TCA7408EVM,TCA5405EVM

This user's guide describes the characteristics, setup and use of the TCA7408EVM/TCA5405EVM Evaluation Module (EVM). This user's guide includes set-up instructions, a schematic diagram, a bill of materials, printed-circuit board layout drawings, software instructions, and operation instructions.

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1 Introduction

The TCA7408-5405EVM is designed to show the used of multiple TI products on a single evaluation board. It shows how the single-wire 5-bit output expander TCA5405 is used to generate LED blinking functions. The Single wire interface is implemented using a single GPIO port on the MSP430, and very simple firmware embedded in the device. The TCA7408 GPIO expander is used to an input handler, that detects Key presses and notifies the MSP430. The EVM also has the TPL0401 that is used for RGB color mixing in conjunction with the TLC59108.

1.1 Features

- Works with MSP430 Launchpad
- Illustrates the use of TPL0401DPOT for color mixing
- TCA7408 used for Key press detection
- Shows the use of Single wire self timed interface in TCA5405
- Color mixing and LED blinking control

1.2 TPL0401A/B

The TPL0401 is an I2C bus controlled, single channel, linear-taper digital potentiometer with 128 wiper positions. TPL0401A/B have an end-to-end resistance of 10k ohms and the low terminal internally connected to ground.

1.3 TCA5405

The TCA5405 is a 5-bit output expander controlled using a single wire input. This device is ideal for portable applications as it has a wide VCC range of 1.65V to 3.6 V. The TCA5405 uses a self-timed serial data protocol with a single data input driven by a master device synchronized to an internal clock of that device.

1.4 TCA7408

This 8-bit I/O expander for the two-line bidirectional bus (I^2C) is designed to provide general-purpose remote I/O expansion via the I^2C interface [serial clock (SCL) and serial data (SDA)]. The major benefit of this device is its wide VCC range. It can operate from 1.65-V to 3.6-V on the GPIO-port side and 1.65-V to 5.5-V on the SDA/SCL side. This allows the TCA7408 to interface with next-generation microprocessors and microcontrollers on the SDA/SCL side, where supply levels are dropping down to conserve power. The TCA7408 open-drain interrupt (INT) output is activated when any GPIO set as an input has a transition to the state opposite of that in the Input Default State register and the corresponding bit in the Interrupt Mask Register is set to 0. It is used to indicate to the system master that an input has changed to a pre-determined state.

1.5 TLC59108

The TLC59108 is an I^2C bus controlled 8-bit LED driver that is optimized for red/green/blue/amber (RGBA) color mixing and backlight application for amusement products. Each LED output has its own 8-bit resolution (256 steps) fixed-frequency individual PWM controller that operates at 97 kHz, with a duty cycle that is adjustable from 0% to 99.6%. The individual PWM controller allows each LED to be set to a specific brightness value. An additional 8-bit resolution group PWM controller has both a fixed frequency of 190 Hz and an adjustable frequency between 24 Hz to once every 10.73 seconds, with a duty cycle that is adjustable from 0% to 99.6%. The group PWM controller dims or blinks all LEDs with the same value. TLC59108 scales up the reference current set by the external resistor (Rext) to sink the output current (Iout) at each output port.

1.6 Requirements

In order to operate this EVM, the following components must be connected and properly configured.

1.6.1 LaunchPad

A Texas Instruments LaunchPad (MSP-EXP430G2) with the male headers and an MSP430G2553 microcontroller installed is required to run the board. A LaunchPad can be acquired here (https://estore.ti.com/MSP-EXP430G2-MSP430-LaunchPad-Value-Line-Development-kit-P2031.aspx)

NOTE: **IMPORTANT:** The code to control the TCA7408EVM/TCA5405EVM was written from an MSP430G2553 and will not work with the MSP430 chips that are included with the LaunchPad kit.

1.6.2 Power Supply (*Optional)

To ensure correct functionality of the LEDs a 5V supply at 300mA is recommended (refer to note in section 2.3.1). If not using a USB cable to power the LaunchPad a 3.3V power supply at 200mA is required.

2 Setup

This section describes the jumpers and connectors on the EVM.

2.1 Connectors and Jumpers

2.1.1 J1 & J2 – LaunchPad Headers

These connectors mate with the male headers on the LaunchPad.

2.1.2 J3 – External LED Power

This connector is where the external +5V supply is attached to power the two RGB LEDs.

2.1.3 J4 – TCA7408 GPIO

This is a pin out of the four unused GPIO pins from the TCA7408, GPIO4-GPIO7.

2.1.4 J5 – Feedback loop

For the TPL0401A to function as a voltage reference circuit the negative feedback loop must be shorted, placing a jumper across this header will short the inverting input to the output.

2.1.5 J6 – LED or Op-amp

This header controls what the TPL0401B is attached to. When shorted across position 1 and 2 the TPL0401B is connected in series with the external resistor to control the current through the LED driver. When shorted across position 2 and 3 the TPL0401B is connected to the inverting input of the op-amp to change the gain of the circuit.

2.1.6 J7 – Op-amp input

This header controls the input to the non-inverting pin of the LMV321. When shorted across position 1 and 2, the TPL0401A in a voltage divider mode is attached to the non-inverting input of the LVM321. This setup is used to test the voltage reference setup. When shorted across pins 2 and 3, the SMA connector is attached to the non-inverting input.

