.3 Output Over-Current Detection

The LM48100Q-Q1 has two over current detection modes, a fixed current limit, and a supply dependent current limit. Bit B1 (ILIMIT) of the Diagnostic Control Register selects the over-current detection mode. Set ILIMIT = 0 to select a fixed current limit of 1.47 A (typ). Set ILIMIT = 1 to select the supply dependent current limit mode. In supply dependent mode, the current limit is determined by Equation 1:

$$I_{SHTCKT} = 0.264 \times V_{DD} \text{ (A)} \quad (1)$$

If the output current exceeds the current limit, the device outputs are disabled and $\overline{\text{FAULT}}$ is driven low. The output over-current detection circuitry remains active when the diagnostics have been disabled (DG_EN = 0).

7.3.4.4 Thermal Overload Detection

The LM48100Q-Q1 has thermal overload threshold of 170 °C (typ). If the die temperature exceeds 170 °C, the outputs are disabled and $\overline{\text{FAULT}}$ is driven low. The thermal overload detection circuitry remains active when the diagnostics have been disabled (DG_EN = 0).

7.3.5 Open $\overline{\text{FAULT}}$ Output

The LM48100Q-Q1 features an open drain, fault indication output, $\overline{\text{FAULT}}$, that asserts when a fault condition is detected by the device. $\overline{\text{FAULT}}$ goes low when either an output short, output open, over current, or thermal overload fault is detected, and the diagnostic test is not ignored, see *Fault Detection Control Register* section. $\overline{\text{FAULT}}$ remains low even after the fault condition has been cleared and the diagnostic tests are repeated. Toggle DG_RESET to clear $\overline{\text{FAULT}}$.

Connect a 1.5-kΩ or higher pullup resistor between $\overline{\text{FAULT}}$ and V_{DD}.

7.3.6 Volume Control

Table 4. Volume Control

VOLUME STEP	VOL4	VOL3	VOL2	VOL1	VOL0	GAIN (dB)
1	0	0	0	0	0	–80
2	0	0	0	0	1	–54
3	0	0	0	1	0	–40.5
4	0	0	0	1	1	–34.5
5	0	0	1	0	0	–30
6	0	0	1	0	1	–27
7	0	0	1	1	0	–24
8	0	0	1	1	1	–21
9	0	1	0	0	0	–18
10	0	1	0	0	1	–15
11	0	1	0	1	0	–13.5
12	0	1	0	1	1	–12
13	0	1	1	0	0	–10.5
14	0	1	1	0	1	–9
15	0	1	1	1	0	–7.5
16	0	1	1	1	1	–6
17	1	0	0	0	0	–4.5

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Table 4. Volume Control (continued)

VOLUME STEP	VOL4	VOL3	VOL2	VOL1	VOL0	GAIN (dB)
18	1	0	0	0	1	–3
19	1	0	0	1	0	–1.5
20	1	0	0	1	1	0
21	1	0	1	0	0	1.5
22	1	0	1	0	1	3
23	1	0	1	1	0	4.5
24	1	0	1	1	1	6
25	1	1	0	0	0	7.5
26	1	1	0	0	1	9
27	1	1	0	1	0	10.5
28	1	1	0	1	1	12
29	1	1	1	0	0	13.5
30	1	1	1	0	1	15
31	1	1	1	1	0	16.5
32	1	1	1	1	1	18

7.3.7 Shutdown Function

The LM48100Q-Q1 features an I^2C selectable low power shutdown mode that disables the device, reducing quiescent current consumption to 0.01 µA. Set bit B4 (POWER_ON) in the Mode Control Register to 0 to disable the device. Set B0 to 1 to enable the device.

7.3.8 Power Dissipation

The increase in power delivered by a BTL amplifier leads to a direct increase in internal power dissipation. The maximum power dissipation for a BTL amplifier for a given supply voltage and load is given by Equation 2:

$$P_{DMAX} = 4 \times V_{DD}^2 / 2\pi^2 R_L \text{ (Watts)} \quad (2)$$

The maximum power dissipation of the HTSSOP package is calculated by Equation 3:

$$P_{DMAX\ (PKG)} = T_{JMAX} - T_A / \theta_{JA} \text{ (Watts)} \quad (3)$$

where

- T_{JMAX} is 150 °C
- T_A is the ambient temperature
- θ_{JA} is the thermal resistance specified in the *Absolute Maximum Ratings*

If the power dissipation for a given operating condition exceeds the package maximum, either decrease the ambient temperature, increase air flow, add heat sinking to the device, or increase the load impedance and/or supply voltage. The LM48100Q-Q1 HTSSOP package features an exposed die attach pad (DAP) that can be used to increase the maximum power dissipation of the package, see *Exposed DAP Mounting Considerations*.

The LM48100Q-Q1 features thermal overload protection that disables the amplifier output stage when the die temperature exceeds 170 °C. See the *Thermal Overload Detection* section.

7.4 Device Functional Modes

The LM48100Q-Q1 output fault diagnostics support two different modes: one-shot mode and continuous diagnostic mode.

