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10-Channel High-Voltage Scan Driver and VCOM Amplifier for TFT LCD Panels

General Description

The MAX17108 includes a 10-channel high-voltage level-shifting scan driver and a VCOM amplifier. The device is optimized for thin-film transistor (TFT) liquid-crystal display (LCD) applications.

The high-voltage level-shifting scan driver can swing from +38V to -12V and can swiftly drive capacitive loads. There are two positive supply inputs, which provide flexibility for system design.

The operational amplifier features rail-to-rail output, high short-circuit output current, fast slew rate, and wide bandwidth.

The MAX17108 is available in a 28-pin, 5mm x 5mm, lead-free thin QFN package with a maximum thickness of 0.8mm for thin LCD panels.

Features

- ◆ High-Current, High-Speed Operational Amplifier
 - ±200mA Output Short-Circuit Current
 - 100V/μs Slew Rate
 - 20MHz to 3dB Bandwidth
 - Rail-to-Rail Outputs
- ◆ High-Voltage Level-Shifting Scan Drivers
 - Logic-Level Inputs
 - +38V to -12V Outputs
- ◆ Thermal-Overload Protection
- ◆ 28-Pin, 5mm x 5mm Thin QFN Package

Applications

LCD TVs
LCD Monitors

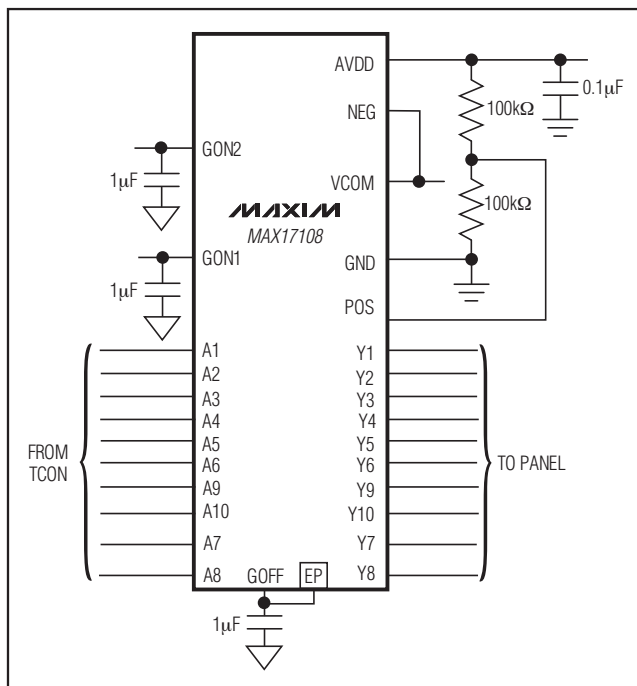
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX17108ETI+	-40°C to +85°C	28 Thin QFN-EP*

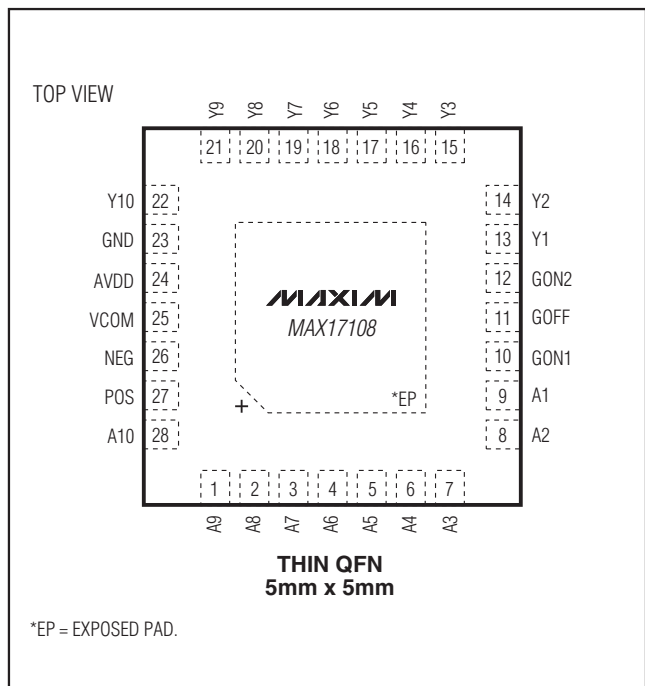
+Denotes a lead-free/RoHS-compliant package.

*EP = Exposed pad.

