

MAX9599A

Low-Power Programmable Gamma Buffers

General Description

The MAX9599A provides multiple programmable reference voltages for gamma correction in TFT LCDs. Each gamma output comprises a 10-bit digital-to-analog converter (DAC) and high current buffer, which reduces the recovery time of the output voltages when critical levels and patterns are displayed. A precision-programmable internal reference sets the full-scale voltage of the DACs.

The gamma output voltages and the programmable reference, programmed digitally through the 1MHz (fast mode plus) I²C interface.

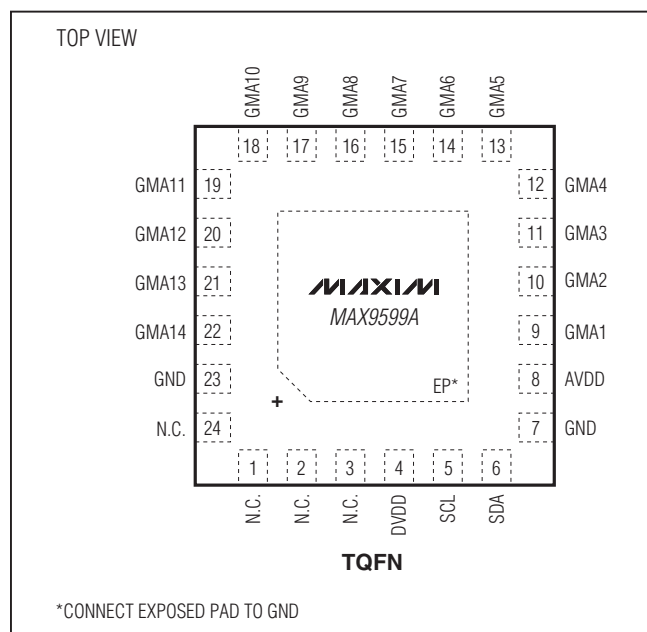
Features

- ◆ 32mW Quiescent Power
- ◆ 4mm x 4mm Package
- ◆ 14-Channel, 10-Bit Programmable Gamma

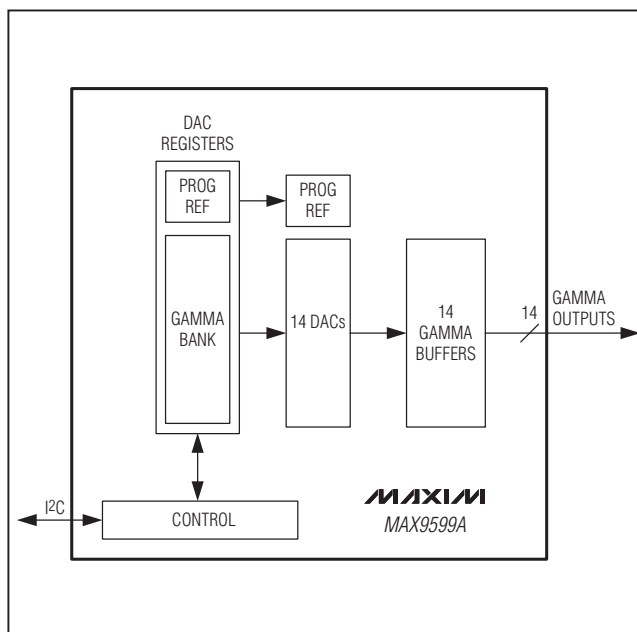
Applications

Notebook and Tablet TFT LCDs
Monitors

Pin Configuration



Simplified Block Diagram



Ordering Information appears at end of data sheet.

For related parts and recommended products to use with this part, refer to www.maxim-ic.com/MAX9599A.related.

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ABSOLUTE MAXIMUM RATINGS

(All voltages are with respect to GND.)

Supply Voltages

AVDD -0.3V to +12V

DVDD -0.3V to +6V

Outputs

GMA1–GMA14 -0.3V to ($V_{AVDD} + 0.3V$)

Inputs

SDA, SCL -0.3V to +6V

Continuous Current

SDA, SCL $\pm 20mA$

GMA1–GMA14 $\pm 50mA$

Continuous Power Dissipation ($T_A = +70^\circ C$)

TQFN Multilayer Board

(derate 27.8mW/ $^\circ C$ above $+70^\circ C$) 2222.2mW

Junction Temperature $+125^\circ C$

Operating Temperature Range $-40^\circ C$ to $+85^\circ C$

Storage Temperature Range $-65^\circ C$ to $+150^\circ C$

Lead Temperature (soldering, 10s) $+300^\circ C$

Soldering Temperature (reflow) $+260^\circ C$

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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

PACKAGE THERMAL CHARACTERISTICS (Note 1)

TQFN

Junction-to-Ambient Thermal Resistance (θ_{JA}) $36^\circ C/W$

Junction-to-Case Thermal Resistance (θ_{JC}) $3^\circ C/W$

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to www.maxim-ic.com/thermal-tutorial.

ELECTRICAL CHARACTERISTICS

($V_{AVDD} = 8V$, $V_{DVDD} = 2.5V$, $V_{GND} = 0V$, programmable reference code = 800, no load, $T_A = -40^\circ C$ to $+85^\circ C$, unless otherwise noted. Typical values are at $T_A = +25^\circ C$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLIES						
AVDD Analog Supply Voltage Range	V_{AVDD1}	Guaranteed by PSRR	7		11	V
Digital Supply Voltage	V_{DVDD}		2.25		5.5	V
AVDD Analog Quiescent Current	I_{AVDD}			3	4	mA
Digital Quiescent Current	I_{DVDD}	No SCL or SDA transitions		3.2	4.5	mA
Thermal Shutdown				160		$^\circ C$
Thermal Shutdown Hysteresis				15		$^\circ C$
DVDD Undervoltage Lockout Threshold	UVLO_D			1.8		V

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ELECTRICAL CHARACTERISTICS (continued)

($V_{AVDD} = 8V$, $V_{DVDD} = 2.5V$, $V_{GND} = 0V$, programmable reference code = 800, no load, $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
PROGRAMMABLE REFERENCE (V_{PREF})						
Full-Scale Voltage		Referred to output, $T_A = +25^{\circ}C$	9.99	10	10.01	V
		$T_A = -40^{\circ}C$ to $+85^{\circ}C$	9.98	10	10.02	
Resolution			10			Bits
Integral Nonlinearity Error		$T_A = +25^{\circ}C$, $16 \leq \text{reference code} \leq 1008$		0.7	1.5	LSB
Differential Nonlinearity Error		$T_A = +25^{\circ}C$, $16 \leq \text{reference code} \leq 1008$		0.5	1	LSB
DAC						
Resolution			10			Bits
Integral Nonlinearity Error		$T_A = +25^{\circ}C$, $16 \leq \text{code} \leq 1008$		0.5	1	LSB
Differential Nonlinearity Error		$T_A = +25^{\circ}C$, $16 \leq \text{code} \leq 1008$		0.5	1	LSB
GAMMA OUTPUTS						
Short-Circuit Current		Output connected to either supply rail		50		mA
Total Output Error		$T_A = +25^{\circ}C$, code = 768		2		mV
Load Regulation		$-5mA \leq I_{LOAD} \leq +5mA$, code = 768		0.5		mV/mA
Low Output Voltage		Sinking 2mA, referred to lower supply rail		0.15	0.2	V
High Output Voltage		Sourcing 2mA, referred to upper supply rail, programmable reference code = 1023	-0.25	-0.15		V
Power-Supply Rejection Ratio		Code = 768, $V_{AVDD} = 7V$ to $11V$	60	90		dB
		Code = 768, frequency = 120kHz		34		
Output Resistance		Buffer is disabled		154		k Ω
Maximum Capacitive Load		Placed directly at output		100		pF
Settling Time		Settling to 0.5 LSB, $C_{LOAD} = 50pF$, 0 to 15mA load step		2		μs

Note 2: 100% production tested at $T_A = +25^{\circ}C$. Specifications over temperature limits are guaranteed by design.

