



# MAX16826 Evaluation Kit

Evaluates: MAX16826

## General Description

The MAX16826 evaluation kit (EV kit) provides a proven design to evaluate the MAX16826, a four-string, I<sup>2</sup>C programmable high-brightness LED (HB LED) driver with PWM dimming control. The EV kit also includes Windows® 2000/XP/Vista®-compatible software that provides a simple graphical user interface (GUI) for exercising the features of the MAX16826. The MAX16826 EV kit PCB comes with a MAX16826ATJ+ installed. The EV kit is configured in a boost application.

This EV kit can be modified by changing component values on the board for other configurations (including RGB LED applications). Refer to the MAX16826 IC data sheet for more information.

## LED Driver Board Specification

PARAMETER	DESCRIPTION
Configuration	7 white LEDs/string
Number of Strings	4 strings
LED Current Adjustment Range	50mA to 150mA
Total Maximum LED Power	16.8W
V <sub>IN</sub> (min)	7.5V
V <sub>IN</sub> (max)	22V
Load Dump	40V for < 400ms
Nominal Boost Voltage Adjustment Range	22.4V to 32V
Nominal OVP Trip Threshold	35V
Boost Stage Switching Frequency	350kHz

## Features

- ◆ Four Independently Controllable LED Strings
- ◆ 7 LEDs Per String Configuration
- ◆ Independently Programmable 50mA to 150mA String Current
- ◆ 7.5V to 22V Input Voltage
- ◆ Can Withstand Automotive Load Dump Up to 40V for 400ms
- ◆ 0% to 100% DIM Duty Cycle Range
- ◆ Shorted LED Protection and Detection
- ◆ Open LED String Detection
- ◆ Adaptive Boost-Stage Voltage Optimization
- ◆ Convenient Breakaway LED Driver Board Easily Adaptable to End Application
- ◆ Low Mechanical Profile
- ◆ Windows 2000/XP/Vista (32-Bit)-Compatible Software
- ◆ USB-PC Interface
- ◆ USB-to-I<sup>2</sup>C On-Board Circuitry
- ◆ Fully Assembled and Tested
- ◆ Lead-Free and RoHS Compliant

## Ordering Information

PART	TYPE
MAX16826EVKIT+	EV Kit

+Denotes lead-free and RoHS compliant.

## Component List

DESIGNATION	QTY	DESCRIPTION
C1, C2, C3, C5–C8, C12, C15, C17, C23, C24	12	100nF ±10%, 16V X7R ceramic capacitors (0603) TDK C1608X7R1C104K
C9	1	33nF ±10%, 50V X7R ceramic capacitor (0603) TDK C1608X7R1H333K
C10, C11	2	22pF ±5%, 50V C0G ceramic capacitors (0603) TDK C1608C0G1H220J
C13, C14, C18–C21	6	1µF ±10%, 16V X7R ceramic capacitors (0603) TDK C1608X7R1C105K
C16, C25	2	10µF ±10%, 10V X5R ceramic capacitors (1210) Murata GRM32FR61A106K

DESIGNATION	QTY	DESCRIPTION
C26, C28	2	10µF ±20%, 50V X5R ceramic capacitors (2220) Murata GRM55DR61H106K
C27	1	10µF ±20%, 50V X7S ceramic capacitor (1210) Taiyo Yuden UMK325BJ106MM-T
C29	1	2.2nF ±5%, 50V C0G ceramic capacitor (0603) Murata GRM1885C1H222K
C30	1	1µF ±10%, 50V X7R ceramic capacitor (1210) Murata GRM32RR71H105K
C32	1	4.7µF ±10%, 6.3V X5R ceramic capacitor (0603) Murata GRM188R60J475K

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## Component List (continued)

DESIGNATION	QTY	DESCRIPTION
C33	1	2200pF $\pm 10\%$ , 50V X7R ceramic capacitor (0402) Murata GRM155R71H222K
C34, C35	2	47 $\mu$ F $\pm 20\%$ , 50V electrolytic capacitors Panasonic EEE-FK1H470XP
C36, C37	0	Not installed, capacitors (0603)
C38	1	1000pF $\pm 5\%$ , 50V C0G ceramic capacitor (0402) Murata GRM155C1H102JA01D
C39	1	220pF $\pm 5\%$ , 50V C0G ceramic capacitor (0402) Murata GRM1555C1H221J
C40	1	100pF $\pm 5\%$ , 50V C0G ceramic capacitor (0402) Murata GRM1555C1H101J
C41–C44	4	0.01 $\mu$ F $\pm 10\%$ , 50V X7R ceramic capacitors (0402) Murata GRM155R71H103K
C45	0	Not installed, capacitor (0402)
D1	1	60V, 1A Schottky diode (SMB) Diodes, Inc. B160B-13-F
J1	1	USB series-B right-angle PC-mount receptacle
J2, J3	0	Not installed
JU2–JU8	7	3-pin headers
L1	1	Ferrite bead (0603) TDK MMZ1608R301A
L2	1	22 $\mu$ H $\pm 20\%$ , 5A, 52m $\Omega$ inductor Coilcraft MSS1260-223MI
LED1	1	Red LED (0603) Panasonic LNJ208R8ARA
P1, P2	2	Connectors, FFC/FPC 18-pos, 1mm
P3	1	Connector, FFC/FPC 6-pos, 1mm
Q1	1	40V, 9A, 2.5W n-channel MOSFET (8 SO) International Rectifier IRF7469
Q2–Q5	4	55V, 1.9A, 160m $\Omega$ n-channel MOSFETs (SOT223) International Rectifier IRFL014NPbF
R1	1	220 $\Omega$ $\pm 5\%$ resistor (0603)
R2	1	2.2k $\Omega$ $\pm 5\%$ resistor (0603)
R3, R9, R10	3	1.5k $\Omega$ $\pm 5\%$ resistors (0603)
R4, R5	2	27 $\Omega$ $\pm 5\%$ resistors (0603)
R6	1	470 $\Omega$ $\pm 5\%$ resistor (0603)
R7	1	100k $\Omega$ $\pm 5\%$ resistor (0603)
R8	1	7.5k $\Omega$ $\pm 1\%$ resistor (0603)
R11	1	68 $\Omega$ $\pm 1\%$ , 0.25W resistor (1206)

