

# MAX16928 Evaluation Kit

## Evaluates: MAX16928

### General Description

The MAX16928 evaluation kit (EV kit) is a fully assembled and tested surface-mount PCB that provides the voltages and features required for automotive thin-film transistor (TFT), liquid-crystal display (LCD) applications. The EV kit includes a boost converter, a 3.3V regulator controller with external npn transistor, two gate voltage regulators, a single-stage positive charge pump, and a single-stage negative charge pump.

The EV kit can operate from 4.5V to 5.5V input voltages and is optimized for automotive TFT-LCD applications. The boost converter is configured for a 12V output that provides at least 400mA. The regulator controller output is 3.3V and provides at least 500mA. The positive-gate voltage regulator provides 18V output and the negative-gate voltage regulator provides -5.9V.

### Features

- ◆ 4.5V to 5.5V Input Range
- ◆ Output Voltages
  - 12V Output at 400mA (Boost Converter)
  - 3.3V Output at 500mA (Regulator Controller)
  - 18V Output (Positive-Gate Voltage Regulator)
  - 5.9V Output (Negative-Gate Voltage Regulator)
- ◆ High-Frequency Operation
  - 2.2MHz (Boost Converter)
- ◆ Single-Stage Positive and Negative Charge Pumps
- ◆ Proven PCB Layout
- ◆ Fully Assembled and Tested

*Ordering Information appears at end of data sheet.*

### Component List

DESIGNATION	QTY	DESCRIPTION
C1, C4, C22, C24	4	10 $\mu$ F $\pm$ 20%, 25V X7R ceramic capacitors (1210) Murata GRM32DR71E106M TDK C3225X7R1E106M
C2, C3, C5, C14, C25, C27	6	0.1 $\mu$ F $\pm$ 10%, 50V X7R ceramic capacitors (0603) Murata GRM188R71H104K TDK C1608X7R1H104K
C6	1	2.2 $\mu$ F $\pm$ 10%, 10V X7R ceramic capacitor (0805) Murata GRM21BR71A225K
C7	1	220pF $\pm$ 10%, 50V X7R ceramic capacitor (0603) Murata GRM188R71H221K
C8	1	22pF $\pm$ 5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H220J
C9	1	150pF $\pm$ 5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H151J
C12, C13, C21	3	1 $\mu$ F $\pm$ 10%, 25V X7R ceramic capacitors (0805) Murata GRM21BR71E105K
C23, C37, C38, C39	0	Not installed, ceramic capacitors (1210)

DESIGNATION	QTY	DESCRIPTION
C26	1	4.7 $\mu$ F $\pm$ 20%, 25V X7R ceramic capacitor (1206) Murata GRM31CR71E475M
D1, D6	2	200mA, 100V dual-series diodes (SOT23) Fairchild MMBD4148SE
D2	1	3A, 30V Schottky diode (M Flat) Toshiba CMS02(TE12L,Q)
D4	1	2A, 50V fast-recovery diode (SMB) Fairchild ES2A
JU1, JU2	2	3-pin headers
L1	1	3.3 $\mu$ H, 9A power inductor Würth 744314330
P1	1	-20V, -2.4A p-channel MOSFET (3 SuperSOT) Fairchild FDN304P
Q1	1	npn bipolar transistor (SOT23) Fairchild MMBT3904
Q2	1	npn high-gain transistor (SOT89) Zetex ZXTN25012EZ
R1	1	30k $\Omega$ $\pm$ 1% resistor (0603)
R2, R13	2	6.8k $\Omega$ $\pm$ 5% resistors (0603)
R5	1	180k $\Omega$ $\pm$ 5% resistor (0603)

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### Component List (continued)

DESIGNATION	QTY	DESCRIPTION
R6	1	169k $\Omega$ $\pm$ 1% resistor (0603)
R7	1	10k $\Omega$ $\pm$ 1% resistor (0603)
R9, R16, R17	3	10k $\Omega$ $\pm$ 5% resistors (0603)
R10	1	100k $\Omega$ $\pm$ 5% resistor (0603)
R11	1	133k $\Omega$ $\pm$ 1% resistor (0603)
R12	1	12.1k $\Omega$ $\pm$ 1% resistor (0603)
R14	1	316k $\Omega$ $\pm$ 1% resistor (0603)