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DIGITAL I/O CHARACTERISTICS

($V_{DVDD} = 2.5V$, $V_{GND} = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input High Voltage	V_{IH}		$0.7 \times V_{DVDD}$			V
Input Low Voltage	V_{IL}				$0.3 \times V_{DVDD}$	V
Hysteresis of Schmitt Trigger Inputs	V_{HYS}		$0.05 \times V_{DVDD}$			V
Low-Level Output Voltage	V_{OL}	Open drain, $I_{SINK} = 3mA$	0		0.4	V
Low-Level Output Current	I_{OL}	$V_{OL} = 0.4V$	20			mA
Input Leakage Current	I_{IH} , I_{IL}	$V_{IN} = 0V$ or $DVDD$	-10	+0.01	+10	μA
Input Capacitance				5		pF
Power-Down Input Current	I_{IN}	$V_{DVDD} = 0V$, $V_{IN} = 1.98V$	-10		+10	μA

I²C TIMING CHARACTERISTICS

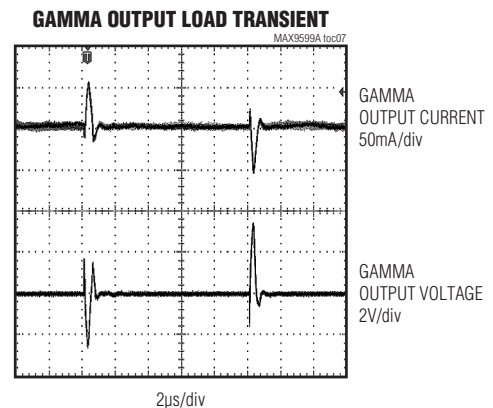
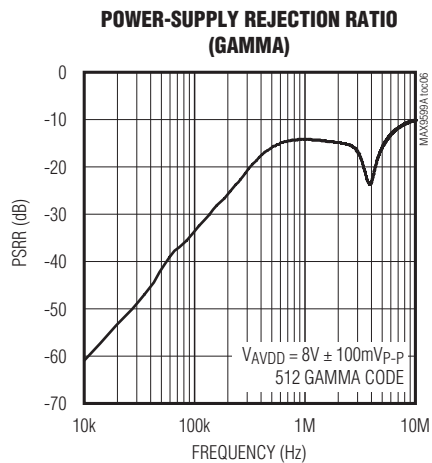
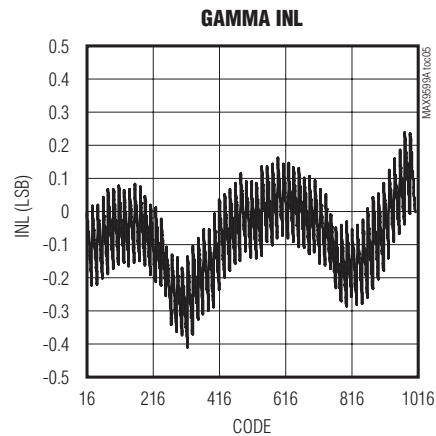
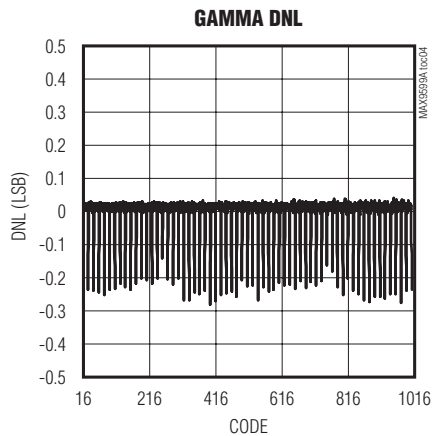
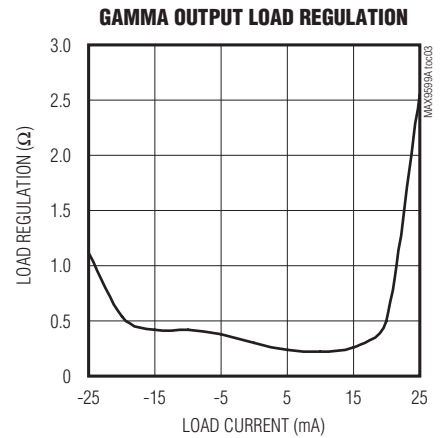
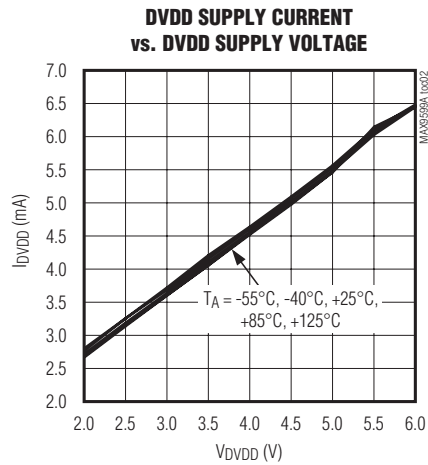
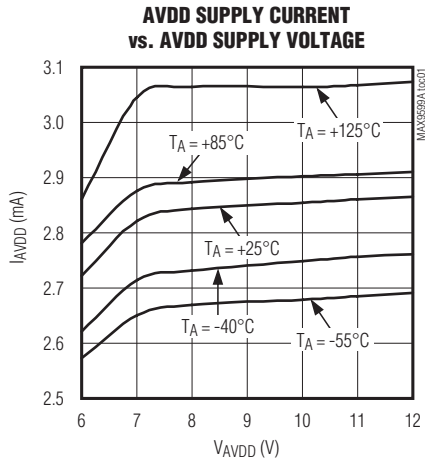
($V_{DVDD} = 2.5V$, $V_{GND} = 0V$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Serial-Clock Frequency	f_{SCL}		0		1000	kHz
Hold Time (REPEATED) START Condition	$t_{HD,STA}$	After this period, the first clock pulse is generated	0.26			μs
SCL Pulse-Width Low	t_{LOW}		0.5			μs
SCL Pulse-Width High	t_{HIGH}		0.26			μs
Setup Time for a REPEATED START Condition	$t_{SU,STA}$		0.26			μs
Data Hold Time	$t_{HD,DAT}$	I ² C bus devices	0			ns
Data Setup Time	$t_{SU,DAT}$		50			ns
SDA and SCL Receiving Rise Time	t_R				120	ns
SDA and SCL Receiving Fall Time	t_F				120	ns
SDA Transmitting Fall Time	t_F				140	ns
Setup Time for STOP Condition	$t_{SU,STO}$		0.26			μs
Bus Free Time Between STOP and START Conditions	t_{BUF}		0.5			μs
Bus Capacitance	C_B				550	pF
Data Valid Time	$t_{VD,DAT}$				0.45	μs
Data Valid Acknowledge Time	$t_{VD,ACK}$				0.45	μs
Pulse Width of Suppressed Spike	t_{SP}		0		50	ns

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Typical Operating Characteristics