Simplified Operating Circuit



Pin Configuration



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ABSOLUTE MAXIMUM RATINGS

A1–A10 to GND	-0.3V to +7.5V	GON1, GON2 RMS Current	350mA
AVDD to GND	-0.3V to +22V	GOFF RMS Current	450mA
POS, NEG, VCOM to GND	-0.3V to (V _{AVDD} to +0.3V)	Continuous Power Dissipation (T _A = +70°C) 28-Pin, 5mm x 5mm Thin QFN (derate 34.5mW/°C above +70°C)	2758.6mW
POS to NEG	-6V to +6V	Junction Temperature	+150°C
GON1, GON2 to GND	-0.3V to +40V	Storage Temperature Range	-65°C to +150°C
GOFF to GND	-14V to +0.3V	Lead Temperature (soldering, 10s)	+300°C
Y1–Y6, Y9, Y10 to GND	(V _{GOFF} - 0.3V) to (V _{GON1} + 0.3V)		
Y7, Y8 to GND	(V _{GOFF} - 0.3V) to (V _{GON2} + 0.3V)		
Y1–Y10 Load RMS Current	140mA		

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.

ELECTRICAL CHARACTERISTICS

(Figure 1 circuit, V_{AVDD} = 16V, V_{GON_} = 38V, V_{GOFF} = -12V, T_A = 0°C to +85°C. Typical values are at T_A = +25°C, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
HIGH-VOLTAGE DRIVER BLOCK					
GON_ Input Voltage Range		12		38	V
GOFF Input Voltage Range		-12		-4	V
GOFF Supply Current	A1–A10 = GND, no load		150	300	μA
GON_ Total Supply Current	A1–A10 = GND, no load		330	540	μA
Output-Voltage Low (Y1–Y10)	I _{Y_} = 10mA		V _{GOFF} + 0.03	V _{GOFF} + 0.06	V
Output-Voltage High (Y1–Y10)	I _{Y_} = 10mA	V _{GON_} - 0.25	V _{GON_} - 0.15		V
Rise Time (Y9, Y10)	T _A = +25°C, V _{GON1} = 30V and V _{GOFF} = -6.2V (Note 1)			200	ns
Fall Time (Y9, Y10)	T _A = +25°C, V _{GON1} = 30V and V _{GOFF} = -6.2V (Note 1)			200	ns
Rise Time (Y1–Y6)	T _A = +25°C, V _{GON1} = 30V and V _{GOFF} = -6.2V (Note 1)			450	ns
Fall Time (Y1–Y6)	T _A = +25°C, V _{GON1} = 30V and V _{GOFF} = -6.2V (Note 1)			120	ns
Rise Time (Y7, Y8)	T _A = +25°C, V _{GON1} = 30V and V _{GOFF} = -6.2V (Note 1)			1600	ns
Fall Time (Y7, Y8)	T _A = +25°C, V _{GON1} = 30V and V _{GOFF} = -6.2V (Note 1)			700	ns
Propagation Delay High-to-Low Transition (Y1–Y10)	V _{GON_} = 30V and V _{GOFF} = -6.2V (Note 1)		35		ns
Propagation Delay Low-to-High Transition (Y1–Y10)	V _{GON_} = 30V and V _{GOFF} = -6.2V (Note 1)		35		ns

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ELECTRICAL CHARACTERISTICS (continued)

(Figure 1 circuit, $V_{AVDD} = 16V$, $V_{GON_} = 38V$, $V_{GOFF} = -12V$, $T_A = 0^{\circ}C$ to $+85^{\circ}C$. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
OPERATIONAL AMPLIFIER					
AVDD Supply Range		6		20	V
AVDD Supply Current	Buffer configuration, $V_{POS} = V_{AVDD}/2$, no load			6	mA
Input Offset Voltage	$2V < (V_{NEG}, V_{POS}) < (V_{AVDD} - 2V)$, $T_A = +25^{\circ}C$	-10		+10	mV
Input Bias Current	$V_{NEG}, V_{POS} = V_{AVDD}/2$, $T_A = +25^{\circ}C$	-50		+50	nA
Input Common-Mode Voltage Range		0		V_{AVDD}	V
Input Common-Mode Rejection Ratio	$2V < (V_{NEG}, V_{POS}) < (V_{AVDD} - 2V)$		80		dB
Output-Voltage Swing High	$I_{VCOM} = 50mA$	$V_{AVDD} - 400$			mV
Output-Voltage Swing Low	$I_{VCOM} = -50mA$			400	mV
Large-Signal Voltage Gain	$V_{VCOM} = 1V$ to $V_{AVDD} - 1V$		80		dB
Slew Rate			100		V/ μs
-3dB Bandwidth			20		MHz
Short-Circuit Current	Short to $V_{AVDD}/2$, sourcing		230		mA
	Short to $V_{AVDD}/2$, sinking		460		
FAULT DETECTION					
Thermal Shutdown	Rising edge, typical hysteresis = $10^{\circ}C$, not latched		+155		$^{\circ}C$
CONTROL INPUTS					
Logic-Input Voltage Range (A1–A10)	(Note 3)			6	V
Logic-Input Voltage Low (A1–A10)				0.8	V
Logic-Input Voltage High (A1–A10)		2			V
Logic-Input Bias Current (A1–A10)	$0 < V_A < 6V$, $T_A = +25^{\circ}C$	-1		+1	μA