DESIGNATION	QTY	DESCRIPTION
R15	1	51.1k $\Omega$ $\pm$ 1% resistor (0603)
R18	1	33 $\Omega$ $\pm$ 5% resistor (0603)
U1	1	TFT-LCD power supply (20 TSSOP-EP) Maxim MAX16928AGUP/V+
—	2	Shunts
—	1	PCB: MAX16928 EVALUATION KIT

### Component Suppliers

SUPPLIER	PHONE	WEBSITE
Fairchild Semiconductor	888-522-5372	www.fairchildsemi.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
TDK Corp.	847-803-6100	www.component.tdk.com
Toshiba America Electronic Components, Inc.	949-623-2900	www.toshiba.com/taec
Würth Elektronik GmbH & Co. KG	201-785-8800	www.we-online.com
Zetex Semiconductors (Division of Diodes Incorporated)	805-446-4800	www.diodes.com

**Note:** Indicate that you are using the MAX16928 when contacting these component suppliers.

### Quick Start

#### Recommended Equipment

- MAX16928 EV kit
- 4.5V to 5.5V, 2A DC power supply
- Voltmeter

#### Procedure

The EV kit is fully assembled and tested. Follow the steps below to verify board operation. **Caution: Do not turn on the power supply until all connections are completed.**

- 1) Verify that a shunt is installed on pins 1-2 on jumper JU1.
- 2) Verify that a shunt is installed on pins 2-3 on jumper JU2.
- 3) Connect the positive terminal of the power supply to the INA PCB pad. Connect the negative terminal of the power supply to the PGNDP PCB pad closest to INA.
- 4) Set the power-supply INA to 5V.
- 5) Turn on the power supply.
- 6) Verify that the step-up switching regulator (VSH) is 12V.
- 7) Verify that the 3.3V regulator is 3.3V.

- 8) Verify that the positive-gate voltage regulator (GH) is approximately 18V.
- 9) Verify that the negative-gate voltage regulator (VGL) is approximately -5.9V.

### Detailed Description of Hardware

#### Jumper Settings

Several jumper settings in the following tables illustrate features of the EV kit.

#### Boost Circuitry and 3.3V Regulator Controller Enable Input (JU1)

The device's ENP pin enables the boost circuitry and the 3.3V regulator controller. For normal operation, drive ENP high by installing a shunt on pins 1-2 on jumper JU1. For shutdown mode, drive ENP low by installing a shunt on pins 2-3 on JU1. See Table 1 for JU1 configuration.

**Table 1. Jumper Functions (JU1)**

SHUNT POSITION	ENP PIN	VSH AND 3.3V OUTPUTS
1-2*	Connected to INA	Enabled
2-3	Connected to GND	Disabled

\*Default position.

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**Table 2. Jumper Functions (JU2)**

SHUNT POSITION	SEQ PIN	SUPPLY SEQUENCING ORDER
1-2	Connected to INA	VSH, VGL, VGH
2-3*	Connected to GND	VSH, VGH, VGL

\*Default position.

### Supply Sequencing (JU2)

The device's SEQ pin controls the order in which the VGH and VGL supplies are sequenced. When a shunt is installed on pins 1-2 on jumper JU2, VGL is turned on first followed by VGH. When a shunt is installed on pins 2-3, VGH is turned on first followed by VGL. See Table 2 for JU2 configuration.