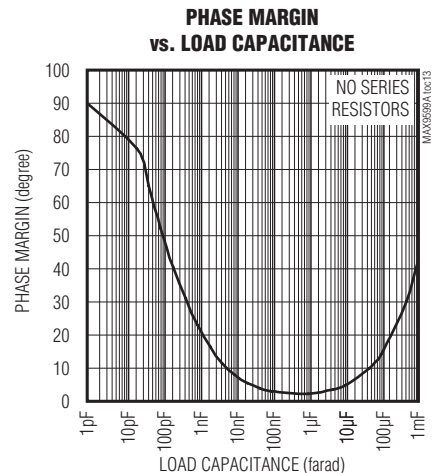
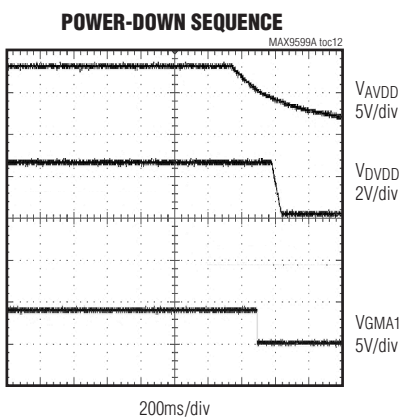
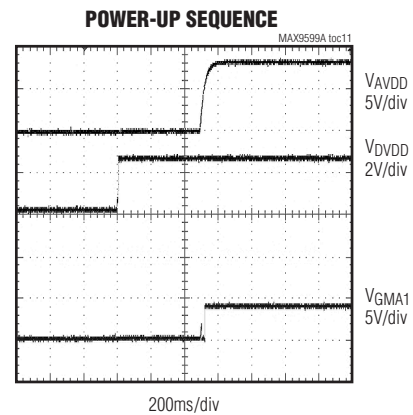
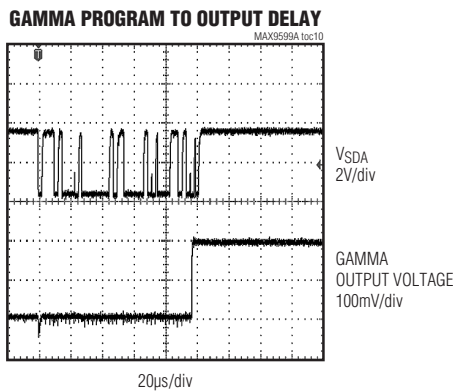
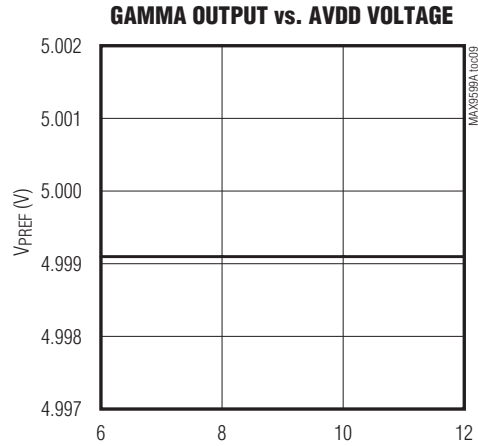
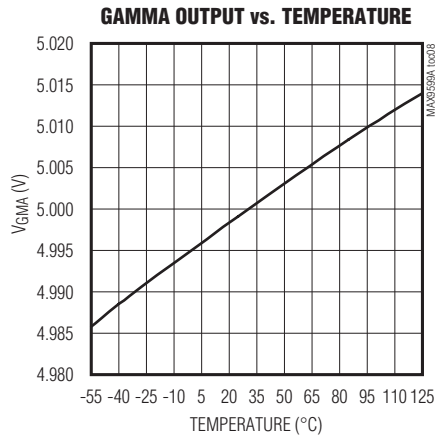
($V_{AVDD} = 8V$, $V_{DVDD} = 2.5V$, $V_{GND} = 0V$, programmable reference code = 800, no load, $T_A = -40^\circ C$ to $+85^\circ C$, unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)



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Typical Operating Characteristics (continued)

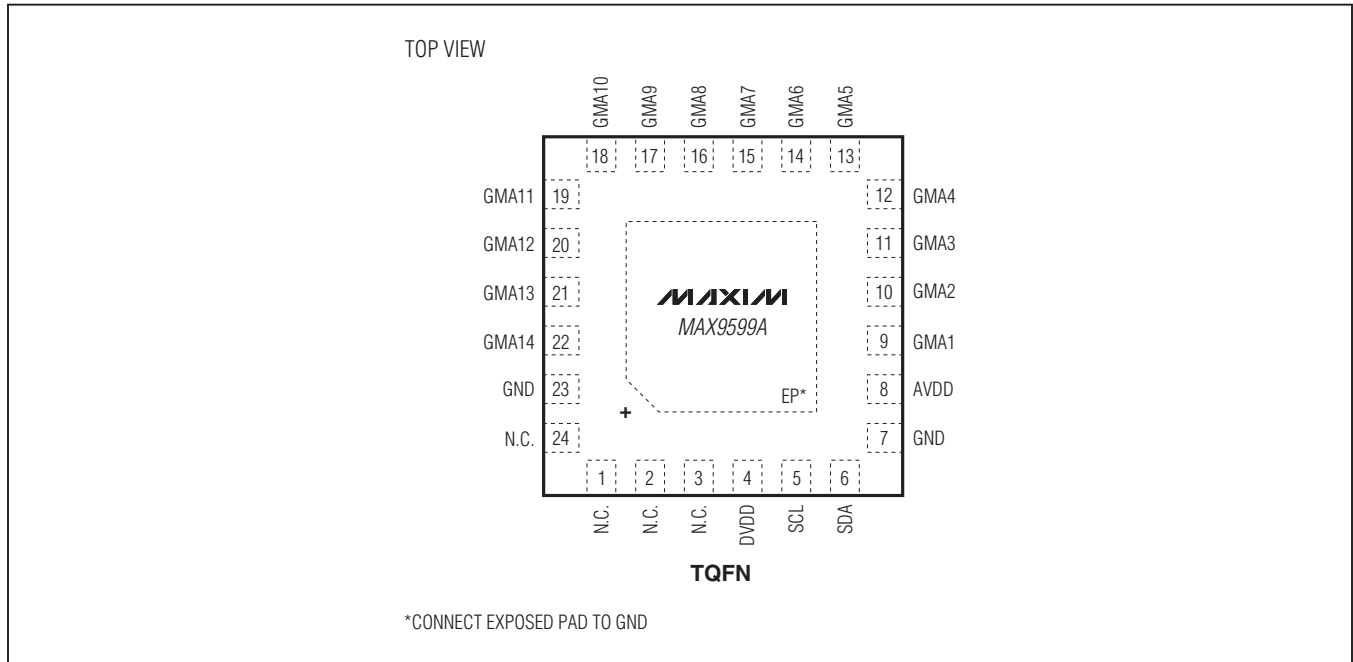
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Pin Configuration



Pin Description

PIN	NAME	FUNCTION
1, 2, 3, 24	N.C.	No Internal Connection
4	DVDD	Digital Power Supply. Bypass DVDD with a 0.1μF capacitor to GND.
5	SCL	I ² C-Compatible Serial-Clock Input
6	SDA	I ² C-Compatible Serial-Data Input/Output
7, 23	GND	Ground Pin. Must be connected to board GND.
8	AVDD	Analog Power Supply. Bypass AVDD with a 0.1μF capacitor to GND.
9	GMA1	Gamma DAC Analog Output 1
10	GMA2	Gamma DAC Analog Output 2
11	GMA3	Gamma DAC Analog Output 3
12	GMA4	Gamma DAC Analog Output 4
13	GMA5	Gamma DAC Analog Output 5
14	GMA6	Gamma DAC Analog Output 6
15	GMA7	Gamma DAC Analog Output 7
16	GMA8	Gamma DAC Analog Output 8
17	GMA9	Gamma DAC Analog Output 9

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Pin Description (continued)

PIN	NAME	FUNCTION
18	GMA10	Gamma DAC Analog Output 10
19	GMA11	Gamma DAC Analog Output 11
20	GMA12	Gamma DAC Analog Output 12
21	GMA13	Gamma DAC Analog Output 13
22	GMA14	Gamma DAC Analog Output 14
—	EP	Exposed Pad. EP must be connected to board GND.

Detailed Description

The MAX9599A contains 14 channels of 10-bit fully-programmable gamma DACs and buffers. The transient response of the gamma output buffers is fast, eliminating display issues caused by source driver charge injection and other transients. In addition, the gamma output buffers are capable of driving large capacitive loads.

The MAX9599A integrates a programmable reference voltage (VPREF) for the DACs, eliminating the need for an external reference voltage. Accuracy of the full-scale programmable reference voltage is $\pm 0.1\%$, and resolution is 10 bits. The programmable reference voltage has very high DC and AC power-supply rejection.

Programmable Reference

The MAX9599A has an internal programmable reference which, when referred to the output, has a full-scale voltage of 10V ($\pm 0.1\%$). The reference voltage is calculated using the following equation:

$$VPREF = (10V \times CODE)/1024$$

where CODE is the numeric value stored in the internal register (0 to 1023). Note that VPREF cannot reach 10V because the maximum value of CODE is 1023, not 1024.

The value of PREF is independent of the AVDD supply voltage because the PREF block is low-voltage internally, so voltage headroom is not an issue. For example, with an AVDD supply of 8V, PREF can be set up to 10V; the actual gamma output voltages are limited by AVDD since the gamma buffers have AVDD as the positive supply.