2.1.7 J9 – Test Points

This connector offers test points for the serial data lines, SDA, SCL and the DIN that drives the TCA5405.

Table 1. Description of Connectors and Jumpers

Label	Description
J1, J2	Connectors to interface with LaunchPad
J3	External 5V for LED
J4	GPIO4-GPIO7 from TCA7408
J5	Control jumper to short feedback loop
J6	Jumper to control LED or Op-Amp
J7	Jumper to control input to Op-Amp
J8	SMA/B Footprint for external input
J9	Test points for DIN, SDA and SCL

2.2 Hardware Setup

There are three different modes that the EVM can be used in, LED mode, Voltage reference mode, and Variable gain mode. To setup any of these three modes, begin by connecting the EVM to the LaunchPad. Note the location of the VCC and GND pins on headers J1 and J2 on both the LaunchPad and the EVM to ensure correct installation.

Install a shorting jumper across pins 1 and 2 of J6. Connect an external +5V supply to J3 and either connect the LaunchPad to a computer through USB or connect a 3.3V power supply to J6* on the LaunchPad to power it up.

NOTE: : It can be possible to power up the LEDs by connecting a wire from the VCC pin of J6 on the LaunchPad to the positive pin of J3. A 5V supply might be required because the max voltage drop across the blue LED plus the drop across the TLC59108 is larger than the supply voltage of the LaunchPad.

3 Operation

The TCA5405 will control when D1-D5 light up. TPL0401B is connected in series to the REXT of the TLC59108 LED driver this setup will control D6 and D7. Each color is set to a fixed PWM to ensure baseline brightness is similar. Color mixing is then accomplished through unique methods. The desired current is set by changing the W-L resistance of the TPL0401B and the desired LED is switched on. This repeats for the other colors and then starts over. The LEDs are multiplexed at about 1000 Hz.

After setting up the EVM as described in section 2.3.1, LEDs D1-D5 should be blinking and D6 and D7 will be blue. To increase the speed at which D1-D5 blink press SW1 and to decrease the speed press SW2.

There are 25 different colors that can be created with D6-7 starting with blue and ending with green. To step through the colors from blue to green press S4. To step through the colors from green to blue press S3.

4 MSP430 Code

4.1 TCA5405

Within the source code for the MSP430 there are two different methods to handle sending data to the TCA5405. This section will explain how the TCA5405 functions and how the MSP430G2xx3 code works.

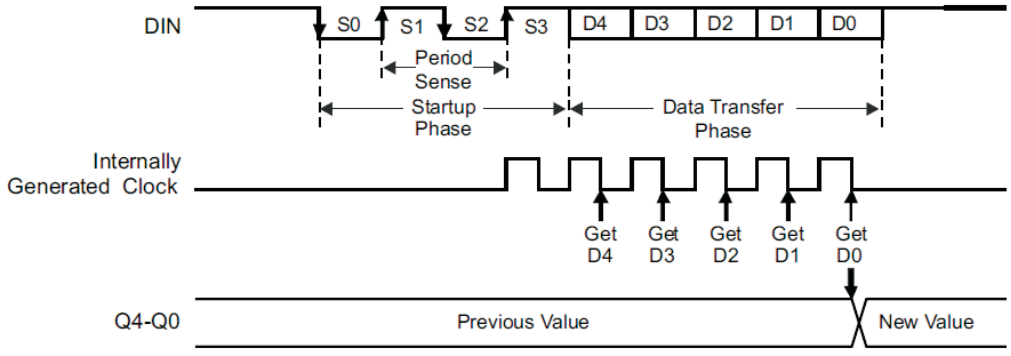

Figure 1. Data Flow for TCA5405

4.1.1 TC5405 Overview

As shown in Figure 1, a ten bit serial transfer is required to set the five outputs on the TCA5405. The first four bits, 0101 (S0-S3), act as a start flag for the TCA5405. S0 is a start bit and S1-S3 are the clock sense bits for the TCA5405. The next five bits (D4-D0) are the data bits associated with each of the outputs. The tenth bit returns the serial line back to high to ready the TCA5405 for the next input.

In the source code there are two methods to handle this communication. These functions are located in Single_Wire.c

1. Use a GPIO (general purpose input/output) and a clock delay to emulate S0-D0.
2. Use one of the MSP430 timers to change the output at a specified bit interval.

4.1.2 bit_bang_TCA5405_byte(unsigned char byte)

The function bi_bang_TCA5405_byte(unsigned char byte) will emulate the required ten bits for communication with the TCA5405. This function works very simply by driving a GPIO pin to high or low and utilizing the _delay_cycles() function to hold the value. After each assert on the GPIO pin a _delay_cycles(16) is called to wait roughly 2 microseconds before the next bit. The section that handles the data bits (D4-D0) only uses a _delay_cycles(10) function; this is to adjust for the time spent on if statements.