7.4.1 One-Shot Mode

If the LM48100Q-Q1 is in one-shot mode, once the test sequence is performed, the DG_EN bit is ignored and the test sequence will not be run again.

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Device Functional Modes (continued)

7.4.2 Continuous Diagnostic Mode

In continuous diagnostic mode, the test sequence is repeated until either a fault condition occurs, DG_RESET is cycled, or the device is taken out of continuous diagnostic mode.

7.5 Programming

7.5.1 Write-Only I²C Compatible Interface

The LM48100Q-Q1 is controlled through an I²C compatible serial interface that consists of a serial data line (SDA) and a serial clock (SCL). The clock line is uni-directional. The data line is bi-directional (open drain). The LM48100Q-Q1 and the master can communicate at clock rates up to 400 kHz. Figure 12 shows the I²C interface timing diagram. Data on the SDA line must be stable during the HIGH period of SCL. The LM48100Q-Q1 is a transmit/receive slave-only device, reliant upon the master to generate the SCL signal. Each transmission sequence is framed by a START condition and a STOP condition (Figure 13). Each data word, device address and data, transmitted over the bus is 8 bits long and is always followed by an acknowledge pulse (Figure 14). The LM48100Q-Q1 device address is 111110X, where X is determined by ADR (Table 6). ADR = 1 sets the device address to 1111101. ADR = 0 sets the device address to 1111100.

7.5.2 I²C Bus Format

The I²C bus format is shown in Figure 14. The START signal, the transition of SDA from HIGH to LOW while SCL is HIGH, is generated, alerting all devices on the bus that a device address is being written to the bus.

The 7-bit device address is written to the bus, most significant bit (MSB) first, followed by the R/$\overline{W}$ bit. R/$\overline{W}$ = 0 indicates the master is writing to the slave device, R$\overline{W}$ = 1 indicates the master wants to read data from the slave device. Set R/$\overline{W}$ = 0; the LM48100Q-Q1 is a WRITE-ONLY device and will not respond the R/$\overline{W}$ = 1. The data is latched in on the rising edge of the clock. Each address bit must be stable while SCL is HIGH. After the last address bit is transmitted, the master device releases SDA, during which time, an acknowledge clock pulse is generated by the slave device. If the LM48100Q-Q1 receives the correct address, the device pulls the SDA line low, generating an acknowledge bit (ACK).

Once the master device registers the ACK bit, the 8-bit register data word is sent. Each data bit should be stable while SCL is HIGH. After the 8-bit register data word is sent, the LM48100Q-Q1 sends another ACK bit. Following the acknowledgement of the register data word, the master issues a STOP bit, allowing SDA to go high.

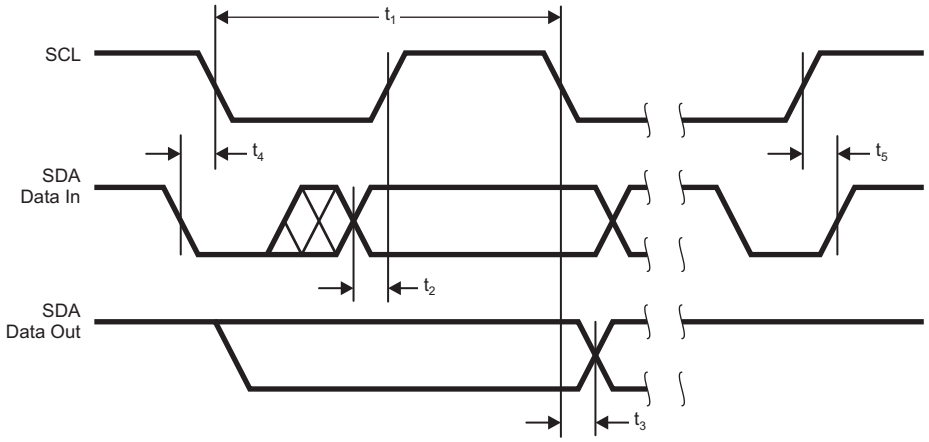


Figure 12. I²C Timing Diagram

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Programming (continued)

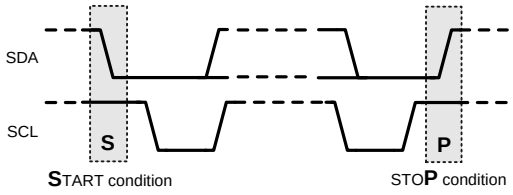


Figure 13. Start and Stop Diagram

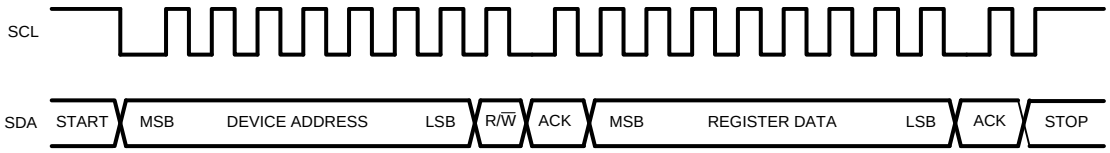


Figure 14. Example Write Sequence

Table 5. Device Address

	B7	B6	B5	B4	B3	B2	B1	B0 R/$\overline{W}$
ADR = 0	1	1	1	1	1	0	0	0
ADR = 1	1	1	1	1	1	0	1	0