10-Bit Digital-to-Analog Converters

VPREF sets the full-scale output of the DACs. Determine the output voltages using the following equations:

$$VGMA_ = (VPREF \times CODE)/1024$$

where CODE is the numeric value of the DAC's binary input code (0 to 1023).

Note that the DAC can never output VPREF because the maximum value of CODE is always one LSB less than the reference.

Gamma Buffers

The source drivers can kick back a great deal of current to the buffer outputs during a horizontal line change or a polarity switch. The DAC output buffers can source/sink 50mA of peak transient current to reduce the recovery time of the output voltages when critical levels and patterns are displayed.

Power-On Reset (POR)/Power-Up

The IC contains an integrated POR circuit that ensures all registers are reset to a known state on power-up. Once DVDD rises above its UVLO threshold, the POR circuit releases the registers for normal operation. Should the internal supply input drop to less than the threshold, the contents of the IC registers can no longer be guaranteed.

Column Driver Protection

During power-up and before valid data is written to the registers, the IC operates in a safe mode to protect the column drivers. While in this mode, the 14 gamma outputs remain in high impedance.

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Thermal Shutdown

The IC features thermal-shutdown protection with temperature hysteresis. When the die temperature reaches +165°C, all of the gamma outputs are disabled (high-impedance). When the die cools down by 15°C, the outputs are enabled again.

I²C Serial Interface

The IC features an I²C/SMBus-compatible, 2-wire serial interface consisting of a serial-data line (SDA) and a serial-clock line (SCL). [Figure 1](#) shows the 2-wire interface timing diagram.

Pullup Resistors and Input Protection

A pullup resistor with a value greater than 500Ω is required between SDA and DVDD. SCL operates as only an input. A pullup resistor with a value greater than 500Ω is required on SCL if there are multiple masters on the bus, or if the master in a single-master system has an open-drain SCL output. Series resistors in line with SDA and SCL are optional. Series resistors protect the digital

inputs of the devices from high-voltage spikes on the bus lines, and minimize crosstalk and undershoot of the bus signals.

Bit Transfer

One data bit is transferred during each SCL cycle. The data on SDA must remain stable during the high period of the SCL pulse. Changes in SDA while SCL is high are control signals. See the [START and STOP Conditions](#) section. SDA and SCL idle high when the I²C bus is not in use.

START and STOP Conditions

A master initiates communication by issuing a START (S) condition. A START condition is a high-to-low transition on SDA with SCL high. A STOP (P) condition is a low-to-high transition on SDA while SCL is high. A START condition from the master signals the beginning of a transmission to the IC. The master terminates transmission, and frees the bus, by issuing a STOP condition. The bus remains active if a REPEATED START (Sr) condition is generated instead of a STOP condition.

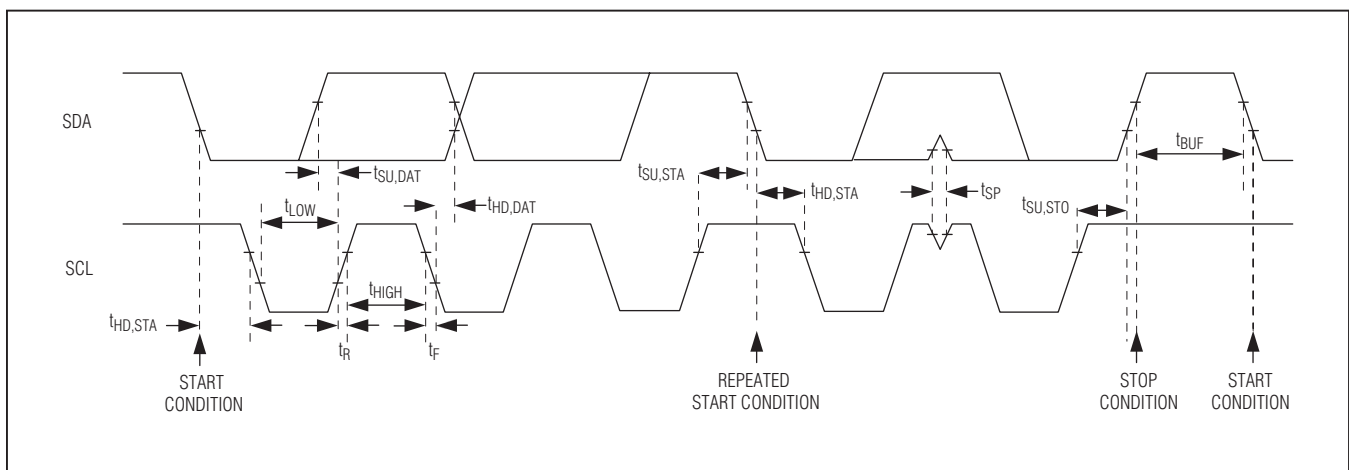


Figure 1. I²C Interface Timing Diagram

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Early STOP Conditions

The IC recognizes a STOP condition at any point during data transmission except if the STOP condition occurs in the same high pulse as a START condition. For proper operation, do not send a STOP condition during the same SCL high pulse as the START condition.

Acknowledge

The acknowledge bit (ACK) is a clocked 9th bit that the IC uses to handshake receipt of each byte of data when in write mode (Figure 3). The IC pulls down SDA during the entire master-generated ninth clock pulse if the previous byte is successfully received. Monitoring ACK allows for detection of unsuccessful data transfers. An unsuccessful data transfer occurs if a receiving device is busy or if a system fault has occurred. In the event of an unsuccessful data transfer, the bus master may retry communication.

The master pulls down SDA during the ninth clock cycle to acknowledge receipt of data when the IC is in read mode. An acknowledge is sent by the master after each read byte to allow data transfer to continue. A not acknowledge (NACK) is sent when the master reads the final byte of data from the IC, followed by a STOP condition.

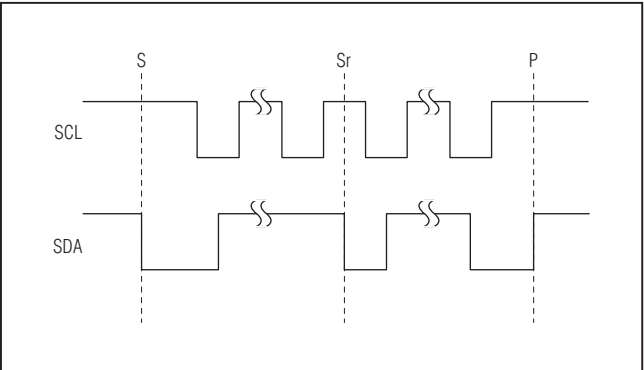


Figure 2. START, STOP, and REPEATED START Conditions

Slave Address

The slave address is defined as the 7 most significant bits (MSBs) followed by the read/write (R/W) bit. Set the R/W bit to 1 to configure the IC to read mode. Set the R/W bit to 0 to configure the IC to write mode. The address is the first byte of information sent to the IC after the START condition. The IC's slave address is set internally. Table 1 shows the possible addresses for the IC.

Table 1. Slave Addresses for the IC

READ ADDRESS	WRITE ADDRESS
E9h (11101001)	E8h (11101000)

10-Bit Register Structure

The IC has a 10-bit register, which requires two data bytes (16 bits) to be read or written in each transaction. Only the 10 least significant bits (LSBs) are written to the registers (Table 2).

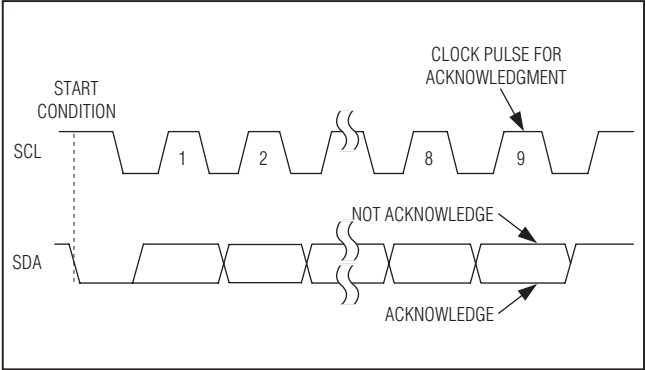


Figure 3. Acknowledge

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Table 2. Data Register Structure

B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
0	0	X	X	X	X	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0

Note: The 10 LSBs contain the 10-bit data, and the 2 MSBs contain write control bits that determine whether the DAC registers are updated. The two MSBs must be set to 0 otherwise the write command is ignored.