DESIGNATION	QTY	DESCRIPTION
R12	1	0.04 $\Omega$ $\pm 1\%$ , 0.5W sense resistor (2010) Vishay/Dale WSL2010R0400FEA
R13	1	215k $\Omega$ $\pm 1\%$ resistor (0402)
R14, R16	2	10k $\Omega$ $\pm 1\%$ resistors (0402)
R15	1	249k $\Omega$ $\pm 1\%$ resistor (0402)
R17	1	1.27k $\Omega$ $\pm 1\%$ resistor (0603)
R18	1	182k $\Omega$ $\pm 1\%$ resistor (0603)
R19	1	2k $\Omega$ $\pm 1\%$ resistor (0402)
R20, R22, R24, R26	4	100k $\Omega$ $\pm 1\%$ resistors (0402)
R21, R23, R25, R27	4	16.5k $\Omega$ $\pm 1\%$ resistors (0402)
R28–R31	4	2.2 $\Omega$ $\pm 1\%$ , 100mW sense resistors (0603) Panasonic ECG ERJ-3RQF2R2V
R32, R33	2	0 $\Omega$ $\pm 5\%$ resistors (0603)
R34–R37	4	0 $\Omega$ $\pm 5\%$ resistors (0402)
R38	1	12.1 $\Omega$ $\pm 1\%$ resistor (0805)
R39	1	470 $\Omega$ $\pm 5\%$ resistor (0402)
R40	1	10k $\Omega$ $\pm 5\%$ resistor (0603)
R41–R44	4	237k $\Omega$ $\pm 1\%$ resistors (0603)
U1	1	LED driver (32 TQFN) Maxim MAX16826ATJ+
U2, U8	2	Microcontrollers (68 QFN-EP*) Maxim MAXQ2000-RAX+
U3	1	UART-to-USB converter (32 TQFP) FTDI FT232BL
U4	1	93C46A 3-wire EEPROM (8 SO) Atmel AT93C46A-10SU-2.7
U5	1	p-channel MOSFET power switch (8 SO) Maxim MAX890LESA+
U6	1	LDO regulator (5 SC70) Maxim MAX8511EXK25+T
U7	1	LDO regulator (5 SC70) Maxim MAX8511EXK33+T
Y1	1	20MHz crystal oscillator
Y2	1	6MHz crystal Hong Kong X'tals SSL6000000E18FAF
—	1	Cable, flat flex 18-position, 1mm, 5in
—	7	Shunts
—	1	USB high-speed A-to-B cable, 5ft (1.5m)
—	1	PCB: MAX16828 Evaluation Kit+

\*Exposed pad.

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## Component Suppliers

SUPPLIER	PHONE	WEBSITE
Coilcraft, Inc.	847-639-6400	www.coilcraft.com
Diodes, Inc.	805-446-4800	www.diodes.com
Hong Kong X'tals Ltd.	852-35112388	www.hongkongcrystal.com
International Rectifier	310-322-3331	www.irf.com
Murata Electronics North America, Inc.	770-436-1300	www.murata-northamerica.com
Panasonic Corp.	800-344-2112	www.panasonic.com
Taiyo Yuden	800-348-2496	www.t-yuden.com
TDK Corp.	847-803-6100	www.component.tdk.com
Vishay/Dale	402-563-6866	www.vishay.com

**Note:** Indicate that you are using the MAX16826 when contacting these component suppliers.

## MAX16826 EV Kit Files

FILE	DESCRIPTION
INSTALL.EXE	Installs the EV kit files on your computer
MAX16826.EXE	Application program
FTDIBUS.INF	USB device driver file
FTDIPOINT.INF	VCP device driver file
UNINST.INI	Uninstalls the EV kit software
USB_Driver_Help.PDF	USB driver installation help file

## Quick Start

### Recommended Equipment

Before beginning, the following equipment is needed:

- MAX16826 EV kit (USB cable included)
- A user-supplied Windows 2000/XP/Vista PC with a spare USB port
- 7V to 24V, 5A DC power supply
- Four strings of white LEDs (7 LEDs/string)

**Note:** In the following sections, software-related items are identified by bolding. Text in **bold** refers to items directly from the EV kit software. Text in **bold and underlined** refers to items from the Windows operating system

### Procedure

The MAX16826 EV kit is fully assembled and tested. Follow the steps below to verify board operation:

- 1) Visit [www.maxim-ic.com/evkitsoftware](http://www.maxim-ic.com/evkitsoftware) to download the latest version of the EV kit software, 16826Rxx.ZIP (xx in the filename denotes the soft-

ware version number). Save the EV kit software to a temporary folder and uncompress the ZIP file.

- 2) Install the EV kit software on your computer by running the INSTALL.EXE program inside the temporary folder. The program files are copied and icons are created in the Windows **Start | Programs** menu.
- 3) Verify that all jumpers (JU2–JU8) are in their default positions, as shown in Table 1.
- 4) Connect the USB cable from the PC to the EV kit board. A **New Hardware Found** window pops up when installing the USB driver for the first time. If you do not see a window that is similar to the one described above after 30 seconds, remove the USB cable from the board and reconnect it. Administrator privileges are required to install the USB device driver on Windows.
- 5) Follow the directions of the **Add New Hardware Wizard** to install the USB device driver. Choose the **Search for the best driver for your device** option. Specify the location of the device driver to be **C:\Program Files\MAX16826** (default installation directory) using the **Browse** button. During device driver installation, Windows may show a warning message indicating that the device driver Maxim uses does not contain a digital signature. This is not an error condition and it is safe to proceed with installation. Refer to the USB\_Driver\_Help.PDF document included with the software for additional information.
- 6) Set the output of the power supply to 12V. Turn off the power supply.
- 7) Connect the positive terminal of the power supply to the VIN pad of the LED driver board.

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- 8) Connect the negative terminal of the power supply to the PGND pad of the LED driver board.
- 9) Ensure that the supplied ribbon cable is firmly connected to the P1 and P2 connectors.
- 10) Connect the anode ends of the LED strings to the P3-1 pin of the P3 connector.
- 11) Connect the cathode ends of the LED strings to the P3-2 to P3-5 pins of the P3 connector.
- 12) Turn on the power supply
- 13) Start the MAX16826 EV kit software by opening its icon in the **Start | Programs** menu. The EV kit software main window appears, as shown in Figure 1.
- 14) Press the **Start** button to start the LED driver.
- 15) Verify that all of the LEDs are lit.

**Table 1. MAX16826 EV Kit Jumper Descriptions (JU2–JU8)**

JUMPER	SHUNT POSITION	DESCRIPTION
JU2	1-2*	On-board PWM signal for Ch1
	2-3	Connect user-supplied PWM signal for Ch1 to the on-board DIM1 pad
JU3	1-2*	On-board PWM signal for Ch2
	2-3	Connect user-supplied PWM signal for Ch2 to the on-board DIM2 pad
JU4	1-2*	MAX16826 SDA signal connected to on-board microcontroller
	2-3	Connect user-supplied SDA signal to the on-board SDA pad
JU5	1-2*	MAX16826 SCL signal connected to on-board microcontroller
	2-3	Connect user-supplied SCL signal to the on-board SCL pad
JU6	1-2*	MAX16826 SYNC/EN signal connected to on-board microcontroller
	2-3	Connect user-supplied SYNC/EN signal to the on-board SYNC/EN pad
JU7	1-2*	On-board PWM signal for Ch3
	2-3	Connect user-supplied PWM signal for Ch3 to the on-board DIM3 pad
JU8	1-2*	On-board PWM signal for Ch4
	2-3	Connect user-supplied PWM signal for Ch4 to the on-board DIM4 pad

\*Default position.