### Output-Voltage Selection

#### Boost Converter

The EV kit's boost-converter output (VSH) is set to 12V by feedback resistors R11 and R12. To generate output voltages other than 12V, select R12 in the 10kΩ to 50kΩ range and select R11 according to the following equation:

$$R11 = R12 \times \left( \frac{V_{VSH}}{V_{FBP}} - 1 \right)$$

where  $V_{VSH}$  is the desired boost output voltage and  $V_{FBP}$  is the boost converter's feedback set point (1V typ). When increasing the boost output voltage, be careful not to exceed the absolute maximum rating of the CP pin (31V with INA = 5V and 29V with INA = 3.3V).

#### Positive-Gate Voltage Regulator

The EV kit's positive-gate voltage regulator output (GH) is set to 18V by feedback resistors R6 and R7. To generate output voltages other than 18V, select R7 in the 10kΩ to 50kΩ range and select R6 according to the following equation:

$$R6 = R7 \times \left( \frac{V_{GH}}{V_{FBGH}} - 1 \right)$$

where  $V_{GH}$  is the desired positive-gate regulator output voltage and  $V_{FBGH}$  is the positive-gate feedback set point (1V typ). With the installed charge-pump doubler, GH voltages greater than approximately 2 x VSH cannot be produced.

### Negative-Gate Voltage Regulator

The EV kit's negative-gate voltage regulator output (VGL) is set to -5.9V by feedback resistors R14 and R15. To generate output voltages other than -5.9V, select R15 to be greater than 20kΩ to avoid loading down the reference output. Select R14 according to the following equation:

$$R14 = R15 \times \left( \frac{V_{FBGL} - V_{GL}}{V_{REF} - V_{FBGL}} \right)$$

where  $V_{GL}$  is the desired negative-gate regulator output voltage,  $V_{REF} = 1.25V$ , and  $V_{FBGL}$  is the negative-gate feedback set point (0.25V typ). Note that the negative-gate voltage regulator is not short-circuit protected and can be damaged by overcurrent.

### Charge Pumps

The EV kit provides a single-stage positive charge pump (VCP) and single-stage negative charge pump (VCN). The output voltages generated on the storage capacitors are given by:

$$V_{VCP} = 2 \times V_{VSH} + V_{SCHOTTKY} - 2 \times V_D$$

$$V_{VCN} = -(V_{VSH} + V_{SCHOTTKY} - 2 \times V_D)$$

where  $V_{SCHOTTKY}$  is the forward-voltage drop of the Schottky diode and  $V_D$  is the forward-voltage drop of the charge-pump diode.

### Evaluating Other Versions of MAX16928

The EV kit comes standard with the MAX16928AGUP/V+ IC installed, but can also evaluate several versions of the MAX16928. The IC provides a variety of power options to meet the most common automotive TFT-LCD display-power requirements, as outlined in the *Ordering Information* table in the MAX16928 IC data sheet. Note some components, such as the inductor value and compensation component values, may need to change when evaluating other versions of the IC. Refer to the *Design Procedure* section of the MAX16928 IC data sheet for further details.



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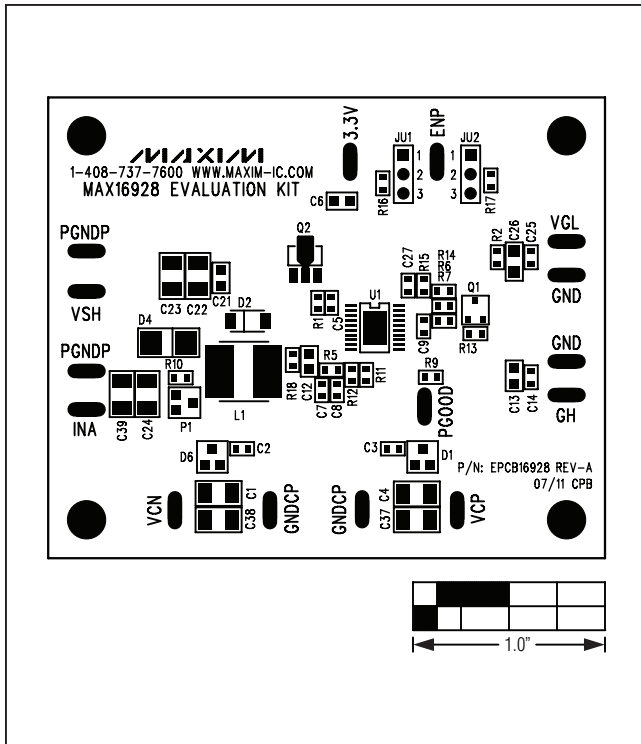