ELECTRICAL CHARACTERISTICS

(Figure 1 circuit, $V_{AVDD} = 16V$, $V_{GON_} = 38V$, $V_{GOFF} = -12V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted.) (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
HIGH-VOLTAGE DRIVER BLOCK					
GON_ Input Voltage Range		12		38	V
GOFF Input Voltage Range		-12		-4	V
GOFF Supply Current	A1–A10 = GND, no load			300	μA
GON_ Total Supply Current	A1–A10 = GND, no load			540	μA
Output-Voltage Low (Y1–Y10)	$I_{Y_} = 10mA$			$V_{GOFF} + 0.06$	V
Output-Voltage High (Y1–Y10)	$I_{Y_} = 10mA$	$V_{GON_} - 0.25$			V

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ELECTRICAL CHARACTERISTICS (continued)

(Figure 1 circuit, $V_{AVDD} = 16V$, $V_{GON_} = 38V$, $V_{GOFF} = -12V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted.) (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
OPERATIONAL AMPLIFIER					
AVDD Supply Range		6		20	V
AVDD Supply Current	Buffer configuration, $V_{POS} = V_{AVDD}/2$, no load			6	mA
Input Common-Mode Voltage Range		0		V_{AVDD}	V
Output-Voltage Swing High	$I_{VCOM} = 50mA$	$V_{AVDD} - 400$			mV
Output-Voltage Swing Low	$I_{VCOM} = -50mA$			400	mV
CONTROL INPUTS					
Logic-Input Voltage Range (A1–A10)	(Note 3)			6	V
Logic-Input Voltage Low (A1–A10)				0.8	V
Logic-Input Voltage High (A1–A10)		2			V

Note 1: The load models for different channels are illustrated in Figure 2.

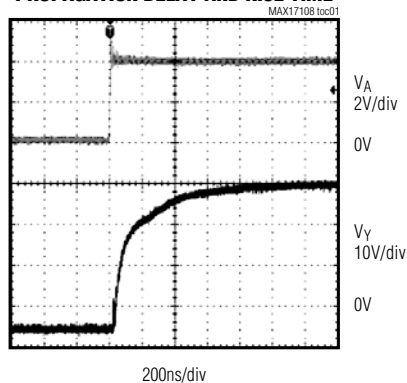
Note 2: $T_A = -40^{\circ}C$ specifications are guaranteed by design, not production tested.

Note 3: For $5.5V < V_{A_} < 6V$, use the IC for no longer than 1% of IC lifetime. For continuous operation, voltage should not exceed 5.5V.

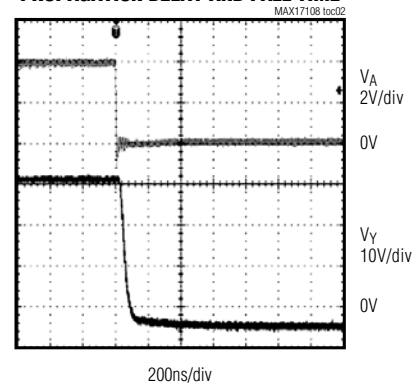
Typical Operating Characteristics

(Circuit of Figure 1, $V_{AVDD} = 16V$, $V_{GON_} = 38V$, $V_{GOFF} = -12V$, $T_A = 0^{\circ}C$ to $+85^{\circ}C$. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.)