4.1.3 send_TCA5405_byte

The function send_TCA5405_byte(unsigned char byte) along with 5405_Timer_ISR() implements the required serial data by using one of the MSP430 timers. When a byte is sent to send_TCA5405_byte(), the function adds the start flag (S0-S3) to the beginning and the stop bit (1) to the end (LSB), stores the new value to a global variable, and enables the timer interrupts. After a set number of clock cycles defined by NEXT_BIT_TIME, 5405_Timer_ISR() is called and adjusts the output of the P2.0 accordingly.

NOTE: The start flag S0-S3 is hard coded into each of these methods

5 Schematics, Layout, and Bill of Materials

5.1 Schematics

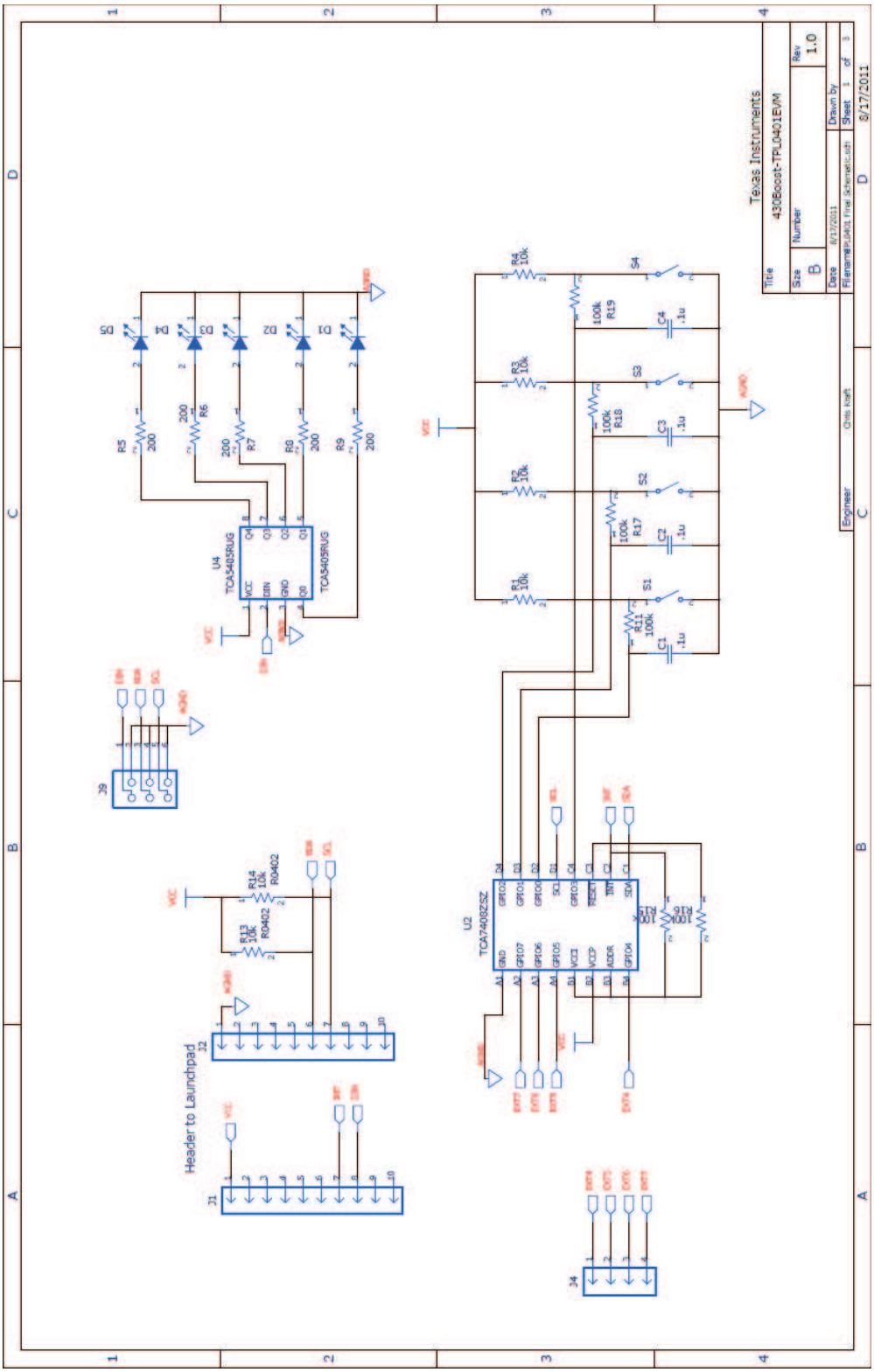

Figure 2. TCA5405, TCA7408 Schematic

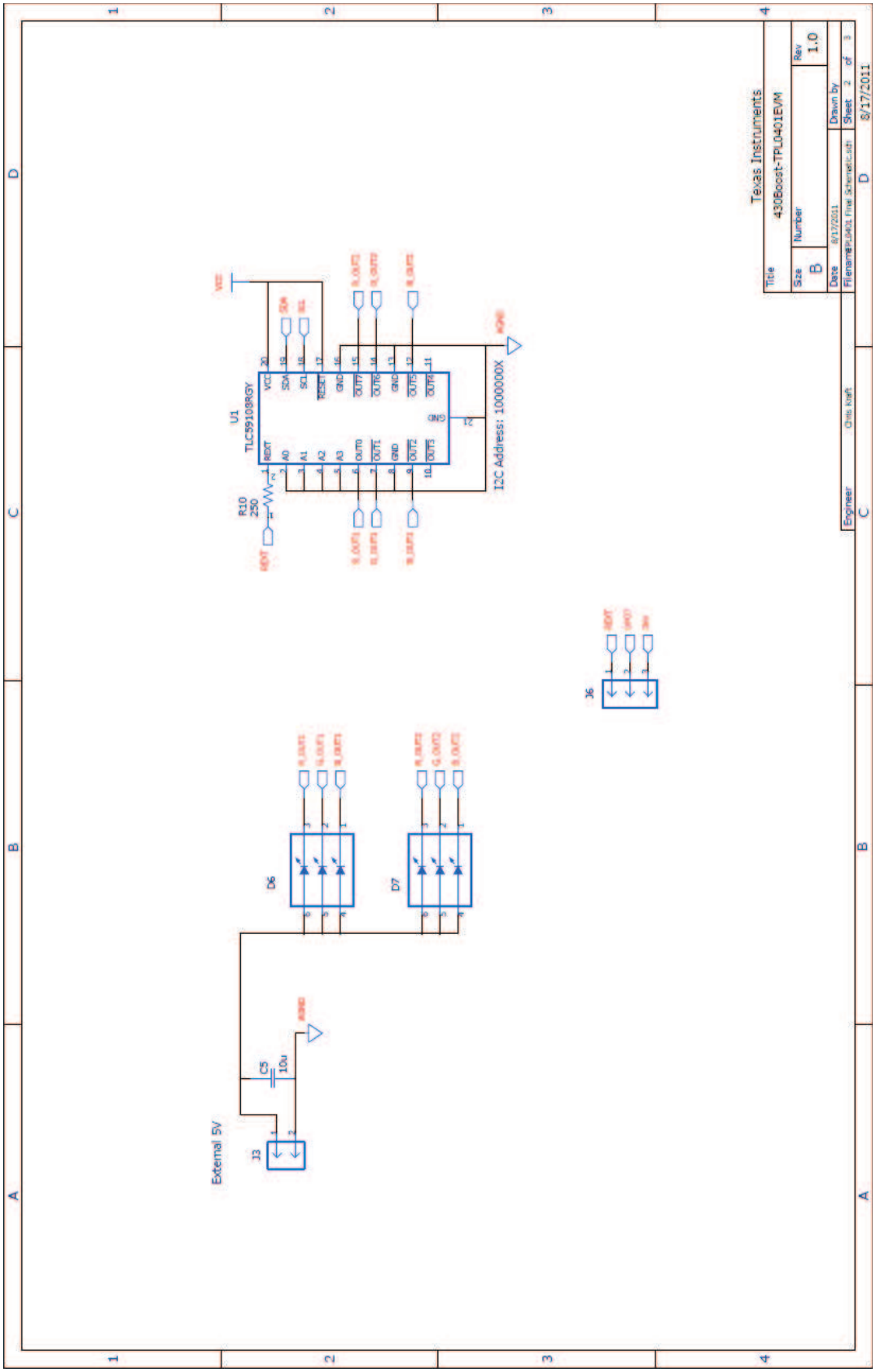

Figure 3. TLC59108 Schematic

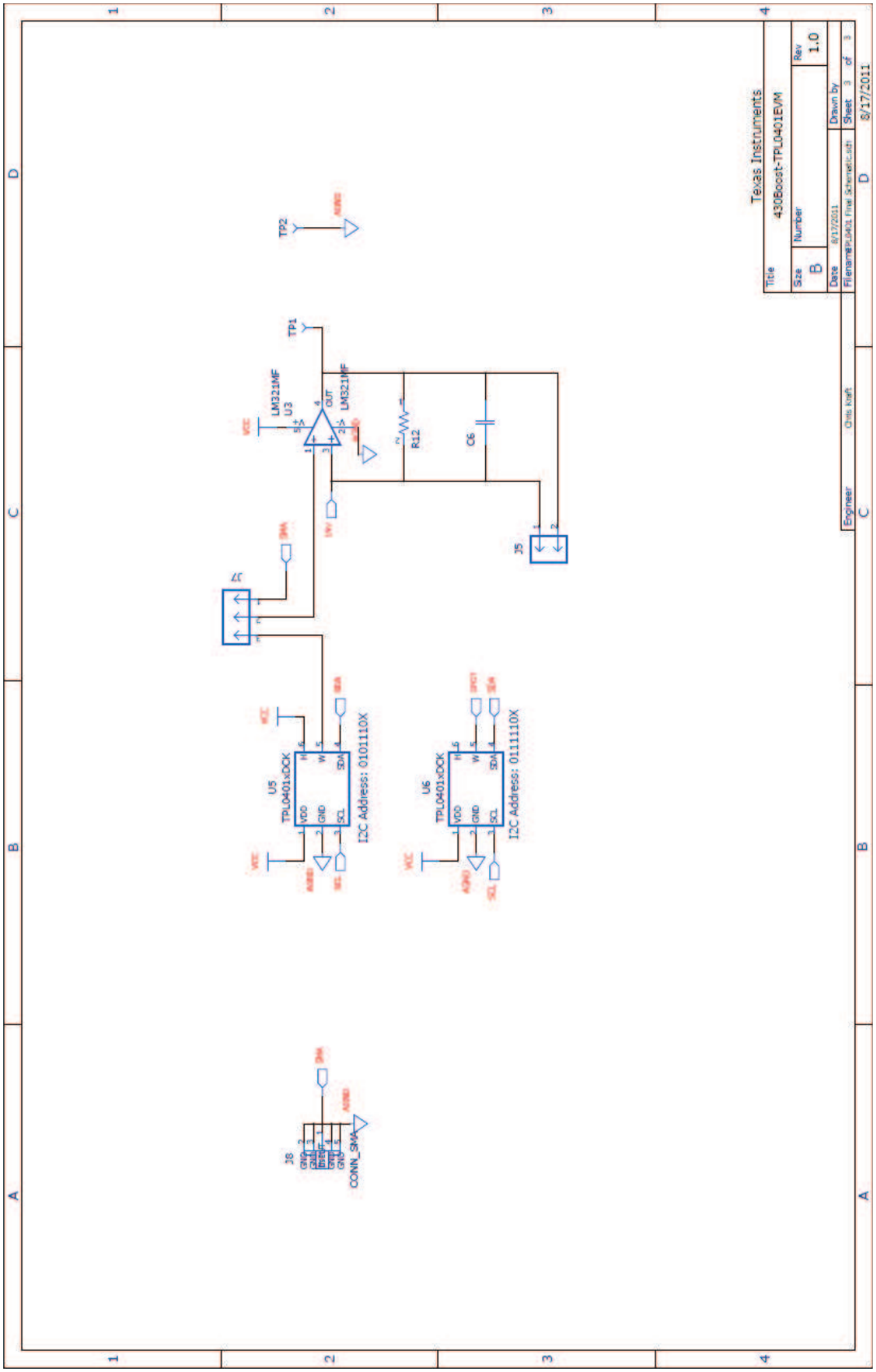

Figure 4. TPL0401 Schematic

5.2 Layout

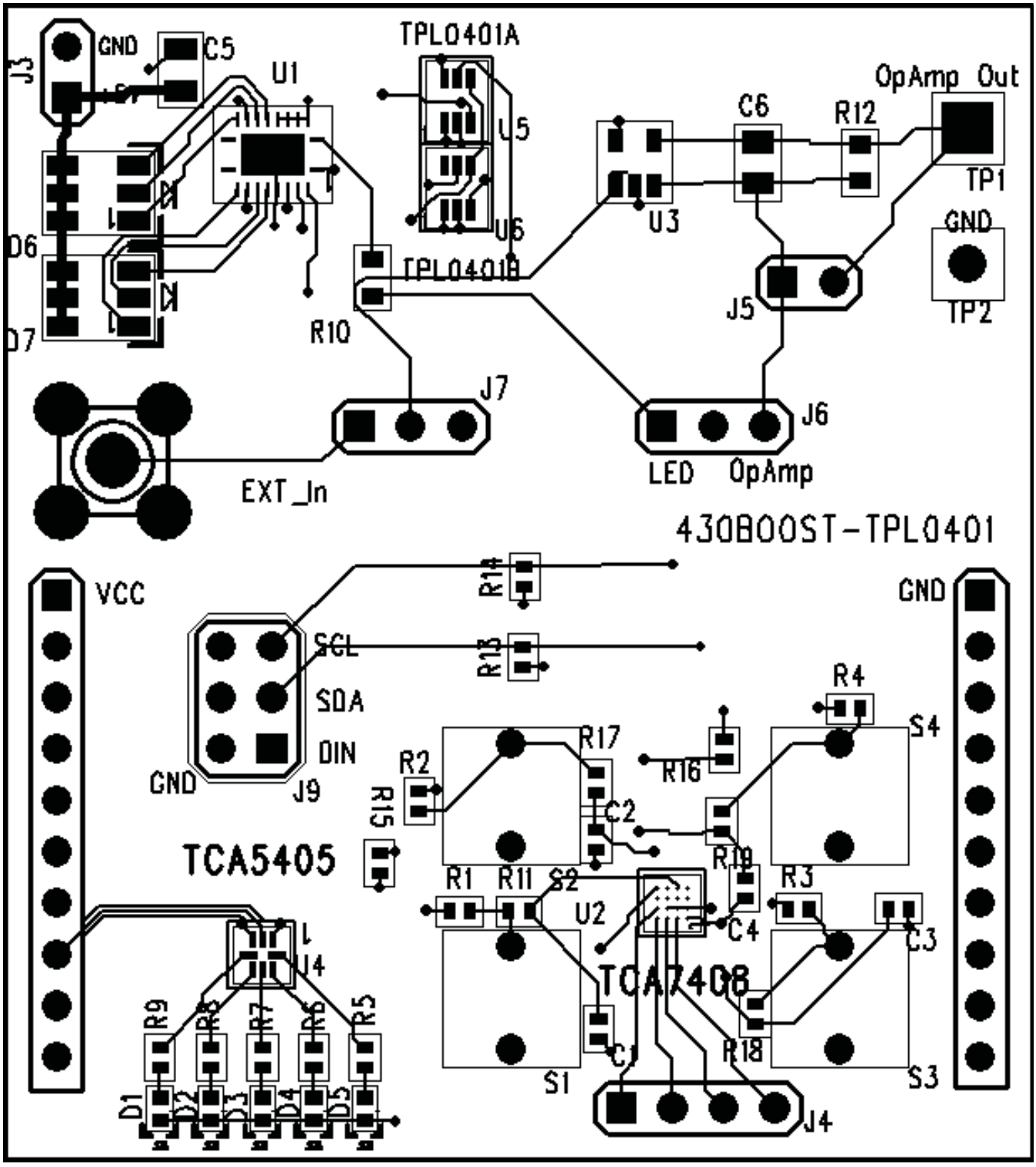

Figure 5. Routing, Assembly and Silkscreen Top