7.6 Register Maps

Table 6. I^2C Control Registers

Register Address	Register Name	B7	B6	B5	B4	B3	B2	B1	B0
0	MODE CONTROL	0	0	0	POWER_ON	INPUT_2	INPUT_1	0	0
1	DIAGNOSTIC CONTROL	0	0	1	DG_EN	DG_CONT	DG_RESET	ILIMIT	0
2	FAULT DETECTION CONTROL	0	1	0	TSD	OCF	RAIL_SHT	OUTPUT _OPEN	OUTPUT _SHORT
3	VOLUME CONTROL 1	0	1	1	VOL1_4	VOL1_3	VOL1_2	VOL1_1	VOL1_0
4	VOLUME CONTROL 2	1	0	0	VOL2_4	VOL2_3	VOL2_2	VOL_2	VOL2_0

Table 7. Mode Control Registers

BIT	NAME	VALUE	DESCRIPTION
B0, B1	RESERVED	0	Unused
B2	INPUT_1	0	IN1 Input unselected
		1	IN1 Input selected
B3	INPUT_2	0	IN2 Input unselected
		1	IN2 Input selected
B4	POWER_ON	0	Device Disabled
		1	Device Enabled

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8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LM48100Q-Q1 is a single-supply, mono, bridge-tied load amplifier with I2C volume control, ideal for automotive applications. It integrates a comprehensive output fault detection system, which can sense the load conditions, protecting the device during short circuit events and detecting open circuit conditions. High power supply rejection ratio allows the device to operate in noisy environments without additional power supply conditioning. The LM48100Q-Q1 features dual audio inputs that can mixed or multiplexed to the device output. Each input path has its own independent, 32-step volume control. The mixer, volume control and device mode select are controlled through an I2C compatible interface. The LM48100Q-Q1 device has an I2C selectable low power shutdown mode that disables the device, reducing quiescent current consumption to 0.01µA

8.2 Typical Application

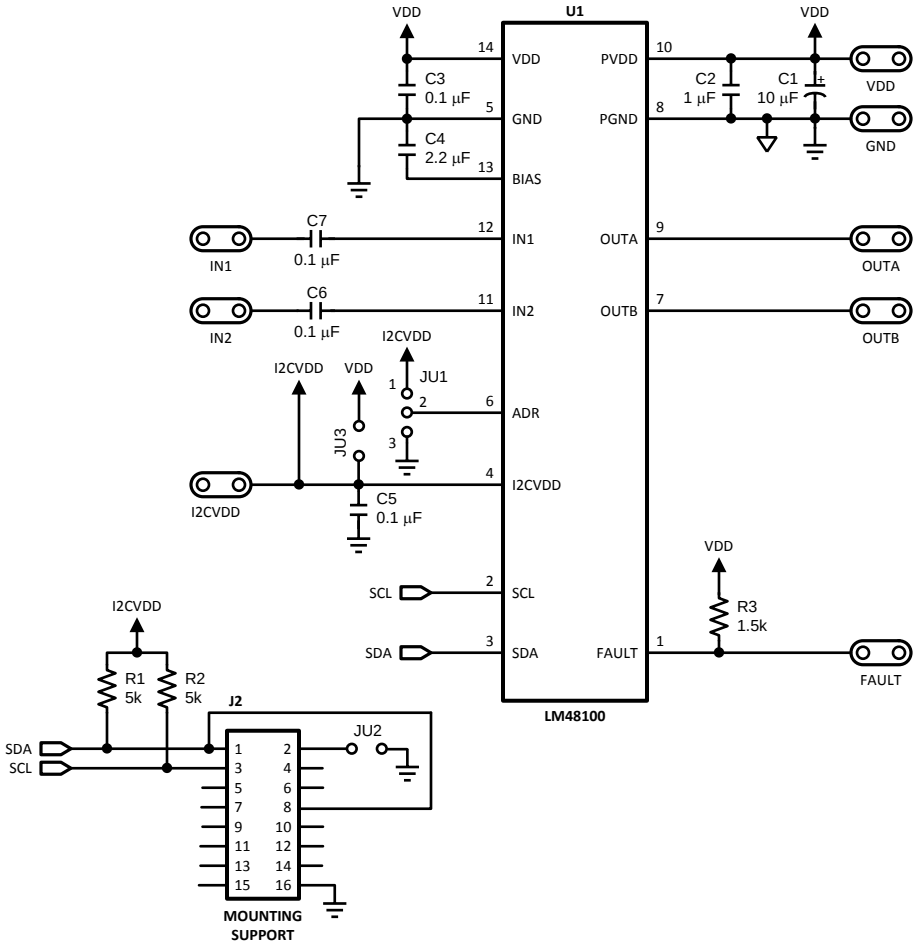


Figure 15. LM48100Q-Q1 Demo Board Schematic

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Typical Application (continued)

8.2.1 Design Requirements

For this design example, use the parameters listed in Table 8 as the input parameters.