Writing Data to the IC

Write Command Format

A write to the IC comprises a START condition, the slave address (with the R/W bit set to 0), one data byte to configure the internal register address pointer, one word (two bytes) of data or more, and a STOP condition. [Figure 4](#) illustrates the proper frame format for writing one word of data to the IC. [Figure 5](#) illustrates the frame format for writing multiple words of data to the IC.

As shown in the figures, the register addresses occupy the 6 LSBs of the address byte. The pointer tells the IC

where to write the next byte of data. An acknowledge pulse is sent by the IC upon receipt of the address pointer data when writing to the DAC registers.

The third and fourth bytes sent to the IC contain the data to be written, along with the two write control bits. The address pointer autoincrements to the next register address after receiving every 16-bit data word (two bytes). This autoincrement feature allows the user to write all of the IC registers within one continuous frame. The two MSBs must be set to 0 otherwise the write command is ignored.

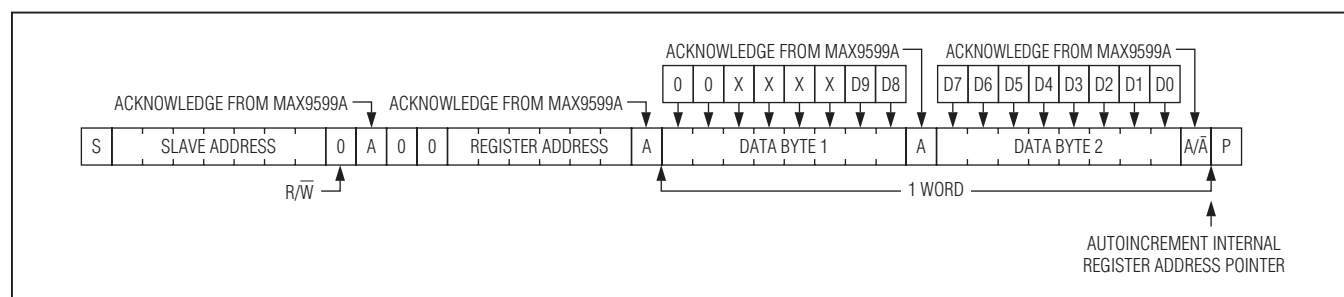


Figure 4. Writing a Word of Data to the IC's DAC Registers

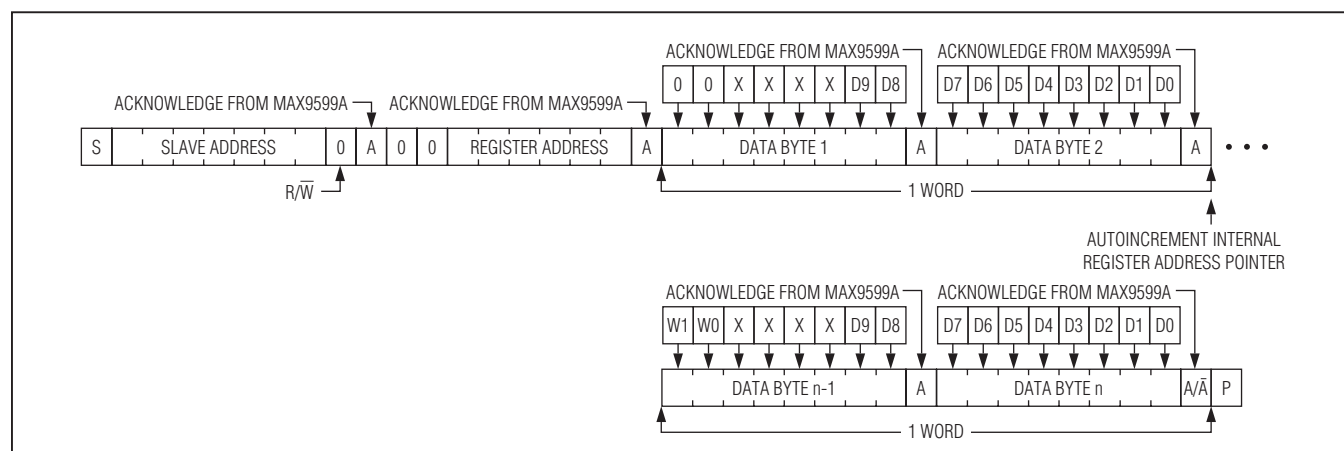


Figure 5. Writing Multiple Words of Data to the IC's DAC Registers

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Reading Data from the IC

Read Data Format

Reading data from the IC requires the master to preset the address pointer by issuing a write command (slave address with R/W bit set to 0), followed by the desired register address. A REPEATED START condition should then be sent, followed by a read command (slave address with the R/W bit set to 1). The IC then transmits data, starting with the contents of the specified register. The address pointer autoincrements after every data word

sent (2 bytes). This autoincrement feature allows all registers to be read sequentially within one continuous frame.

A STOP condition can be issued after any number of read data bytes. The STOP condition does not reset the address pointer, so subsequent reads picks up where the previous one left off.

The I²C master must acknowledge all received data bytes except for the last byte. The final byte must be followed by a not acknowledge from the master and then a STOP condition. [Figure 6](#) and [Figure 7](#) illustrate the frame format for reading data from the IC.