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## Detailed Description of Software

The MAX16826 evaluation kit software has all the functions to evaluate the MAX16826 IC. To start the MAX16826 EV kit software, click **Start | Programs |**

Maxim MAX16826 Evaluation Kit | Maxim MAX16826 Evaluation Kit that is created during installation. The GUI main window appears as shown in Figure 1.

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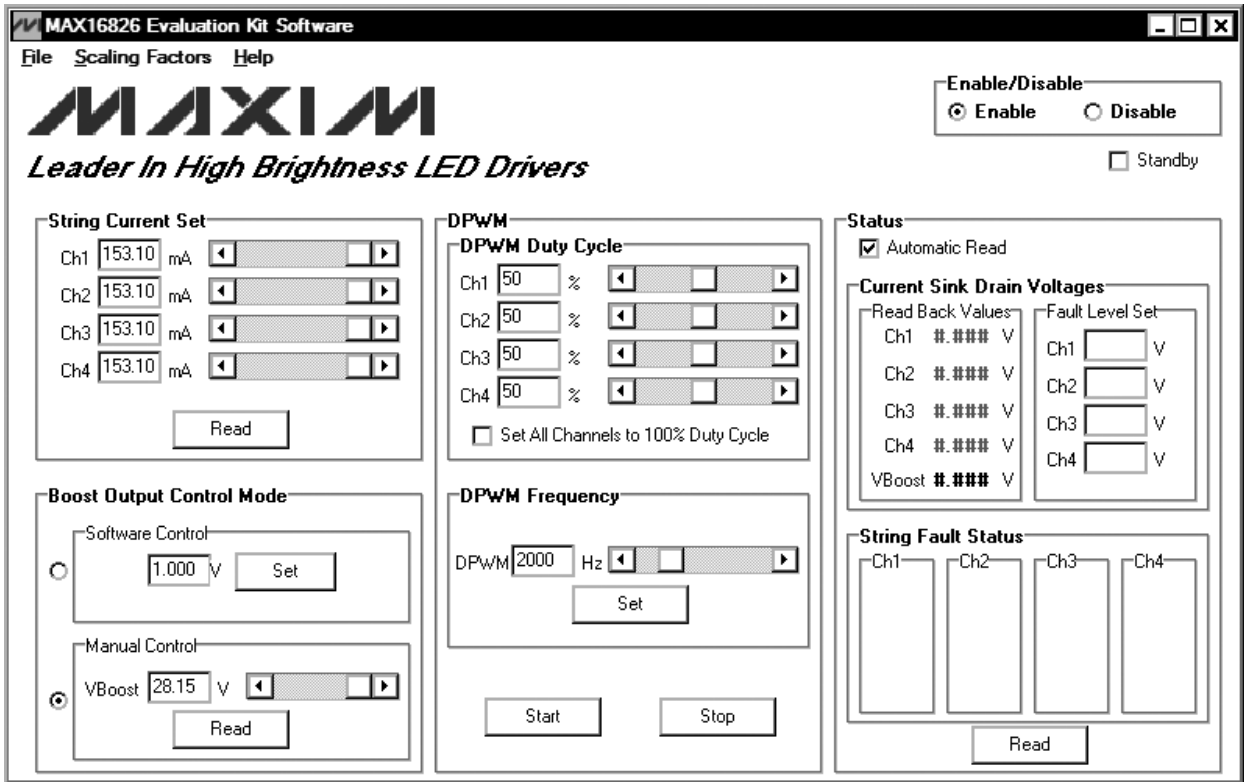


Figure 1. MAX16826 EV Kit Software Main Window

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## String Current Set

The **String Current Set** group box is located at the upper left corner of the main window. Use the scrollbars to adjust the current of the LED strings. The corresponding values of the current will be shown in the adjacent edit boxes. Press the **Read** button to read the values from the linear regulator output registers of the MAX16826. The equivalent values of the output current will be shown in the edit boxes.

## Boost Output Control

The **Boost Output Control Mode** group box has the functions to control the boost output voltage.

To control the boost output voltage manually, click on the radio button next to the **Manual Control** group box. Use the scrollbar to adjust the output voltage, and the voltage value will be displayed in the adjacent edit box. The actual boost output voltage can be seen in the **Read Back Values** group box.

To use the software automatic control, click on the radio button next to the **Software Control** group box. The edit box next to the **Set** button is used to change the Drain to GND regulated voltage of the current sink FETs on the LED string with the highest voltage drop. This voltage setting will depend on how much overhead the user is willing to have. If the set value is too low, the LED currents will no longer be well regulated and may indeed drop because the boost voltage might fall too low. The scrollbar in this mode will move automatically to compensate and regulate the output voltage. The update rate is approximately once per second. In any case, the channel with the lowest voltage across the sink FET will be regulated to the value in the edit box.

## DIM Pulse Width Modulation (DPWM)

The **DPWM** group box is located at the center of the main window. The four DIM PWM signals generated by the on-board MAXQ2000 microcontrollers are used to control the brightness of the LEDs. Adjust the scrollbars in the **DPWM Duty Cycle** group box to change the duty cycles of the PWM signals and the values of the duty cycle (%) are shown in the adjacent edit boxes. Check the **Set All Channels to 100% Duty Cycle** checkbox to force all channel duty cycles to 100%.

In the **DPWM Frequency** group box, change the DPWM frequency by adjusting the scrollbar position and press the **Set** button. The frequency value will be shown in the edit box.

To guarantee that the leading edge of all the DIM signals are synchronized, press the **Set** button in the **DPWM Frequency** group box.

Press the **Start** button to start to generate the PWM signals.

Press the **Stop** button to stop all PWM signals.

## Status

The **Status** group box is located at the right of the main window. The software reads the external FET drain voltage measurements, and the boost output voltage measurement from the ADC output registers of the MAX16826. The software multiplies the measured values by the appropriate scaling factor and then displays them in the **Read Back Values** group box.

Enter the values into the edit boxes in the **Fault Level Set** group box to set the fault-detection values. When the value in the **Read Back Values** group box is less than the fault-detection value, then the color of the read-back value changes to dark green. When the read-back value is 0 to 10% higher than the fault-detection value, the read-back value turns a lime color. If the read-back value is more than 10% higher than the fault-detection value, then the read-back value turns purple. The read-back value turns red when it is more than 20% higher than the fault-detection value.

The software also reads the fault register to detect the fault conditions. If a fault condition exists, it will be shown in the **String Fault Status** group box. See Table 2 for the fault-condition explanations.