Figure 2. MAX16928 EV Kit Component Placement Guide—Component Side

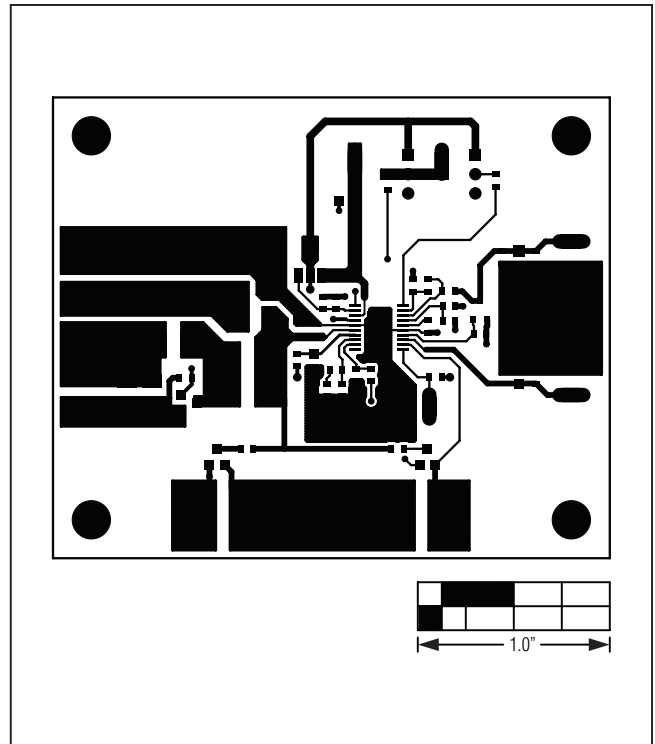


Figure 3. MAX16928 EV Kit PCB Layout—Component Side

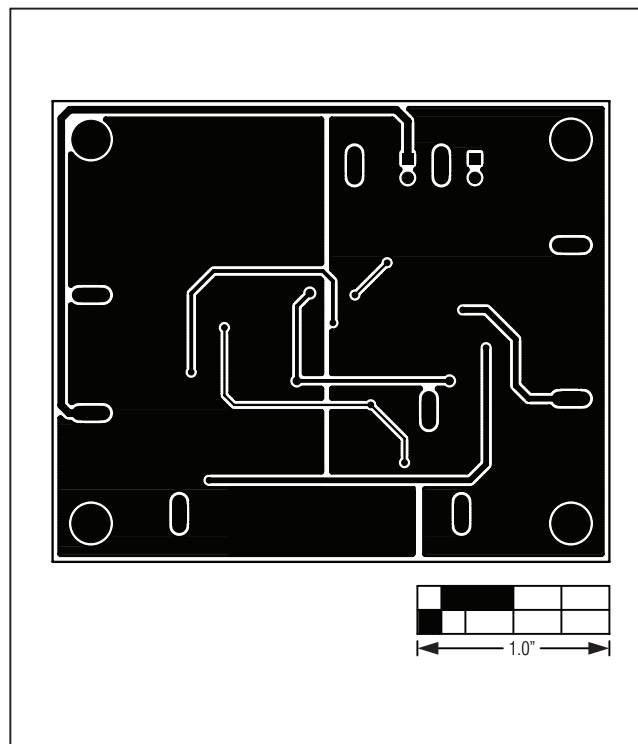


Figure 4. MAX16928 EV Kit PCB Layout—Solder Side

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### ***Ordering Information***

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PART	TYPE
MAX16928EVKIT#	EV Kit

#Denotes RoHS compliant.

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### *Revision History*

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	10/11	Initial release	—

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