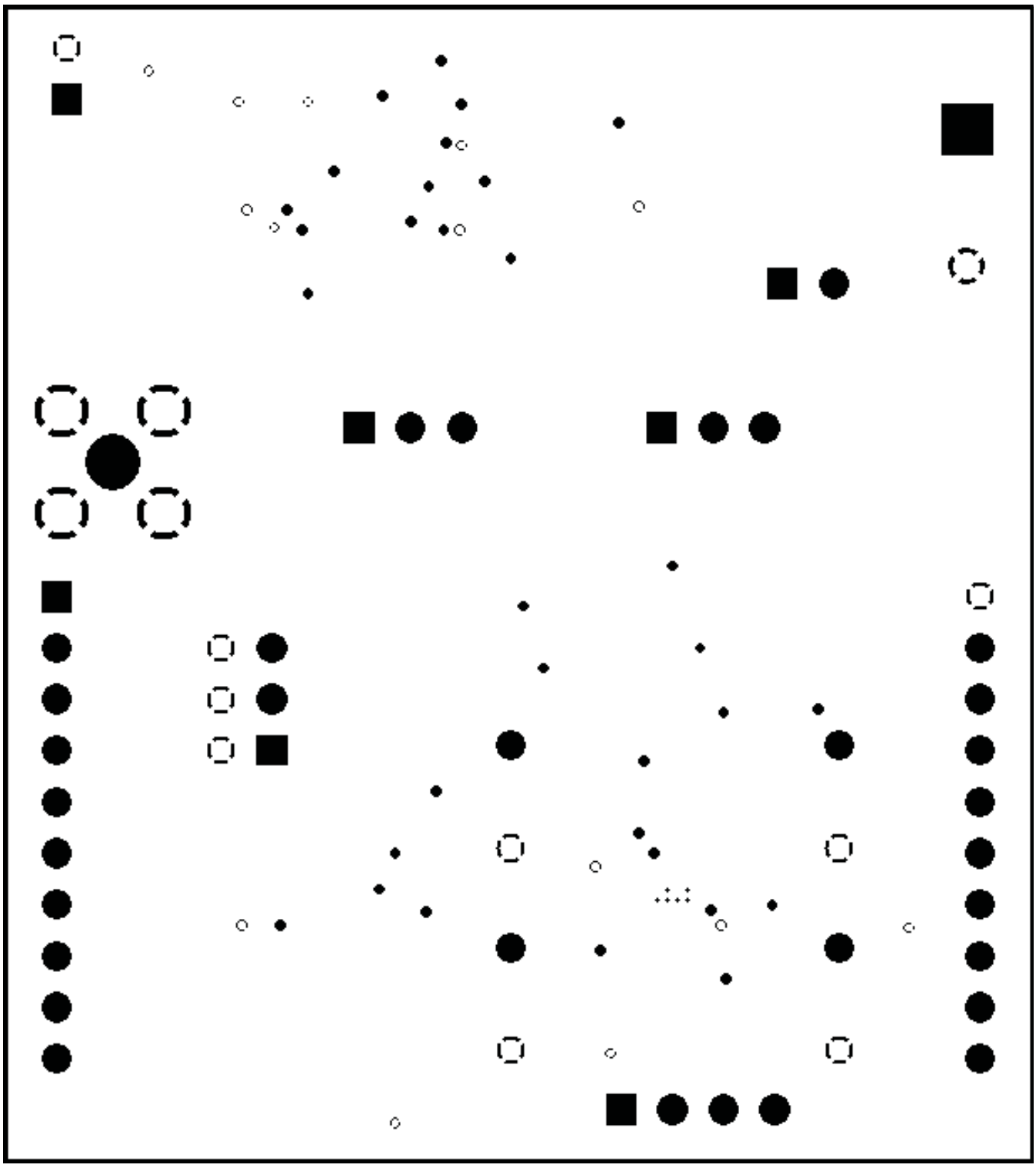

Figure 6. Layer 2 Power Plane

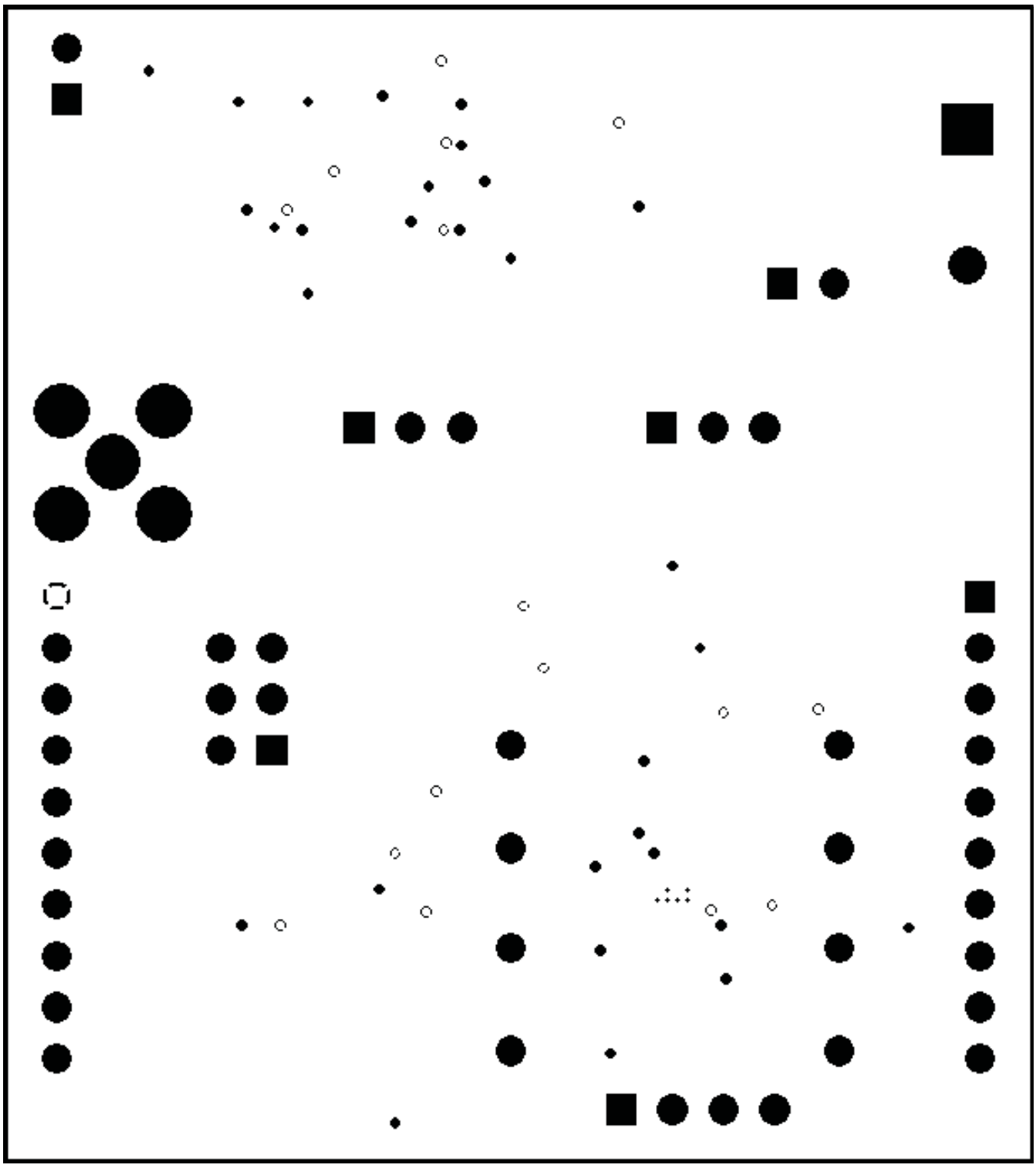

Figure 7. Layer 3 Ground Plane

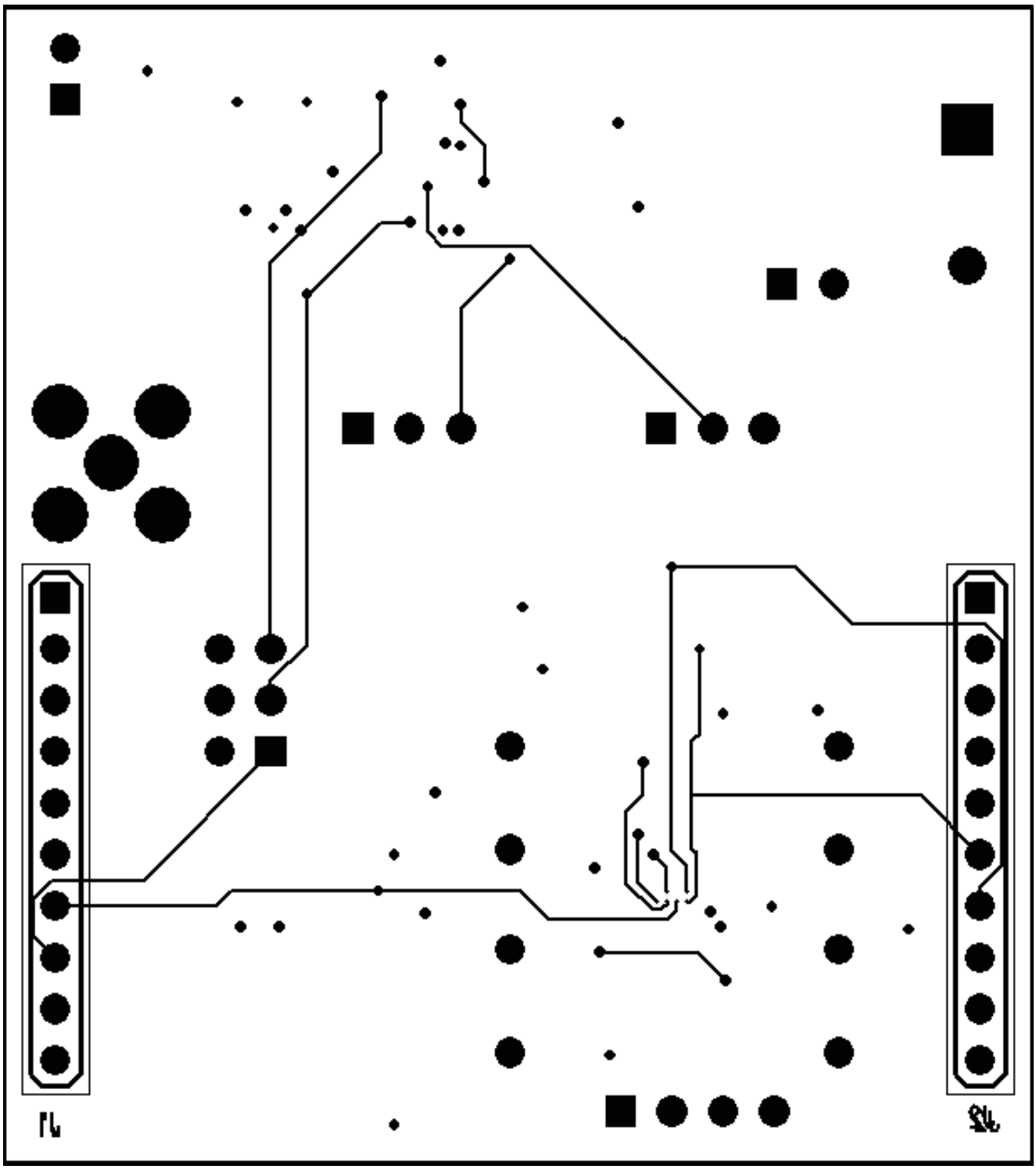

Figure 8. Routing and Assembly Bottom

5.3 Bill of Materials

Table 2. TCA7408EVM/TCA5405EVM Bill of Material

Qty	RefDes	Value	Description	Part Number	MFG	Notes
4	C1-4	0.1µ	Capacitor, Ceramic			
1	C5	10µ	Capacitor, Ceramic			
1	C6		Capacitor, Ceramic			DNI