**Table 2. Fault Conditions**

FAULT NAME	CONDITION
TO	ADC conversion timeout; also corresponds to open string condition*
Open	LED string open
Short	LED string shorted
OVP	Overvoltage

\*Open LED string detection may require multiple flag examination.

Press the **Read** button to update the **Status** group box. By checking the **Automatic Read** checkbox, the **Status** group box will be automatically updated every second.

## Enable/Disable

The **Enable/Disable** group box controls the signal on the SYNC/EN pin. Click on the **Enable** radio button to set the signal high and enable the MAX16826. Click on the **Disable** radio button to set the signal low and disable the MAX16826.

## Standby

Check the **Standby** checkbox to set the MAX16826 to standby mode. Refer to the MAX16826 IC data sheet for more information regarding standby mode.

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### Scaling Factors

The calculations for the LED string current, boost output voltage, and the read-back values are based on the scaling factors. You can change the scaling factor by selecting the **Scaling Factor** menu item under the **Scaling Factors** menu bar. In the pop-up window shown in Figure 2, enter the appropriate scaling factor.

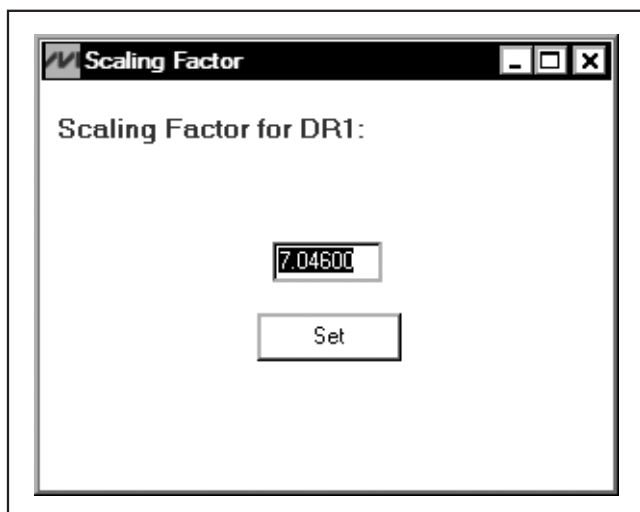


Figure 2. Scaling Factor Window

See Table 3 for the formulas for the scaling factors. These values can be used for calibration against actual read values with external instruments.

When the default values are changed, they are stored in the software. Re-enter the default values to bring the software back to the default setting.

Table 3. Scaling Factor

SCALING FACTOR	FORMULA	DEFAULT VALUE
<b>DR1</b> (ADC read-back voltage across Drain and GND for the sink FET on Ch1)	$1 + (R20/R21)$	7.046
<b>DR2</b> (ADC read-back voltage across Drain and GND for the sink FET on Ch2)	$1 + (R22/R23)$	7.046
<b>DR3</b> (ADC read-back voltage across Drain and GND for the sink FET on Ch3)	$1 + (R24/R25)$	7.046
<b>DR4</b> (ADC read-back voltage across Drain and GND for the sink FET on Ch4)	$1 + (R26/R27)$	7.046
<b>Read Back VBoost</b> (ADC read-back boost output voltage)	$1 + (R15/R16)$	25.900
<b>String Current Set Ch1</b> (LED string current for Ch1)	R31	2.200
<b>String Current Set Ch2</b> (LED string current for Ch2)	R30	2.200
<b>String Current Set Ch3</b> (LED string current for Ch3)	R29	2.200
<b>String Current Set Ch4</b> (LED string current for Ch4)	R28	2.200
<b>VBoost</b> (Boost output voltage)	$1 + (R13/R14)$	22.500

# MAX16826 Evaluation Kit

## **Detailed Description of Hardware**

The MAX16826 EV kit board provides a proven layout for evaluating the MAX16826 IC. This EV kit consists of a controller board and an LED driver board. The break-away slots at the center of the EV kit make it easier for the user to break and separate the controller board from the LED driver board. This is done so that once the evaluation is complete with the included software, the driver board can easily be used in the target application environment with the target system microcontroller.

To connect the power, ground, PWM, and the I<sup>2</sup>C interface signals of the boards, attach the ribbon cable to the P1 connector of the controller board and attach the other end of the ribbon cable to the P2 connector of the LED driver board.

### **Controller Board**

The controller board acts as the bridge between the software in the PC and the actual LED driver board containing the MAX16826. In addition to the USB connectivity, it generates the four adjustable PWM DIM signals that control the brightness of the LEDs. The controller board communicates with the driver board through the I<sup>2</sup>C interface, and is able to read or change the values of the registers in the MAX16826.

The user can use the MAX16826 evaluation kit software to control the controller board.

See Table 1 to control the MAX16826 with a user-supplied PWM signal.

### **LED Driver Board**

The LED driver board is able to drive up to four LED strings (7 LEDs/string). LED strings can be connected to the LED driver board through the P3 connector by using a ribbon cable. Connect all of the anode ends of

the LED strings to the P3-1 pin (which connects to the boost output) of the P3 connector. Then connect the cathode ends of the LED strings to the P3-2 to P3-5 pins (that connects to the drains of the sink FETs) of the P3 connector.

### **User-Supplied I<sup>2</sup>C Interface**

To use the MAX16826 EV kit with a user-supplied I<sup>2</sup>C interface, install the shunts on pins 2-3 of JU4 and JU5. Connect SDA, SCL, and GND lines from the user-supplied I<sup>2</sup>C interface to the SDA, SCL, and PGND pads on the MAX16826 controller board.

After the LED driver board has broken away from the controller board, the user may connect their supplied I<sup>2</sup>C, DIM, and power signals to the LED driver board through the P2 connector using a ribbon cable. See Table 4 for the pin description of the P2 connector.

**Table 4. Pin Description for P2 Connector**

PIN NUMBER	DESCRIPTION
P2-1 to P2-5	Connect to the VIN pin of the MAX16826
P2-6	Not connected
P2-7 to P2-11	Connect to the ground
P2-12	Connects to the SYNC/EN pin of the MAX16826
P2-13	Connects to the SDA pin of the MAX16826
P2-14	Connects to the SCL pin of the MAX16826
P2-15	Connects to the DIM4 pin of the MAX16826
P2-16	Connects to the DIM3 pin of the MAX16826
P2-17	Connects to the DIM2 pin of the MAX16826
P2-18	Connects to the DIM1 pin of the MAX16826