Table 8. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUES
Supply Voltage Range	3 V to 5.5 V
I2C Supply Voltage Range	1.8 V to 5.5 V
Temperature Range	–40 °C to 105 °C
Input Voltage Range	–0.3 V to V_{DD} = 0.3 V

8.2.2 Detailed Design Procedure

8.2.2.1 Power Supply Bypassing/Filtering

Proper power supply bypassing is critical for low noise performance and high PSRR. Place the supply bypass capacitors as close to the device as possible. Place a 1-µF ceramic capacitor from V_{DD} to GND. Additional bulk capacitance may be added as required.

8.2.2.2 Input Capacitor Selection

Input capacitors may be required for some applications, or when the audio source is single-ended. Input capacitors block the DC component of the audio signal, eliminating any conflict between the DC component of the audio source and the bias voltage of the LM48100Q-Q1. The input capacitors create a high-pass filter with the input resistors R_{IN}. The –3 dB point of the high-pass filter is found using Equation 4.

$$f = 1 / 2\pi R_{IN} C_{IN} \text{ (Hz)} \quad (4)$$

where

- R_{IN} is given in the *Electrical Characteristics tables* found in *Specifications*

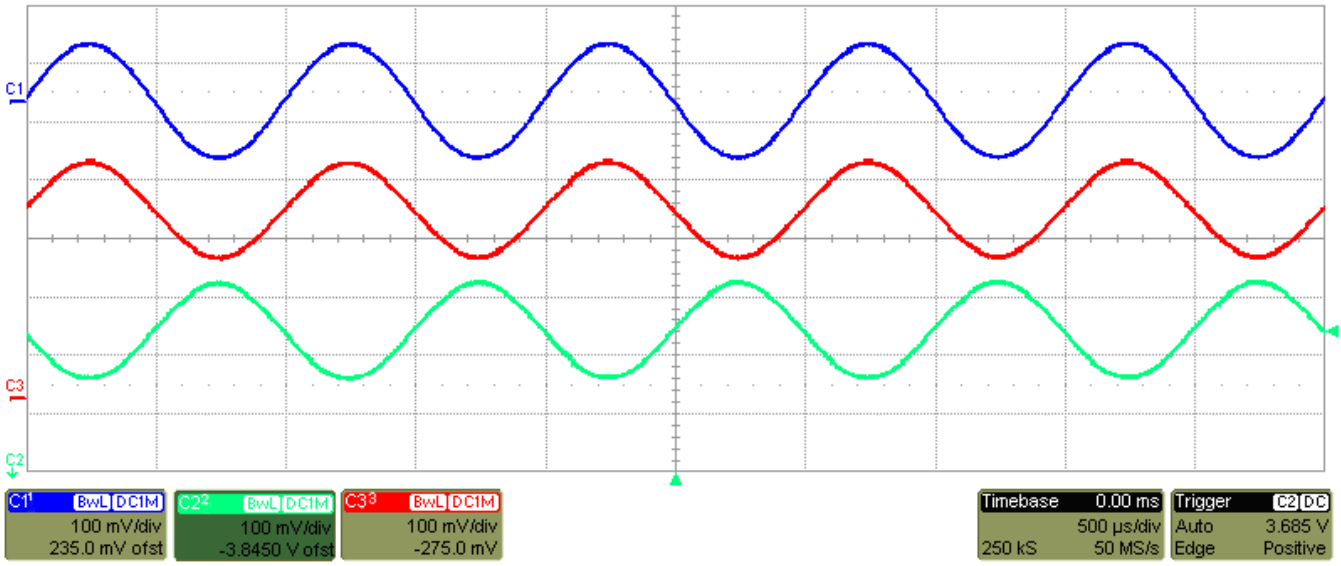
High pass filtering the audio signal helps protect the speakers. When the LM48100Q-Q1 is using a single-ended source, power supply noise on the ground is seen as an input signal. Setting the high-pass filter point above the power supply noise frequencies, filters out the noise such that it is not amplified and heard on the output. Capacitors with a tolerance of 10% or better are recommended for impedance matching and improved PSRR.

8.2.2.3 Bias Capacitor Selection

The LM48100Q-Q1 internally generates a $V_{DD}/2$ common-mode bias voltage. The BIAS capacitor C_{BIAS}, improves PSRR and THD+N by reducing noise at the BIAS node. Use a 2.2-µF ceramic placed as close to the device as possible.