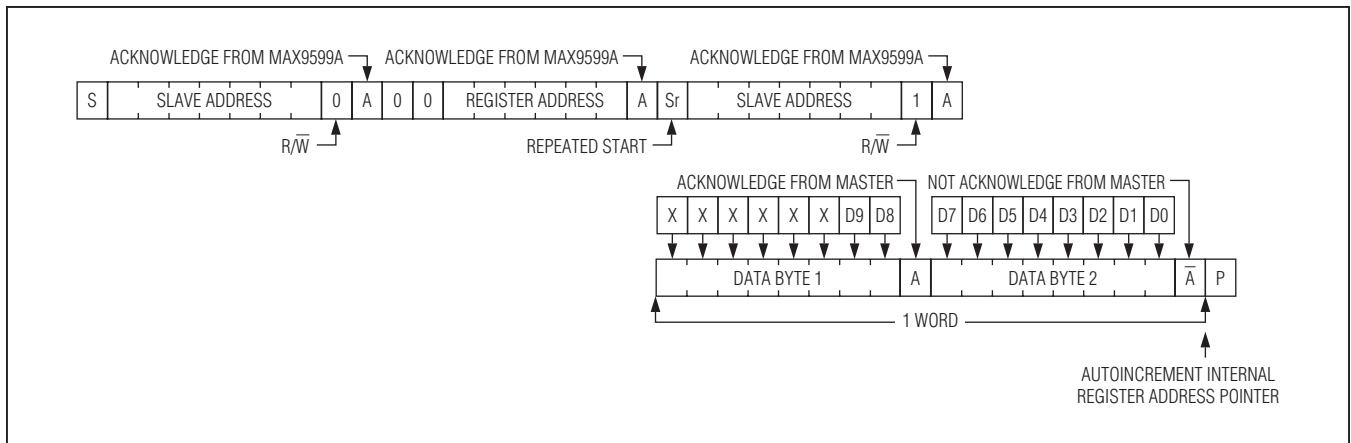


Figure 6. Reading One Word of Data from the IC

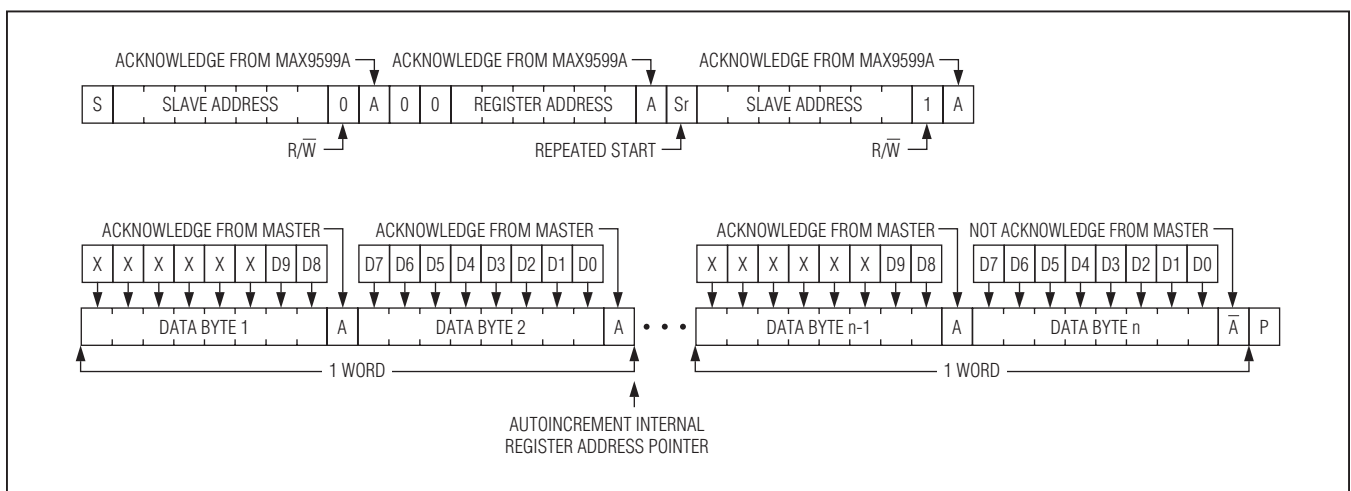


Figure 7. Reading Multiple Words of Data from the IC

Low-Power Programmable Gamma Buffers

Register and Bit Descriptions

Table 3 shows the register map for the IC. Each register address points to a 10-bit register of data that must be read and written using two full bytes through the I²C interface. The least significant byte (LSB) holds the bottom 8 bits of the 10-bit data, while the most significant byte (MSB) holds the top 2 bits, as shown in Table 2.

Applications Information

Power Sequencing

The AVDD and DVDD supply pins are independent of each other, and can be powered up and powered down in any sequence without damage to the IC. The sequence in Figure 8 is recommended to ensure that the analog outputs are always in a known state.

PCB Layout and Grounding

If the IC is mounted using reflow soldering or waver soldering, the ground vias for the exposed pad should have a finished hole size of at least 14 mils to ensure adequate wicking of soldering onto the exposed pad. If the IC is

mounted using solder mask technique, the vias requirement does not apply. In either case, the exposed pad on the TQFN package is electrically connected to both digital and analog grounds through a low thermal resistance path to ensure adequate heat dissipation. Do not route traces under these packages. The layout of the exposed pad should have multiple small vias over a single large via as shown as Figure 9. Thermal resistance between top and ground layers can be optimized with multiple small vias, and it is recommended to have plated via with 15 mils diameter. The vias should be flooded with solder for good thermal performance.

Power-Supply Bypassing

The IC operates from a single analog supply (AVDD) and a single digital supply (DVDD). Bypass AVDD to GND with 0.1μF and 10μF capacitors in parallel. Use an extensive ground plane to ensure optimum performance. Bypass DVDD to GND with 0.1μF capacitors. The 0.1μF bypass capacitors should be as close as possible to the IC and appropriately rated to handle the voltages. Refer to the MAX9599A Evaluation Kit for a proven PCB layout.

Table 3. Detailed Description of the IC's 10-Bit DAC Registers

REGISTER ADDRESS	REGISTER NAME	REGISTER DESCRIPTION	READ/WRITE?
0x00	PREF	Programmable voltage reference	Read and write
0x01	GMA1	Gamma 1	Read and write
0x02	GMA2	Gamma 2	Read and write
0x03	GMA3	Gamma 3	Read and write
0x04	GMA4	Gamma 4	Read and write
0x05	GMA5	Gamma 5	Read and write
0x06	GMA6	Gamma 6	Read and write
0x07	GMA7	Gamma 7	Read and write
0x08	GMA8	Gamma 8	Read and write
0x09	GMA9	Gamma 9	Read and write
0x0A	GMA10	Gamma 10	Read and write
0x0B	GMA11	Gamma 11	Read and write
0x0C	GMA12	Gamma 12	Read and write
0x0D	GMA13	Gamma 13	Read and write
0x0E	GMA14	Gamma 14	Read and write

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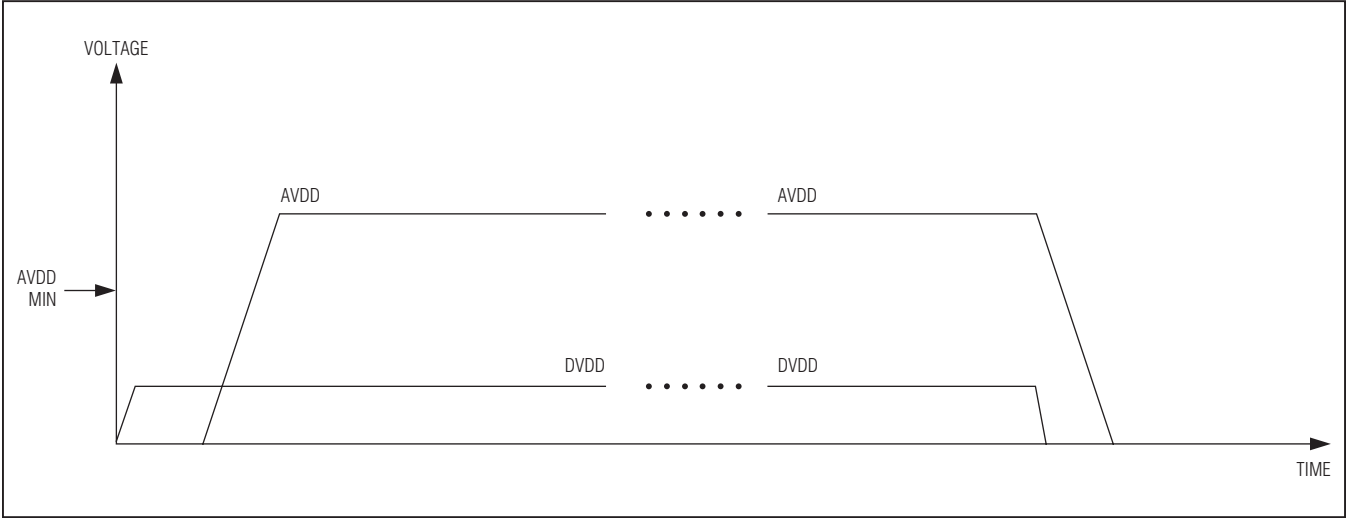