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Evaluates: MAX16826

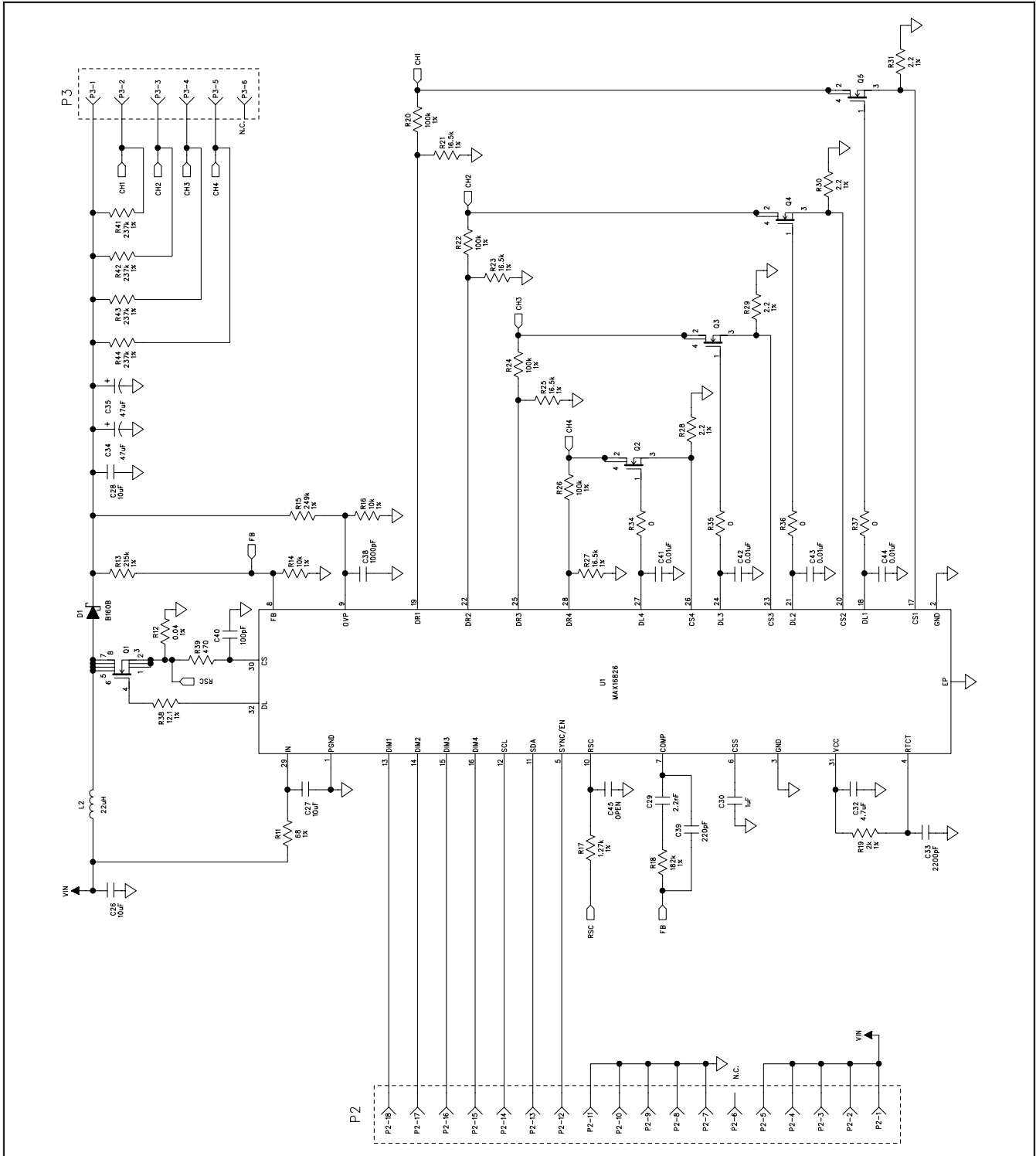


Figure 3. MAX16826 EV Kit LED Driver Board Schematic

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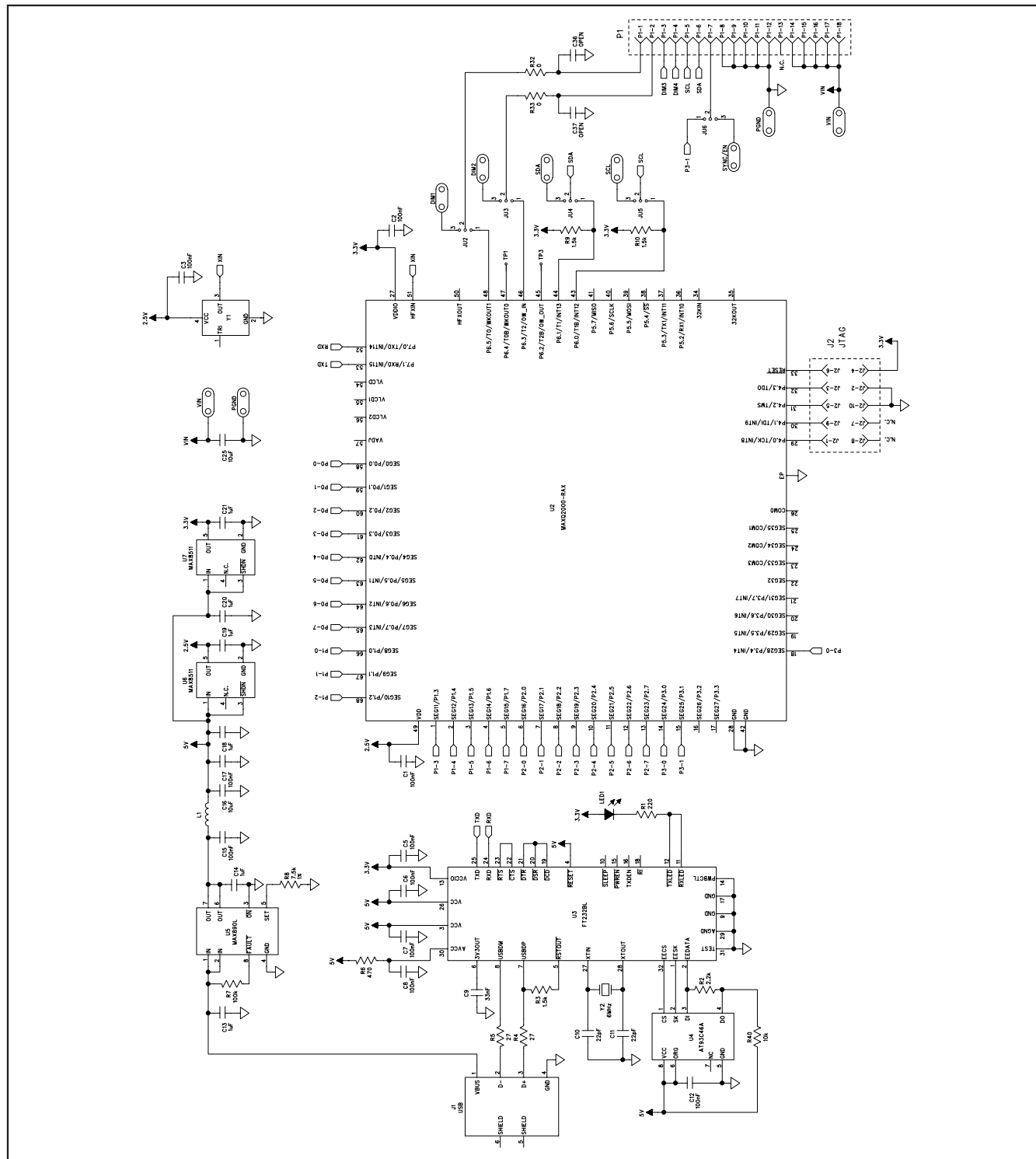