**SCAN DRIVER OUTPUT RISING EDGE (Y1–Y6)
PROPAGATION DELAY AND RISE TIME**



**SCAN DRIVER OUTPUT FALLING EDGE (Y1–Y6)
PROPAGATION DELAY AND FALL TIME**

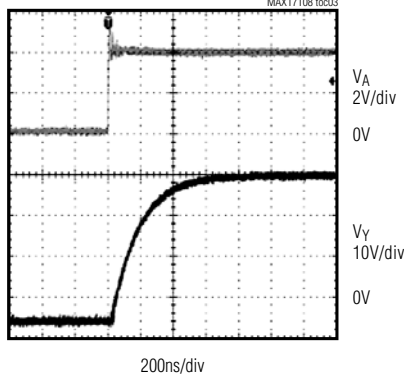


10-Channel High-Voltage Scan Driver and VCOM Amplifier for TFT LCD Panels

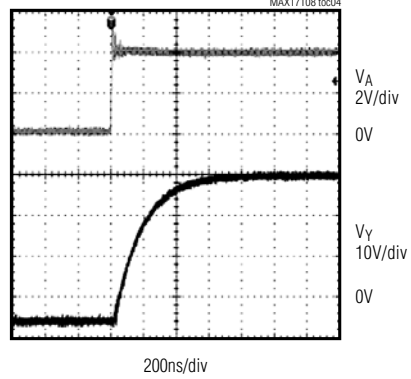
Typical Operating Characteristics (continued)

(Circuit of Figure 1, $V_{AVDD} = 16V$, $V_{GON-} = 38V$, $V_{GOFF} = -12V$, $T_A = 0^{\circ}C$ to $+85^{\circ}C$. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.)

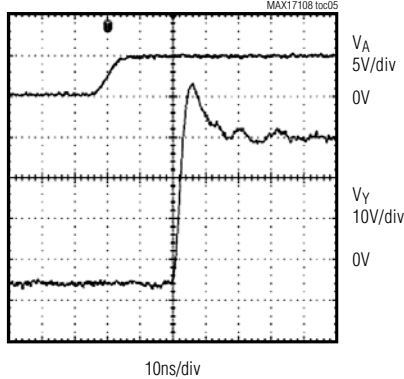
**SCAN DRIVER OUTPUT RISING EDGE (Y7 AND Y8)
PROPAGATION DELAY AND RISE TIME**



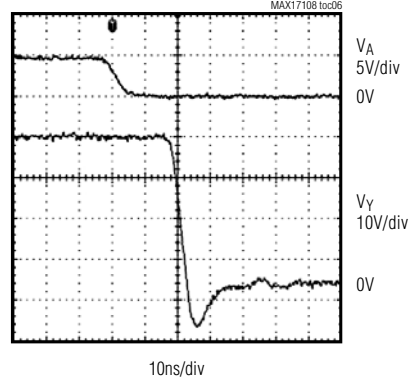
**SCAN DRIVER OUTPUT FALLING EDGE (Y7 AND Y8)
PROPAGATION DELAY AND FALL TIME**



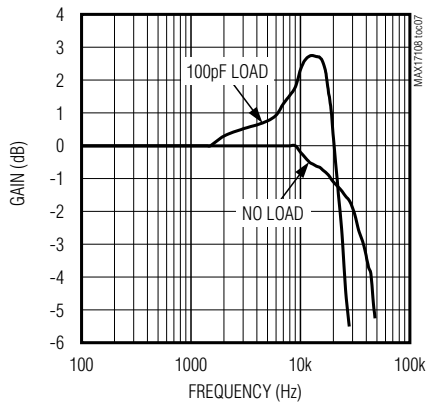
**SCAN DRIVER OUTPUT RISING EDGE (Y9 AND Y10)
PROPAGATION DELAY AND RISE TIME**



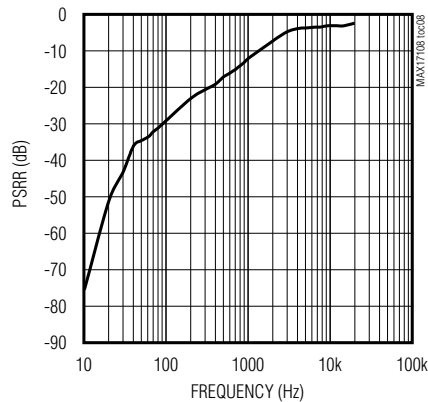
**SCAN DRIVER OUTPUT FALLING EDGE (Y9 AND Y10)
PROPAGATION DELAY AND FALL TIME**