Figure 8. Conventional Power-Up and Power-Down Sequence

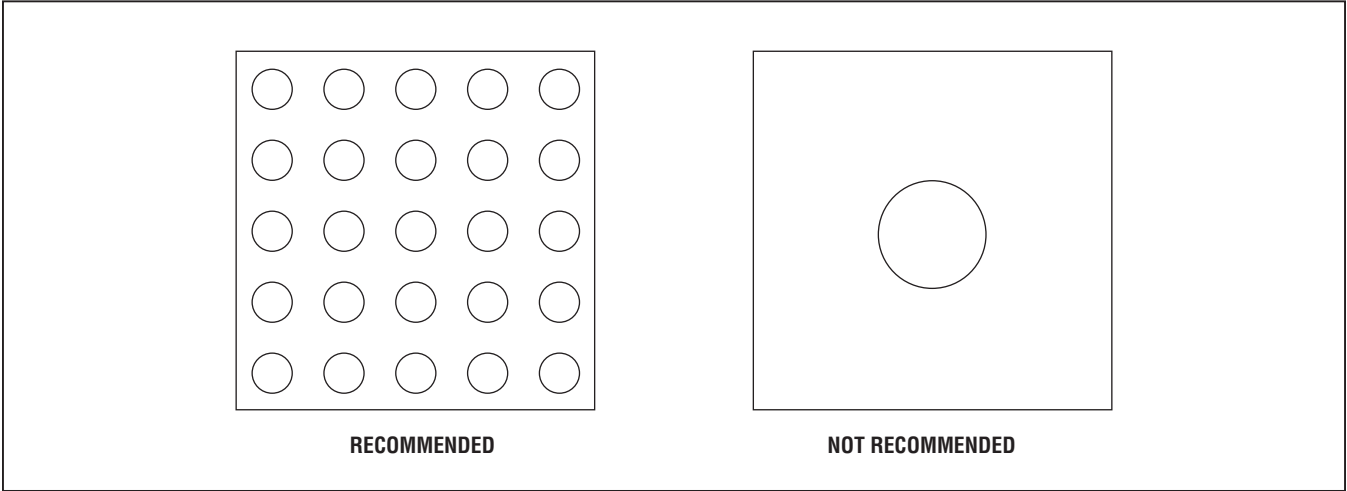
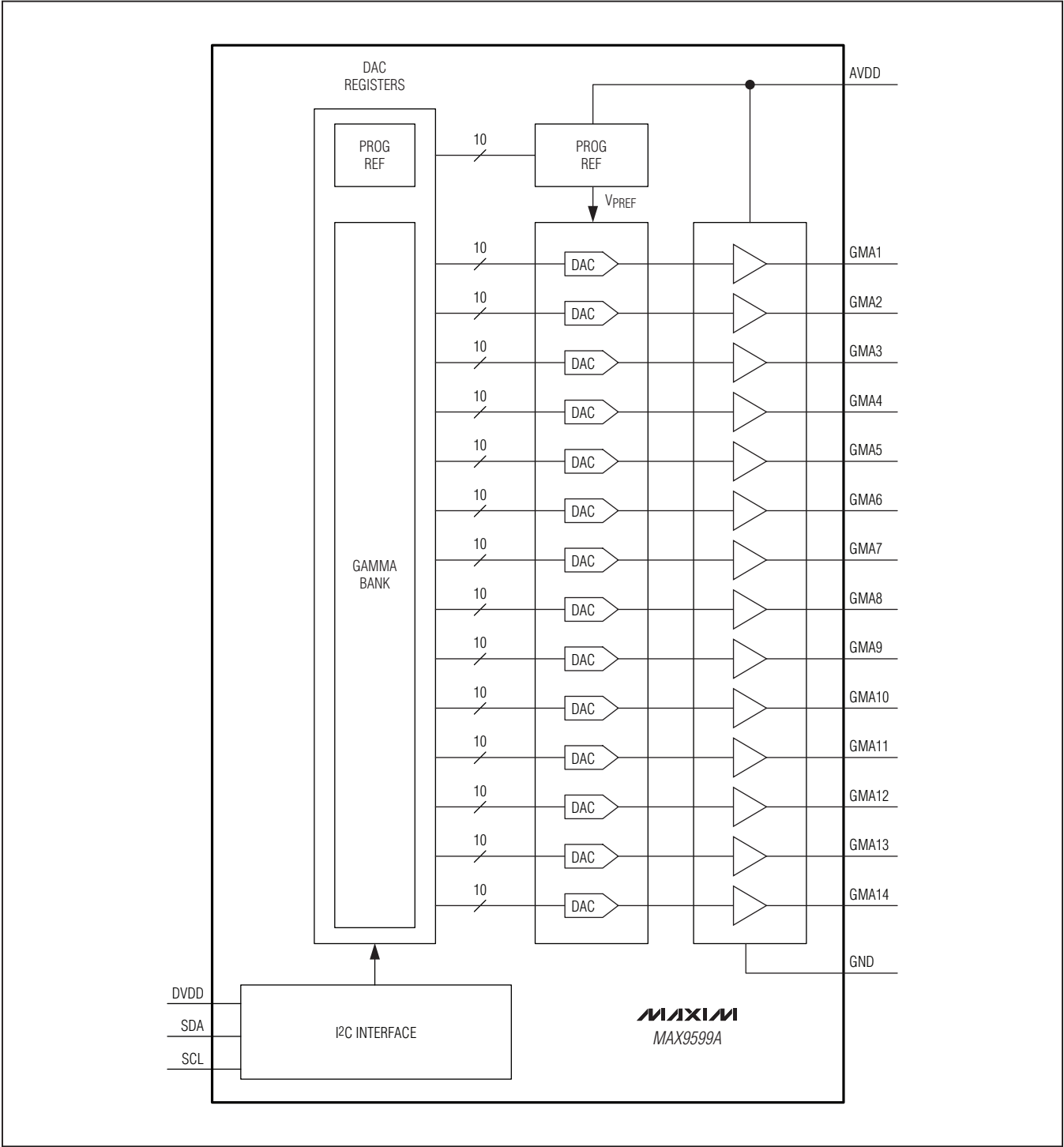


Figure 9. Multiple Small Vias are Recommended over a Single Large Via in the PCB Layout

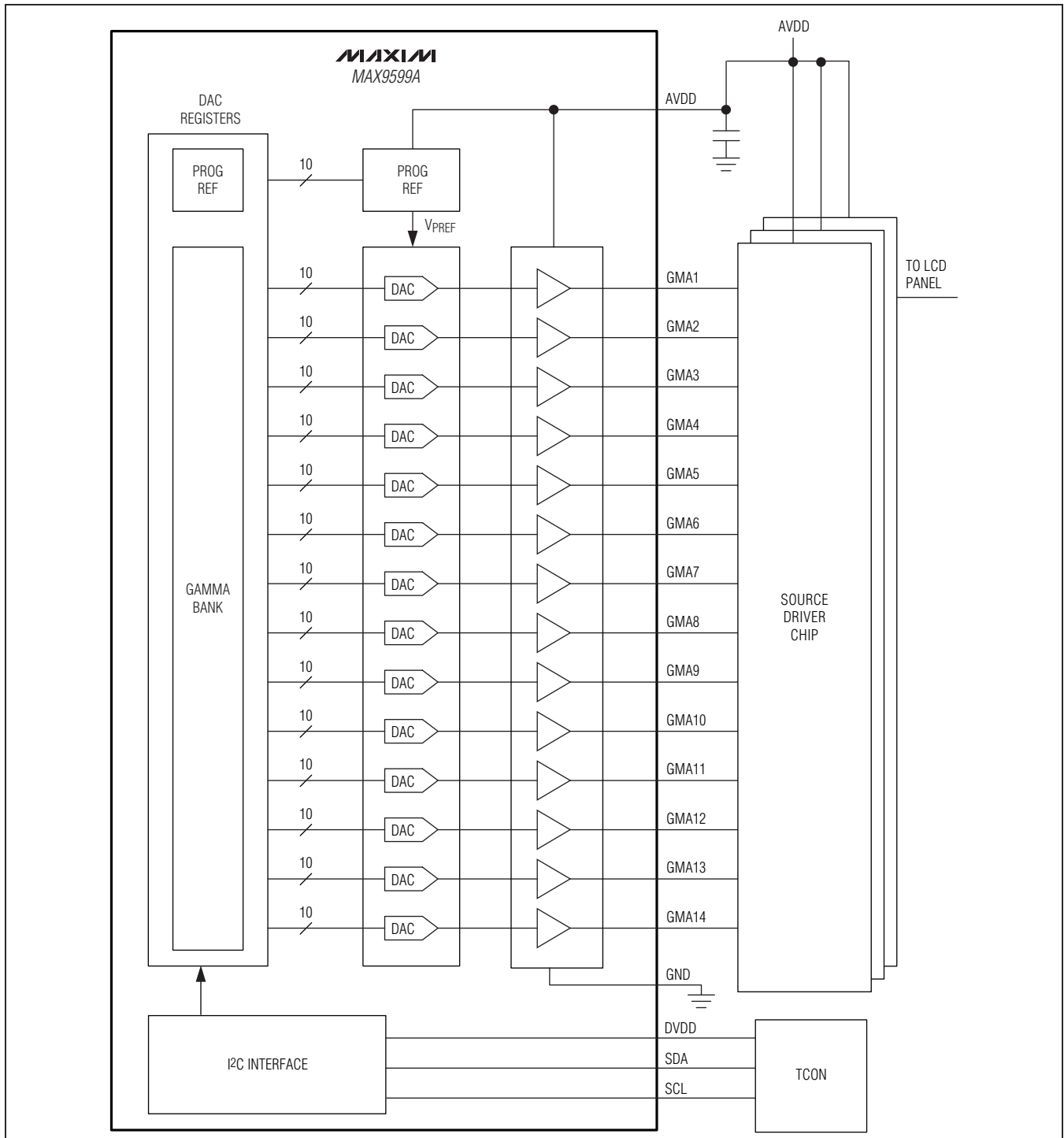
Low-Power Programmable Gamma Buffers

Functional Diagram



Low-Power Programmable Gamma Buffers

Typical Application Circuit



MAX9599A

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Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX9599AETG+	-40°C to +85°C	24 TQFN-EP*

+ Denotes a lead(Pb)-free/RoHS-compliant package.