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8.2.3 Application Curve



(1) IN1
(2) OUTB
(3) OUTA

Figure 16. Input and Output Waveforms for a 1kHz Sine Wave

9 Power Supply Recommendations

The LM48100Q-Q1 is designed be operate with a power supply between 3.0 V and 5.5 V. Proper power supply bypassing is critical for low noise performance and high PSRR. Place the supply bypass capacitors as close to the device as possible. Place a 1-µF ceramic capacitor from VDD to GND. Additional bulk capacitance may be added as required.

10 Layout

10.1 Layout Guidelines

Minimize trace impedance of the power, ground and all output traces for optimum performance. Voltage loss due to trace resistance between the LM48100Q-Q1 and the load results in decreased output power and efficiency. Trace resistance between the power supply and ground has the same effect as a poorly regulated supply, increased ripple and reduced peak output power. Use wide traces for power supply inputs and amplifier outputs to minimize losses due to trace resistance, as well as route heat away from the device. Proper grounding improves audio performance, minimizes crosstalk between channels and prevents digital noise from interfering with the audio signal. Use of power and ground planes is recommended.

Place all digital components and route digital signal traces as far as possible from analog components and traces. Do not run digital and analog traces in parallel on the same PCB layer. If digital and analog signal lines must cross either over or under each other, ensure that they cross in a perpendicular fashion.

10.1.1 Exposed DAP Mounting Considerations

The LM48100Q-Q1 HTSSOP-EP package features an exposed die-attach (thermal) pad on its backside. The exposed pad provides a direct heat conduction path from the die to the PCB, reducing the thermal resistance of the package. Connect the exposed pad to GND with a large pad and via to a large GND plane on the bottom of the PCB for best heat distribution.

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10.2 Layout Example

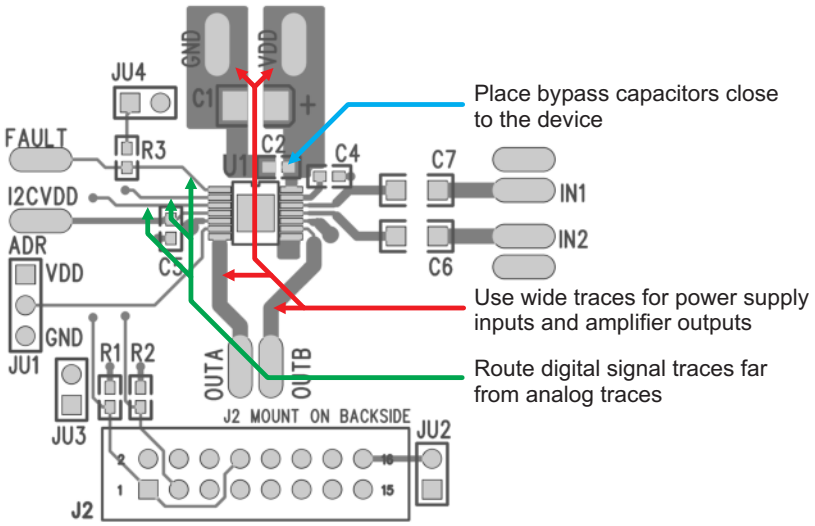


Figure 17. Example Board Layout Implementing Layout Guidelines

11 Device and Documentation Support

11.1 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.2 Trademarks

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All other trademarks are the property of their respective owners.

11.3 Electrostatic Discharge Caution



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.

11.4 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM48100QMH/NOPB	Active	Production	HTSSOP (PWP) | 14	94 | TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 105	L48100Q
LM48100QMH/NOPB.A	Active	Production	HTSSOP (PWP) | 14	94 | TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 105	L48100Q
LM48100QMHE/NOPB	Active	Production	HTSSOP (PWP) | 14	250 | SMALL T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 105	L48100Q
LM48100QMHE/NOPB.A	Active	Production	HTSSOP (PWP) | 14	250 | SMALL T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 105	L48100Q
LM48100QMHX/NOPB	Active	Production	HTSSOP (PWP) | 14	2500 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 105	L48100Q
LM48100QMHX/NOPB.A	Active	Production	HTSSOP (PWP) | 14	2500 | LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 105	L48100Q

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

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

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

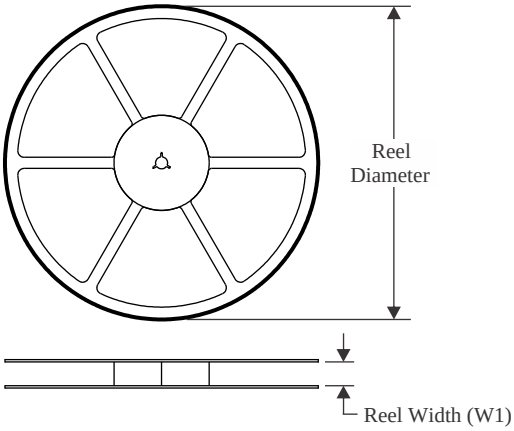
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

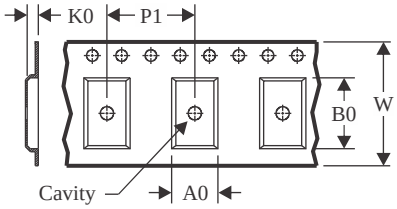
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