**OPERATIONAL AMPLIFIER
FREQUENCY RESPONSE**



**OPERATIONAL AMPLIFIER
POWER-SUPPLY REJECTION RATIO**

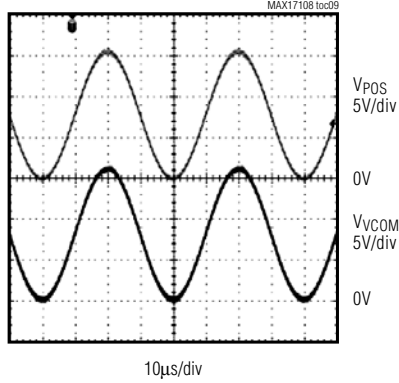


10-Channel High-Voltage Scan Driver and VCOM Amplifier for TFT LCD Panels

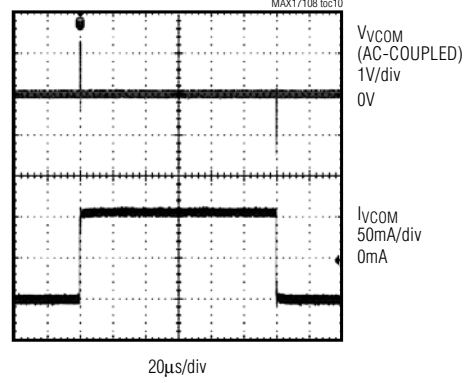
Typical Operating Characteristics (continued)

(Circuit of Figure 1, $V_{AVDD} = 16V$, $V_{GON-} = 38V$, $V_{GOFF} = -12V$, $T_A = 0^{\circ}C$ to $+85^{\circ}C$. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.)

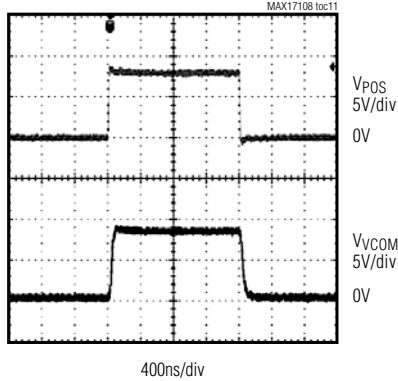
OPERATIONAL AMPLIFIER RAIL-TO-RAIL INPUT/OUTPUT WAVEFORMS



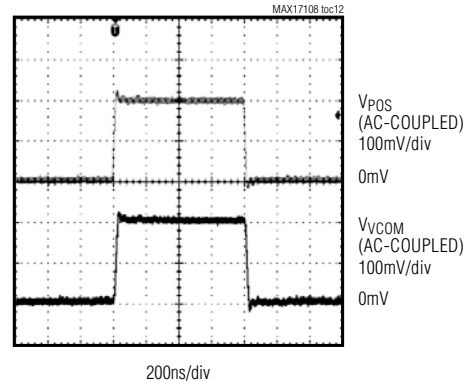
OPERATIONAL AMPLIFIER LOAD-TRANSIENT RESPONSE



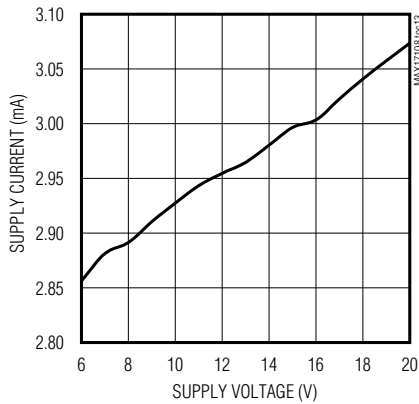
OPERATIONAL AMPLIFIER LARGE-SIGNAL STEP RESPONSE



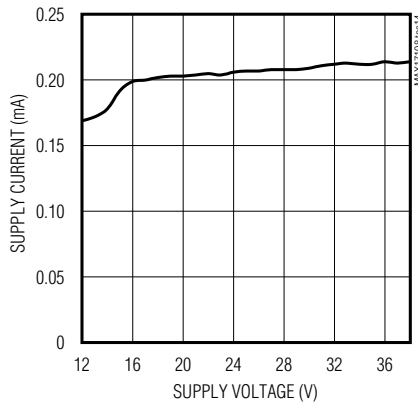
OPERATIONAL AMPLIFIER SMALL-SIGNAL STEP RESPONSE