Figure 4a. MAX16826 EV Kit Controller Board Schematic (Sheet 1 of 2)

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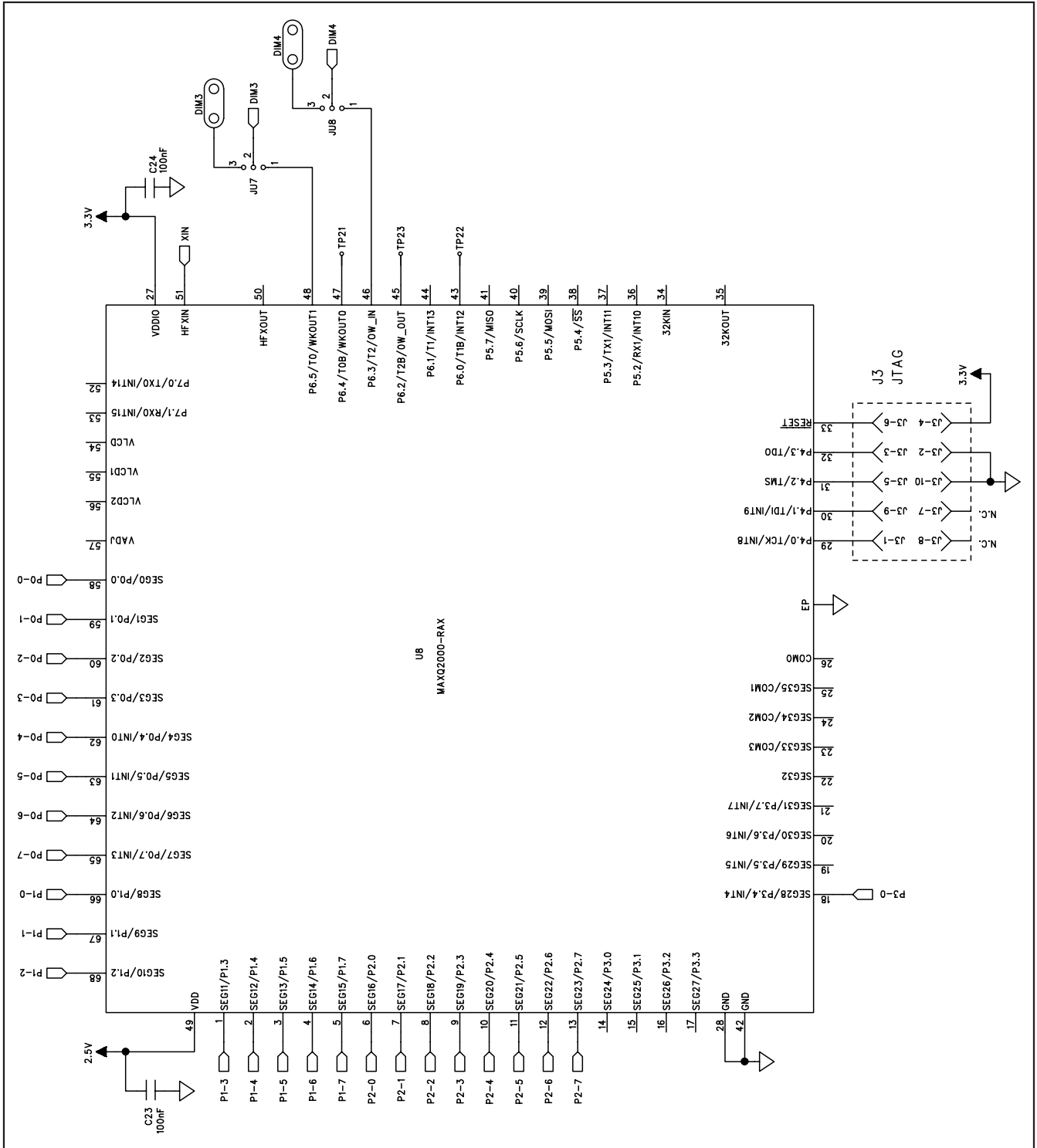


Figure 4b. MAX16826 EV Kit Controller Board Schematic (Sheet 2 of 2)

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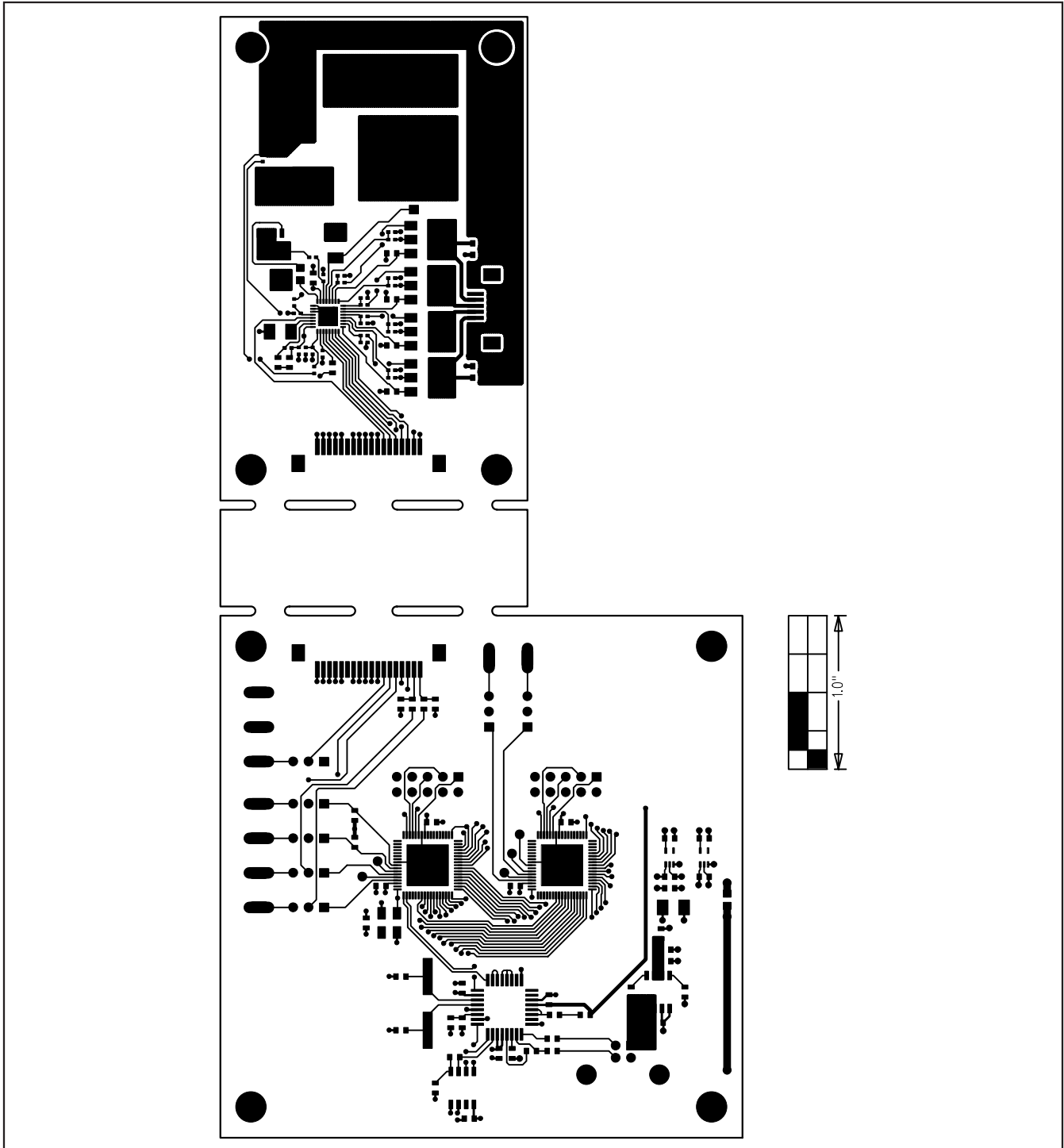