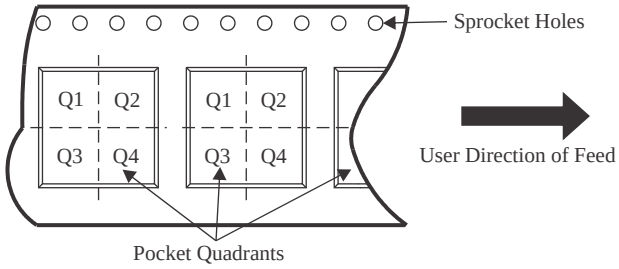


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

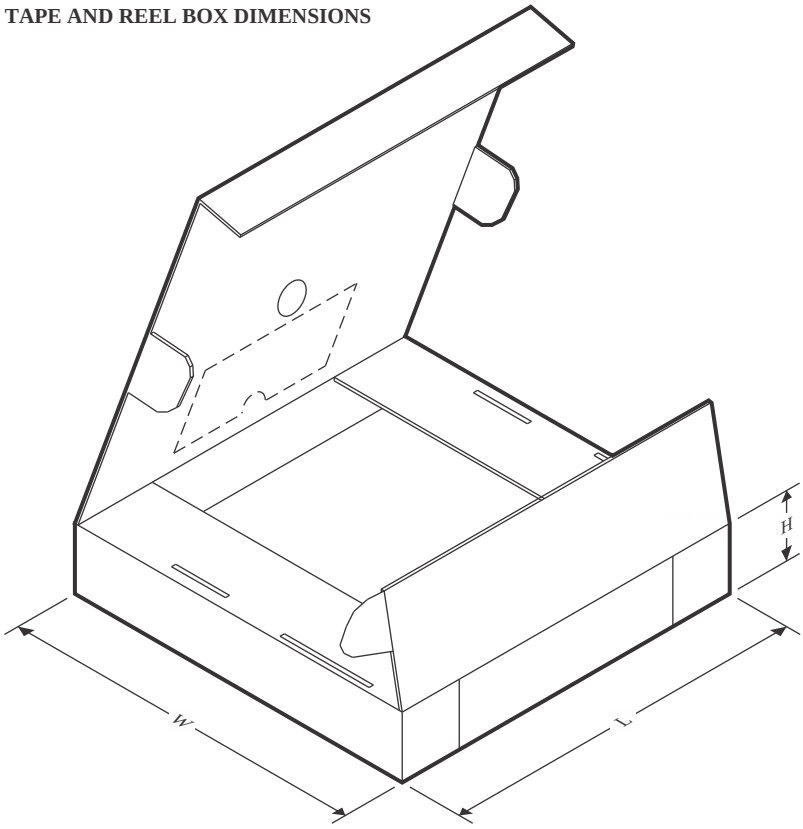
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LM48100QMHE/NOPB	HTSSOP	PWP	14	250	177.8	12.4	6.9	5.6	1.6	8.0	12.0	Q1
LM48100QMHX/NOPB	HTSSOP	PWP	14	2500	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

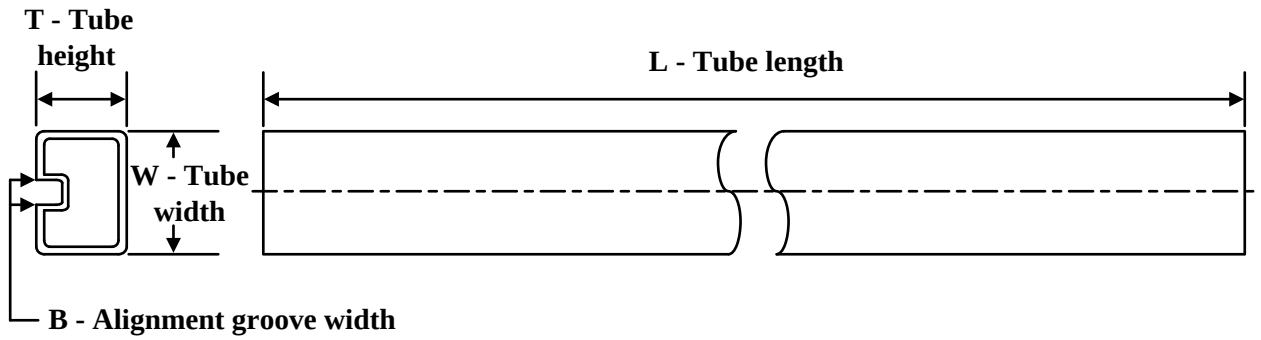
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

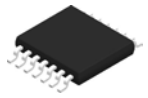
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM48100QMHE/NOPB	HTSSOP	PWP	14	250	208.0	191.0	35.0
LM48100QMHX/NOPB	HTSSOP	PWP	14	2500	367.0	367.0	35.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
LM48100QMH/NOPB	PWP	HTSSOP	14	94	495	8	2514.6	4.06
LM48100QMH/NOPB.A	PWP	HTSSOP	14	94	495	8	2514.6	4.06