AVDD SUPPLY QUIESCENT CURRENT vs. AVDD SUPPLY VOLTAGE



GON1 SUPPLY QUIESCENT CURRENT vs. GON1 SUPPLY VOLTAGE

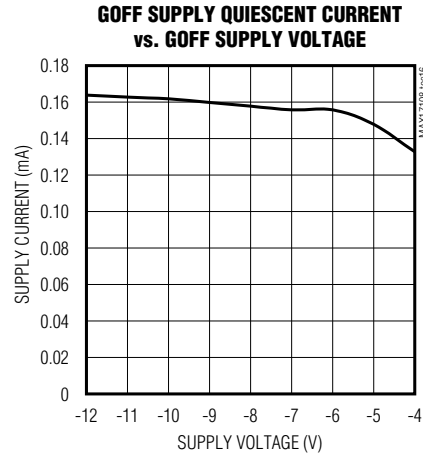
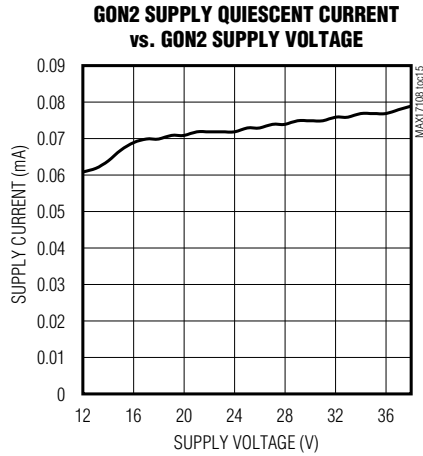


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Typical Operating Characteristics (continued)

(Circuit of Figure 1, $V_{AVDD} = 16V$, $V_{GON-} = 38V$, $V_{GOFF} = -12V$, $T_A = 0^{\circ}C$ to $+85^{\circ}C$. Typical values are at $T_A = +25^{\circ}C$, unless otherwise noted.)



Pin Description

PIN	NAME	FUNCTION
1–9	A9–A1	Level-Shifter Logic-Level Input
10	GON1	Gate-On Supply Input 1. GON1 is the positive supply for the Y1–Y6, Y9, and Y10 level shifters. Bypass GON1 with a minimum of 1 μ F ceramic capacitor to GND.
11	GOFF	Gate-Off Supply Input. GOFF is the negative supply for the Y1–Y10 level shifters. Bypass GOFF with a minimum of 1 μ F ceramic capacitor to GND.
12	GON2	Gate-On Supply Input 2. GON2 is the positive supply for the Y7 and Y8 level shifters. Bypass GON2 with a minimum of 1 μ F ceramic capacitor to GND.
13–22	Y1–Y10	Level-Shifter Outputs
23	GND	Ground
24	AVDD	Operational Amplifier Supply Voltage. Bypass AVDD with a minimum of 1 μ F ceramic capacitor to GND.
25	VCOM	Operational Amplifier Output
26	NEG	Operational Amplifier Negative Input
27	POS	Operational Amplifier Positive Input
28	A10	Level-Shifter Logic-Level Input
—	EP	Exposed Backside Pad. Connect to V_{GOFF} . Copper area should be maximized for thermal performance.

10-Channel High-Voltage Scan Driver and VCOM Amplifier for TFT LCD Panels

Detailed Description

The MAX17108 includes a 10-channel, high-voltage level-shifting scan driver, an operational amplifier for VCOM, and a linear regulator that provides the internal bias for the step-up controller. Figure 1 shows the MAX17108 functional block diagram and typical operating circuit.