Figure 6. MAX16826 EV Kit PCB Layout—Component Side

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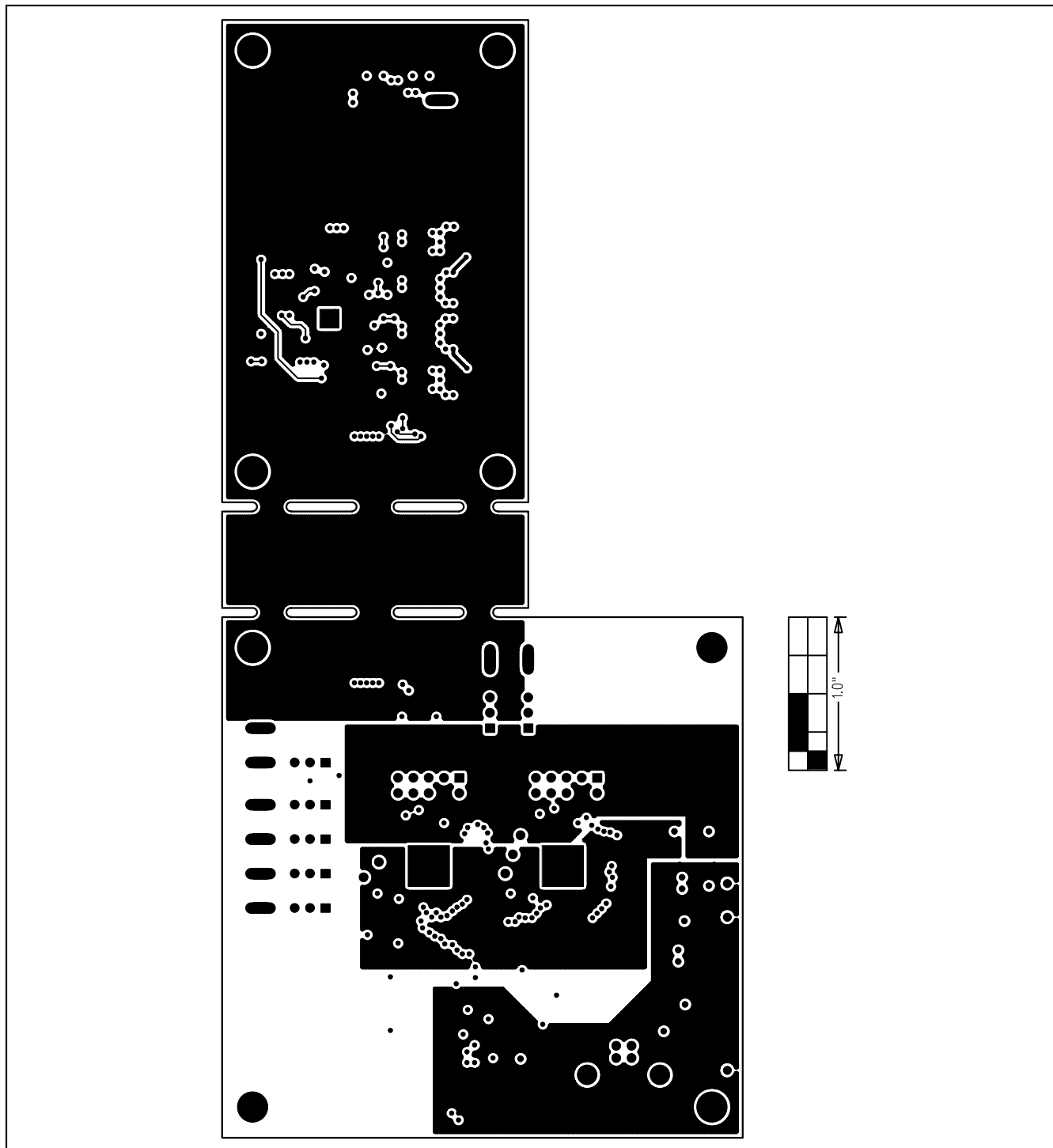