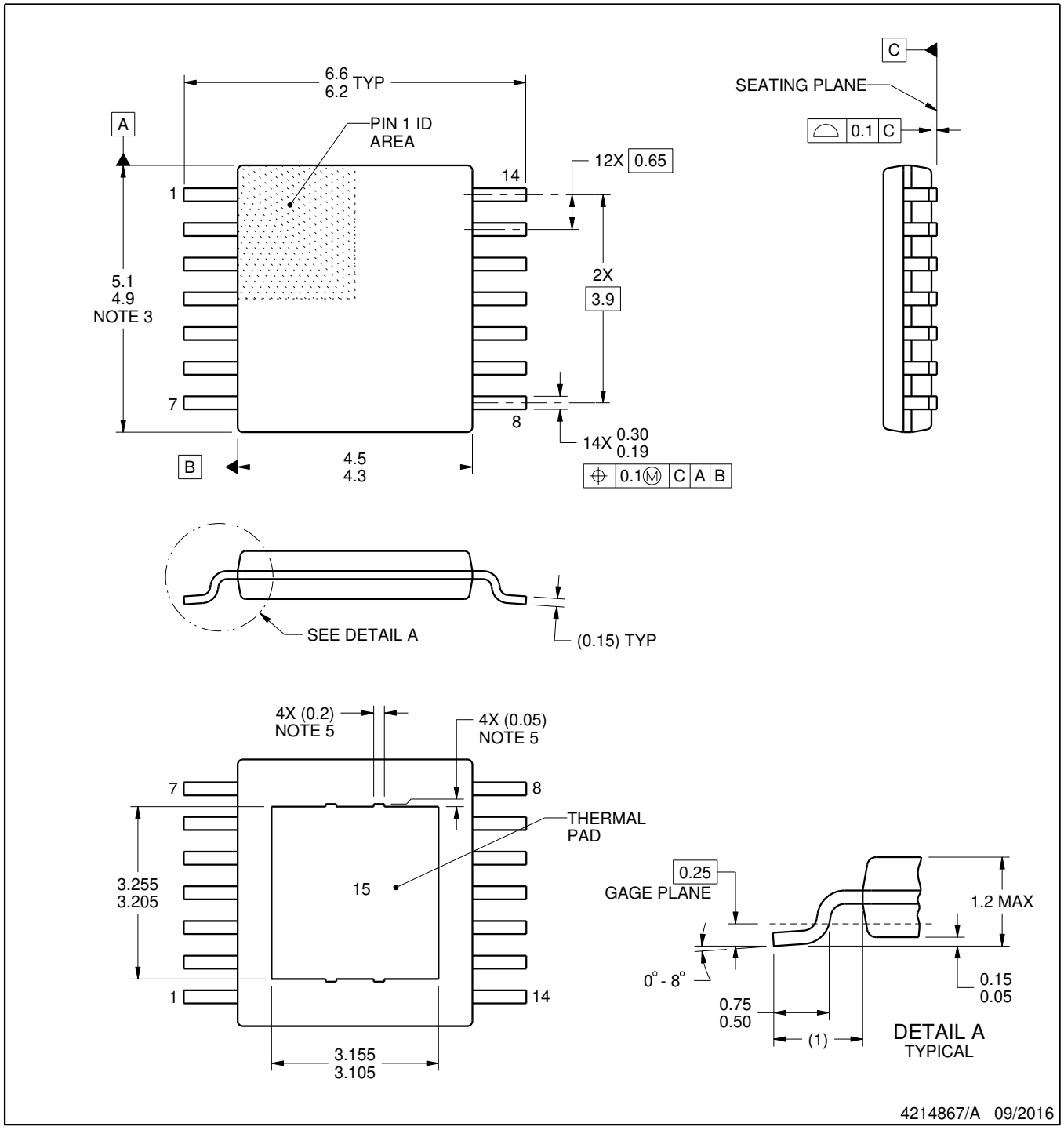


PACKAGE OUTLINE

PWP0014A

PowerPAD™ TSSOP - 1.2 mm max height

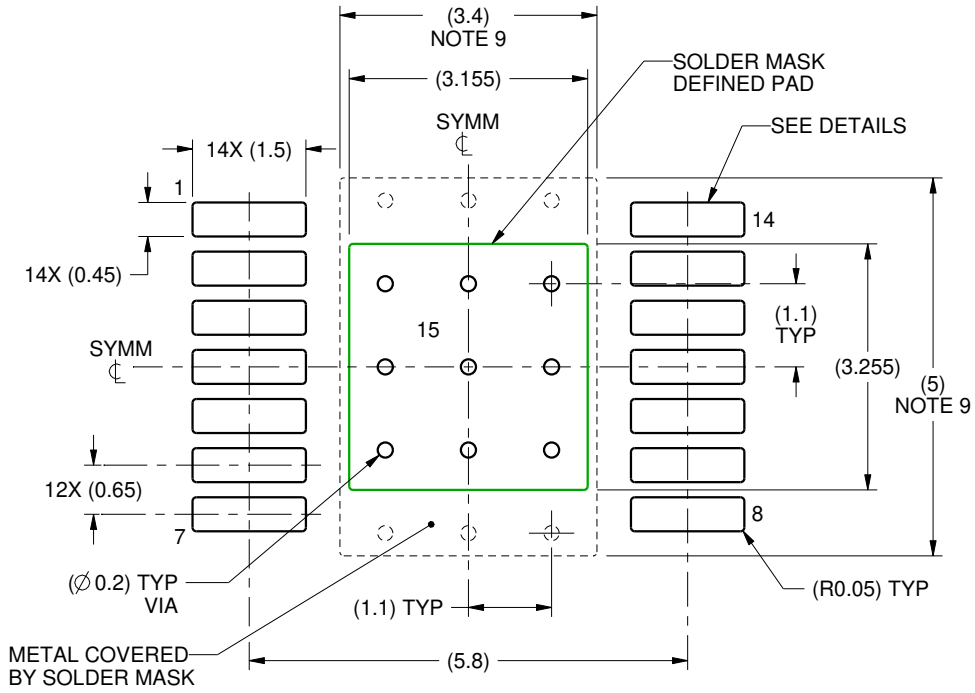
PLASTIC SMALL OUTLINE



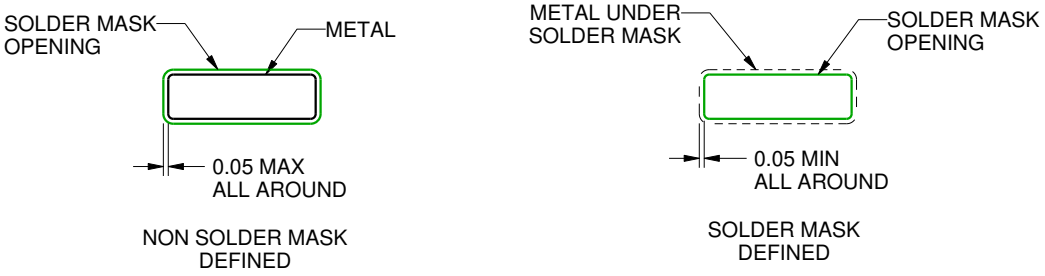
PowerPAD is a trademark of Texas Instruments.

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.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.
5. Features may differ and may not be present.



LAND PATTERN EXAMPLE
SCALE:10X

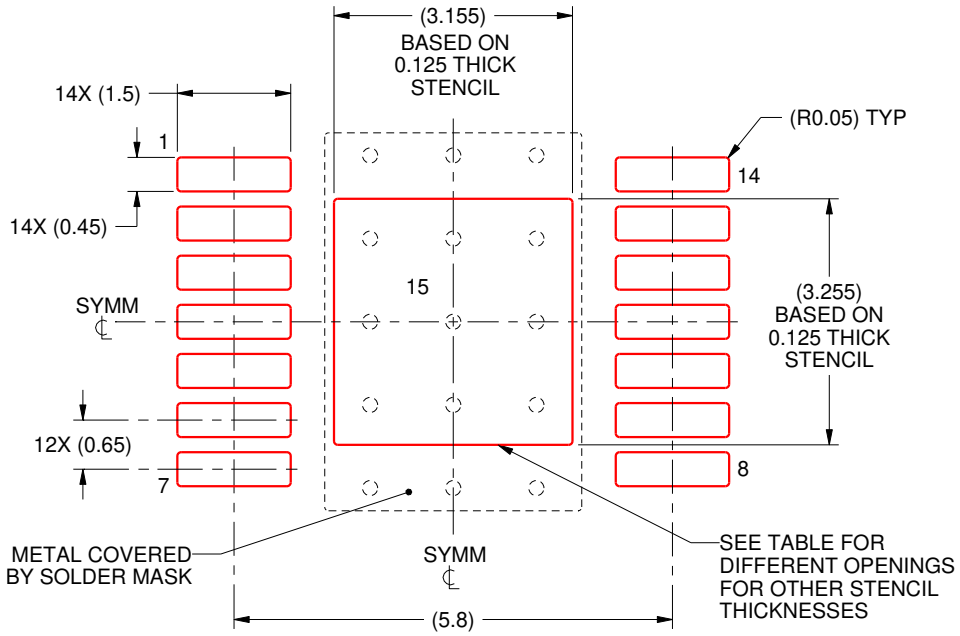


SOLDER MASK DETAILS
PADS 1-14

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NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.



SOLDER PASTE EXAMPLE
EXPOSED PAD
100% PRINTED SOLDER COVERAGE BY AREA
SCALE:10X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	3.53 X 3.64
0.125	3.155 X 3.255 (SHOWN)
0.15	2.88 X 2.97
0.175	2.67 X 2.75

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NOTES: (continued)

10. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
11. Board assembly site may have different recommendations for stencil design.

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