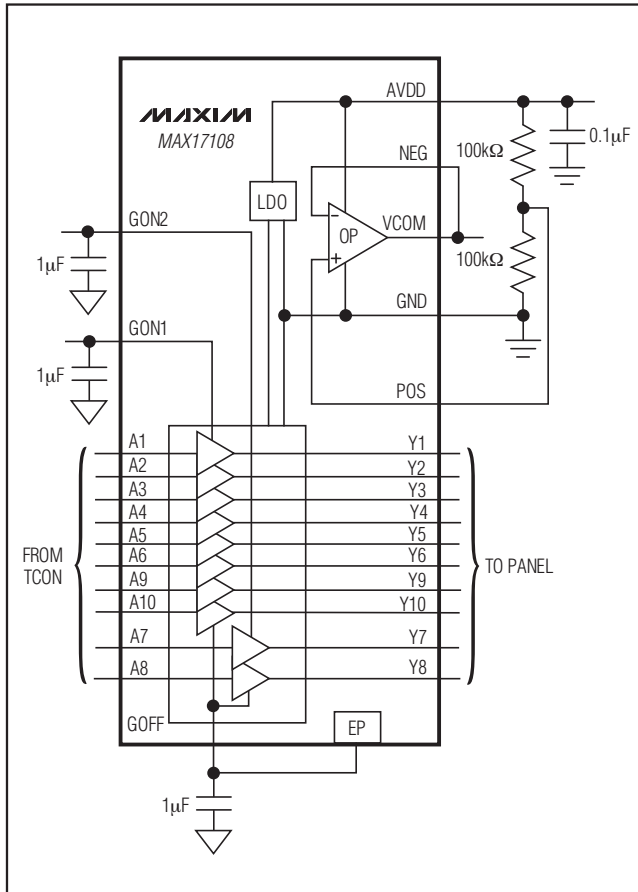


Figure 1. Functional Block Diagram and Typical Operating Circuit

Load Models for Different Channels

Figure 2 shows the load models for different channels.

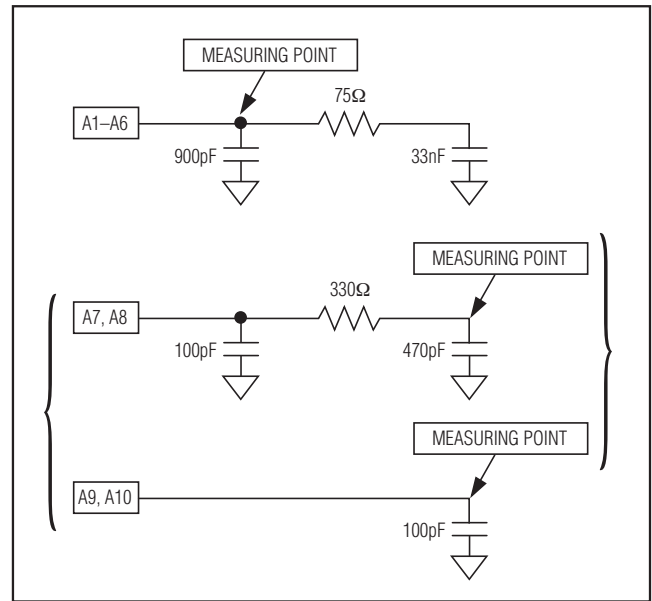


Figure 2. Load Models for Different Channels

Operational Amplifier

The MAX17108 has one operational amplifier that is typically used to drive the LCD backplane (VCOM). The operational amplifier features a $\pm 200\text{mA}$ output short-circuit current, $100\text{V}/\mu\text{s}$ slew rate, 20MHz bandwidth, and rail-to-rail output.

Short-Circuit Current Limit

The operational amplifier limits the short-circuit current to approximately $\pm 200\text{mA}$. If the short-circuit condition persists, the junction temperature of the IC rises until it reaches the thermal-shutdown threshold ($+155^\circ\text{C}$ typ). Once the junction temperature reaches the thermal-shutdown threshold, an internal thermal sensor shuts off the operational amplifier. The thermal protection is not latched and the device recovers once the temperature drops below the hysteric threshold ($+10^\circ\text{C}$ typ).

10-Channel High-Voltage Scan Driver and VCOM Amplifier for TFT LCD Panels

Driving Pure Capacitive Loads

The operational amplifier is typically used to drive the LCD backplane (VCOM). The LCD backplane consists of a distributed series capacitance and resistance, a load that can be easily driven by the operational amplifier. However, if the operational amplifier is used in an application with a pure capacitive load, steps must be taken to ensure stable operation.

As the operational amplifier's capacitive load increases, the amplifier's bandwidth decreases and gain peaking increases. A 5Ω to 50Ω resistor placed between VCOM and the capacitive load reduces peaking but also reduces the gain. An alternative method of reducing peaking is to place a series RC network (snubber) in parallel with the capacitive load. The RC network does not continuously load the output or reduce the gain. Typical values of the resistor are between 100Ω and 200Ω and the typical value of the capacitor is 10pF .

High-Voltage Level-Shifting Scan Driver

The MAX17108 includes 10 logic-level to high-voltage level-shifting buffers, which can buffer 10 logic inputs (A1–A10) and shift them to a desired level (Y1–Y10) to drive TFT-LCD row logic. The driver outputs, Y1–Y10, swing between their power-supply rails, according to the input-logic level on A1–A10. The driver output is V_{GOFF} when its respective input is logic-low, and V_{GON_} when its respective input is logic-high.