*EP = Exposed pad.

Chip Information

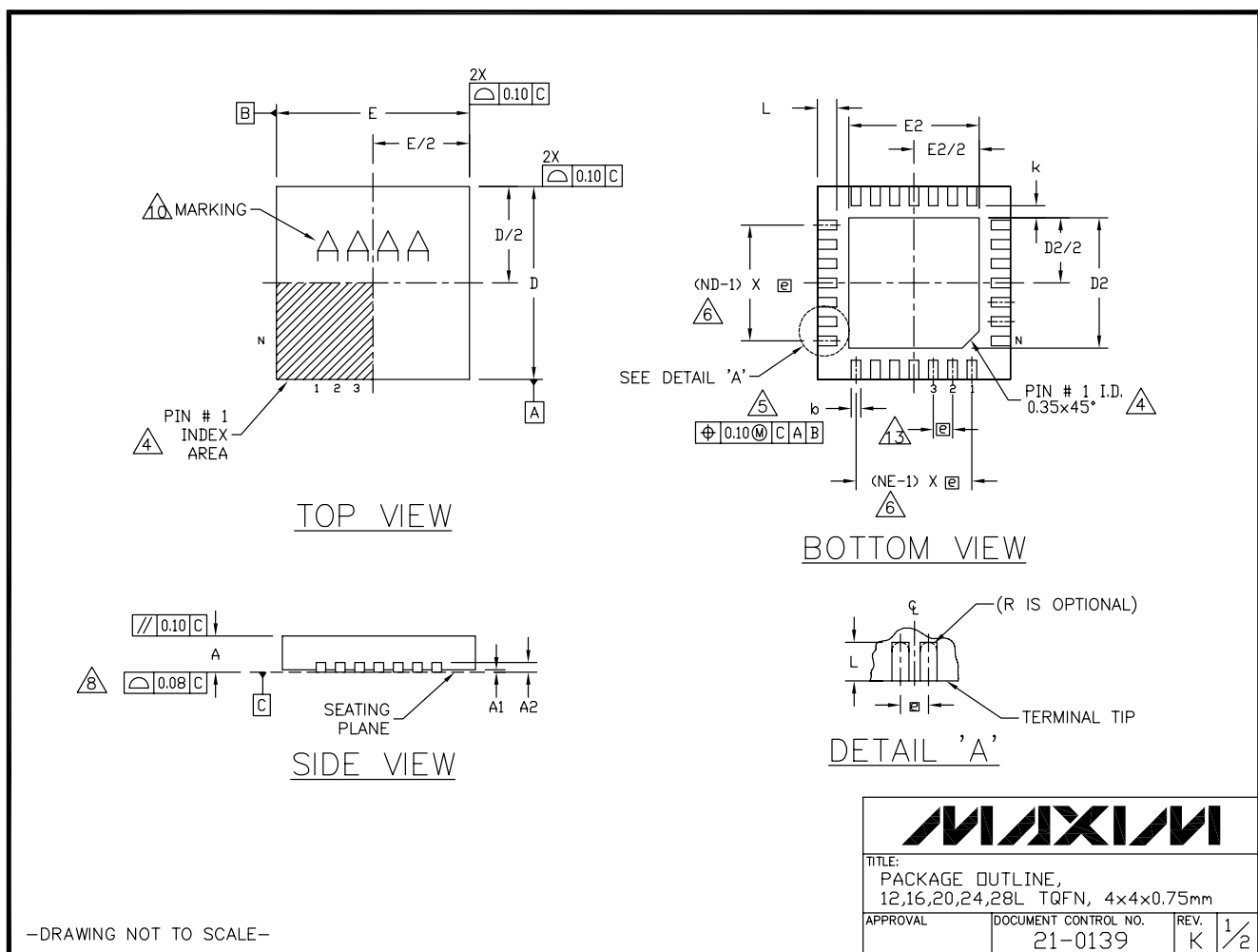
PROCESS: BiCMOS

Low-Power Programmable Gamma Buffers

Package Information

For the latest package outline information and land patterns (footprints), go to www.maxim-ic.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
24 TQFN-EP	T2444+4	21-0139	90-0067



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Package Information (continued)

For the latest package outline information and land patterns (footprints), go to www.maxim-ic.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

COMMON DIMENSIONS															
PKG	12L 4x4			16L 4x4			20L 4x4			24L 4x4			28L 4x4		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80
A1	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05
A2	0.20 REF			0.20 REF			0.20 REF			0.20 REF			0.20 REF		
b	0.25	0.30	0.35	0.25	0.30	0.35	0.20	0.25	0.30	0.18	0.23	0.30	0.15	0.20	0.25
D	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
E	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
e	0.80 BSC.			0.65 BSC.			0.50 BSC.			0.50 BSC.			0.40 BSC.		
k	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-
L	0.45	0.55	0.65	0.45	0.55	0.65	0.45	0.55	0.65	0.30	0.40	0.50	0.30	0.40	0.50
N	12			16			20			24			28		
ND	3			4			5			6			7		
NE	3			4			5			6			7		
JeDEC Var.	WGGB			WGGC			WGGD-1			WGGD-2			WGGE		

EXPOSED PAD VARIATIONS						
PKG. CODES	D2			E2		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
T1244-3	1.95	2.10	2.25	1.95	2.10	2.25
T1244-4	1.95	2.10	2.25	1.95	2.10	2.25
T1644-3	1.95	2.10	2.25	1.95	2.10	2.25
T1644-4	1.95	2.10	2.25	1.95	2.10	2.25
T2044-2	1.95	2.10	2.25	1.95	2.10	2.25
T2044-3	1.95	2.10	2.25	1.95	2.10	2.25
T2444-2	1.95	2.10	2.25	1.95	2.10	2.25
T2444-3	2.45	2.60	2.63	2.45	2.60	2.63
T2444-4	2.45	2.60	2.63	2.45	2.60	2.63
T2444N-4	2.45	2.60	2.63	2.45	2.60	2.63
T2444M-1	2.45	2.60	2.63	2.45	2.60	2.63
T2844-1	2.50	2.60	2.70	2.50	2.60	2.70
T2844N-1	2.65	2.70	2.75	2.65	2.70	2.75

DIMENSION VARIATIONS								
PKG. CODE	D2			E2			L	
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	MAX.
T2044-4	2.85	2.90	2.95	2.85	2.90	2.95	0.25	0.35

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25mm AND 0.30mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220, EXCEPT FOR T2444-3, T2444-4 AND T2844-1.
10. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
11. COPLANARITY SHALL NOT EXCEED 0.08mm.
12. WARPAGE SHALL NOT EXCEED 0.10mm.
13. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION 'e', ±0.05.
14. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
15. MATERIAL MUST COMPLY WITH BANNED AND RESTRICTED SUBSTANCES SPEC # 10-0131.
16. ALL DIMENSIONS ARE THE SAME FOR LEADED (-) & PbFREE (+) PACKAGE CODES.

-DRAWING NOT TO SCALE-

MAXIM			
TITLE: PACKAGE OUTLINE, 12,16,20,24,28L TQFN, 4x4x0.75mm			
APPROVAL	DOCUMENT CONTROL NO. 21-0139	REV. K	2/2

Low-Power Programmable Gamma Buffers***Revision History***

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	12/11	Initial release	—

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.

Maxim Integrated Products, 160 Rio Robles, San Jose, CA 95134 1-408-601-1000 _____ **20**