1	J8		Connector, SMA , Straight, PC mount	901-144-8RFX	AMP	DNI
5	D1-5	SML-P12PTT86	Diode, LED, GREEN 2.2V 20mA	SML-P12PTT86	ROHM	
2	D6-7	APF3236SURKZGQBDC	LED SMD TRI Color	APF3236SURKZGQBDC	Kingbright	
2	J3 J5		Header, Male 2-pin, 100mil spacing		Sullins	
2	J6-7		Header, Male 3-pin, 100mil spacing		Sullins	
1	J4		Header, Male 4-pin, 100mil spacing		Sullins	
2	J1-2	PPTC101LFBN-RC	Header, Female 10-pin, 100mil spacing	PPTC101LFBN-RC	Sullins	
1	J9		Header, Male 2x3-pin, 100mil spacing		Sullins	DNI
2	R15-16	100k	Resistor, Chip, 1/16W 5%			
10	R1-R4 R11 R13-R14 R17-R19	10k	Resistor, Chip, 1/16W 5%			
5	R5-9	200	Resistor, Chip, 1/16W 1%			
1	R10	250	Resistor, Chip, 1/16W, 1%			
1	R12	{value}	Resistor, Chip, 1/16W, 5%			DNI
1	TP2	5001	Test Point, Black, Thru Hole Color Keyed	5001	Keystone	
1	TP1	5013	Test Point, Orange, Thru Hole	5013	Keystone	
4	S1-4	EVQ221304M	Switch, SPST, 20-mA, 15-V	EVQ21304M; EVQ21305R; EVQ21307K	Panasonic	Prefer EVQ21304M if unavailable use 305R or 307K
1	U3	LMV321IDBVR	IC Low Power Single Op-amp	LMV321IDBVR	TI	
1	U4	TCA5405RUG	IC, Low Voltage 5-Bit Self-Timed, Single-Wire Output Expander	TCA5405RUG	TI	
1	U2	TCA7408ZSZ	IC, Low-Voltage 8-Bit I2C and SMBus I/O Expander	TCA7408ZSZ	TI	
1	U1	TLC59108RGY	IC, 8-BIT Fm+ I2C-Bus Constant-Current LED Sink Driver	TLC59108RGY	TI	
1	U5	TPL0401ADCK	IC, Digital POT, 1Chan, 128Tap	TPL0401ADCK	TI	
1	U6	TPL0401BDCK	IC, Digital POT, 1Chan, 128Tap	TPL0401BDCK	TI	

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