These 10 driver channels are grouped for different high-level supplies. A1–A6 and A9–A10 are supplied from GON1; A7 and A8 are supplied from GON2.

The high-voltage, level-shifting scan drivers swing from +38V to -12V and can swiftly drive capacitive loads. The typical propagation delays are 35ns.

Thermal Shutdown

The MAX17108 includes a thermal-protection circuit. When the local IC temperature exceeds +155°C (typ), the device shuts down and recovers when the die temperature drops by 10°C (typ).

Design Procedure

All MAX17108 designs should be prototyped and tested prior to production. Table 1 provides a list of components for the typical operating circuit. Table 2 shows a component supplier.

Table 1. Component List

DESIGNATION	DESCRIPTION
1 μF bypassing capacitors	1 $\mu\text{F} \pm 10\%$, 50V X7R ceramic capacitors (0805) Murata GRM21BR71H105K
0.1 μF bypassing capacitors	0.1 $\mu\text{F} \pm 10\%$, 25V X5R ceramic capacitors (0603) Murata GRM188R61E104K

Table 2. Component Supplier

SUPPLIER	PHONE	WEBSITE
Murata Electronic North America, Inc.	770-436-1300	www.murata.com

Applications Information

Power Dissipation

An IC's maximum power dissipation depends on the thermal resistance from the die to the ambient environment and the ambient temperature. The thermal resistance depends on the IC package, PCB copper area, other thermal mass, and airflow.

The MAX17108, with its exposed backside pad soldered to 1in^2 of PCB copper, can dissipate approximately 2700mW into +70°C still air. More PCB copper, cooler ambient air, and more airflow increase the possible dissipation, while less copper or warmer air decreases the IC's dissipation capability. The major components of power dissipation are the power dissipated in the operational amplifier and the high-voltage scan drivers.

Operational Amplifier

The power dissipated in the operational amplifiers depends on the output current, the output voltage, and the supply voltage:

$$PD_{\text{SOURCE}} = I_{\text{VCOM_SOURCE}} \times (V_{\text{AVDD}} - V_{\text{VCOM}})$$

$$PD_{\text{SINK}} = I_{\text{VCOM_SINK}} \times V_{\text{VCOM}}$$

where $I_{\text{VCOM_SOURCE}}$ is the output current sourced by one operational amplifier, and $I_{\text{VCOM_SINK}}$ is the output current that the operational amplifier sinks.

In a typical case, where the supply voltage is 8V and the output voltage is 4V with an output source current of 30mA for the operational amplifier, the power dissipated is 120mW.

10-Channel High-Voltage Scan Driver and VCOM Amplifier for TFT LCD Panels

Scan Driver Outputs

When driving a pure capacitive load, the power dissipated by the scan driver outputs (A1–A6; A7–A10 are low-frequency outputs and the power dissipation by these outputs can be omitted) depends on the scan frequency, the capacitive load, and the difference between the GON1 and GOFF supply voltages:

$$PD_{SCAN} = 6 \times f_{SCAN} \times C_{PANEL} \times (V_{GON1} - V_{GOFF})^2$$

If the six scan drivers operate at a frequency of 50kHz, the load of the six outputs is 5nF, and the supply voltage difference is 30V, then the power dissipated is 1.35W.

PCB Layout Guidelines

Careful PCB layout is important for proper operation. Use the following guidelines for good PCB layout:

- Avoid using vias in the high-current paths. If vias are unavoidable, use many vias in parallel to reduce resistance and inductance.

- Create VGOFF plane, connect it to EP.
- Create a ground island (GND) consisting of the input and output capacitor grounds and GND pin. Connect all these together with short, wide traces or a small ground plane.
- Place the voltage-divider resistors as close as possible to the POS pin. The divider's center trace should be kept short. Placing the resistors far away causes the POS trace to become an antenna that can pick up switching noise.
- Minimize the length and maximize the width of the traces between the output capacitors and the load for best transient responses.

Refer to the MAX17108 Evaluation Kit for an example of proper board layout.

Chip Information

TRANSISTOR COUNT: 2918
PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns, go to www.maxim-ic.com/packages.

PACKAGE TYPE	PACKAGE CODE	DOCUMENT NO.
28 TQFN	T2855-6	21-0140

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10 **Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600**