Figure 7. MAX16826 EV Kit PCB Layout—Layer 2

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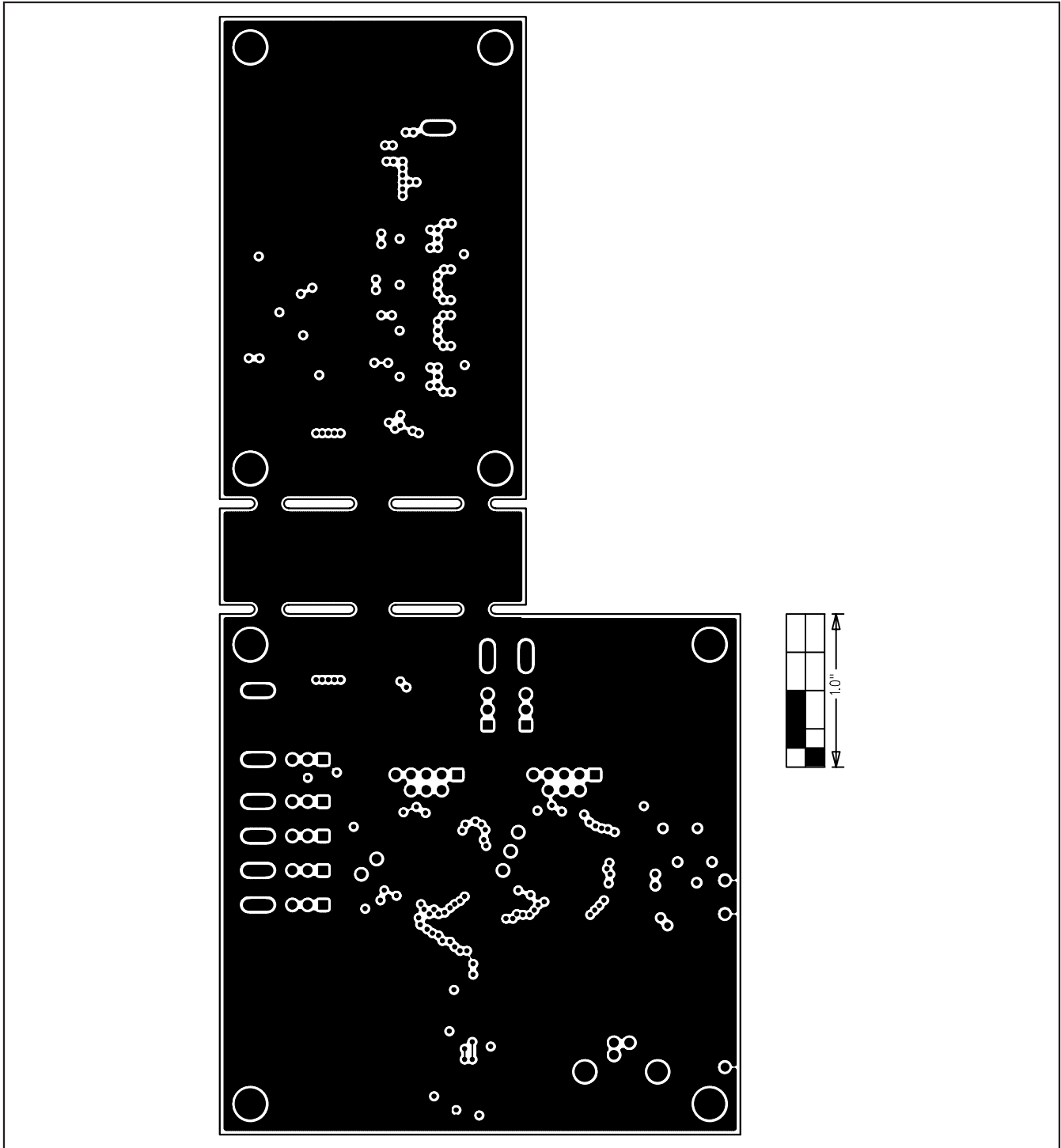


Figure 8. MAX16826 EV Kit PCB Layout—Layer 3

## MAX16826 Evaluation Kit

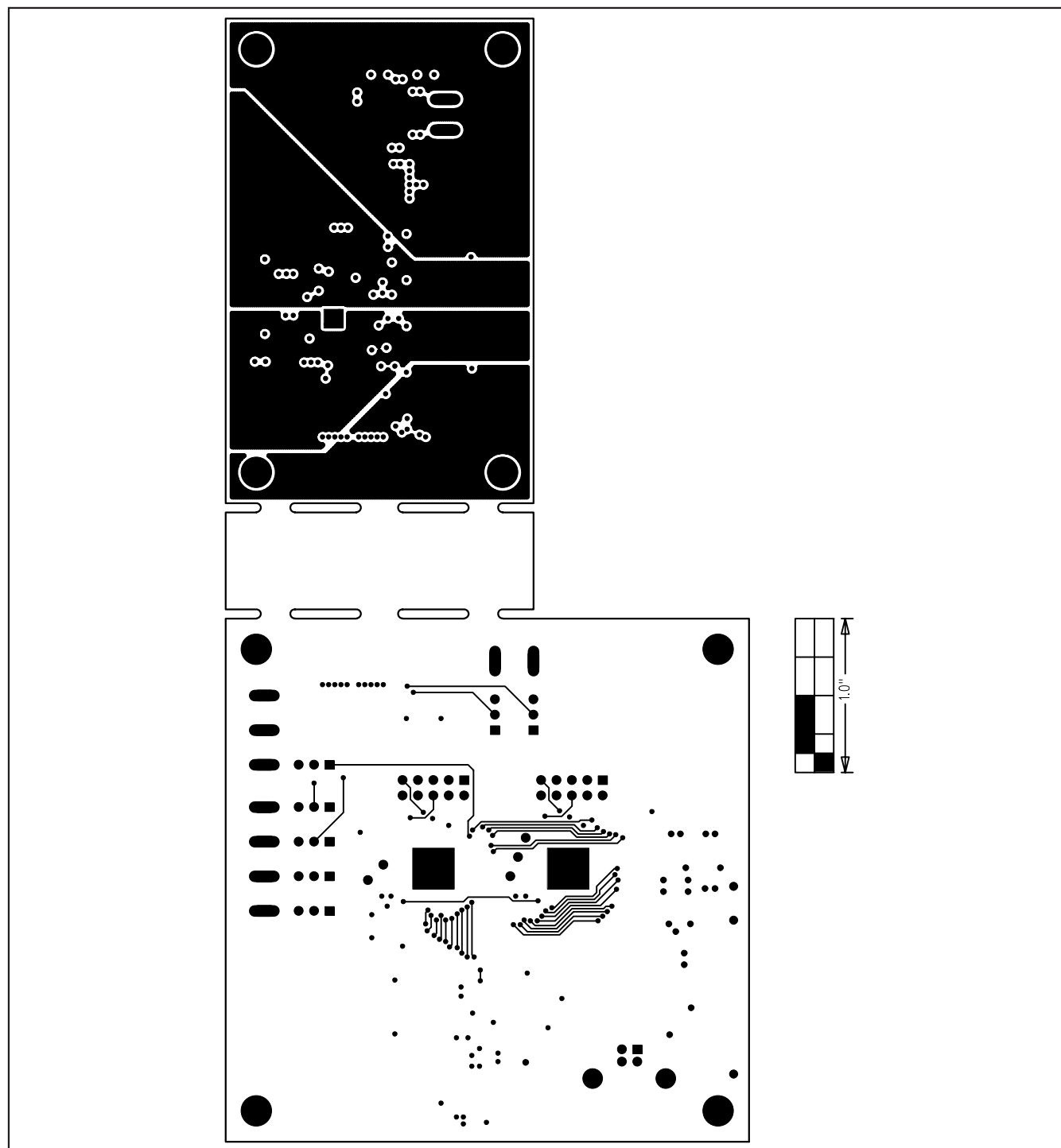


Figure 9. MAX16826 EV Kit PCB Layout—Solder Side

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