TEXAS INSTRUMENTS

bq2400x Single- and Two-Cell Li-Ion Charge-Management IC With Integrated Power FET EVM

User's Guide

July 2002

Advanced Analog Products

SLUU083A

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Preface

Read This First

About This Manual

This user's guide describes the bq2400x evaluation module. The EVM conveniently evaluates a linear Li-ion bq2400x charge-management solution for one- and two-cell battery-pack applications. This guide describes a complete designed-and-tested charger, which delivers up to 1.2 A of continuous-charge current for one- or two-cell applications

How to Use This Manual

This document contains the following chapters:

- ❏ Chapter 1—Introduction
- ❏ Chapter 2—Test Summary
- ❏ Chapter 3—Physical Layouts
- ❏ Chapter 4—Bill of Materials
- ❏ Appendix A—Schematic

Related Documentation From Texas Instruments

- ❏ bq24001, bq24002, bq24003 data sheet, literature number SLUS462A
- ❏ bq24004, bq24005, bq24006 data sheet, literature number SLUS476

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Chapter 1

Introduction

This user's guide describes the bq2400x Evaluation Module (SLUP051). The EVM conveniently evaluates a linear Li-ion bq2400x charge-management solution for one- and two-cell battery-pack applications. This guide describes a complete designed-and-tested charger, which delivers up to 1.0 A of continuous-charge current for one- or two-cell applications.

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1.1 Background

The bq2400x series ICs are advanced Li-Ion linear charge management devices for highly integrated and space-limited applications. They combine high-accuracy current and voltage regulation; FET pass-transistor and reverse-blocking Schottky; battery conditioning, temperature, or input-power monitoring; charge termination; charge-status indication; and charge timer in a small, 20-lead TSSOP PowerPAD package.

The bq2400x continuously measures battery temperature using an external thermistor. For safety reasons, the bq2400x inhibits charge until the battery temperature is within the user-defined thresholds. Alternatively, the user can monitor the input voltage to qualify charge. The bq2400x series then charge the battery in three phases: preconditioning, constant current and constant voltage. If the battery voltage is below the internal low-voltage threshold, the bq2400x uses trickle-charge to condition the battery. A preconditioning timer is provided for additional safety. Following preconditioning, the bq2400x applies a constant-charge current to the battery. An external sense-resistor sets the magnitude of the current. The constant-current phase is maintained until the battery reaches the charge-regulation voltage. The bq2400x then transitions to the constant voltage phase. The user can configure the device for cells with either coke or graphite anodes.

Charge is terminated by either of the following methods:

- ❏ Maximum time
- ❏ Minimum current detection

1.2 Performance Specification Summary

This section summarizes the performance specifications of the SLUP051 EVM. Table 1–1 gives the performance specifications of the hubs.

The bq2400x automatically restarts the charge if the battery voltage falls below an internal recharge threshold.

Table 1–1. Performance Specification Summary (One Cell)

Specification		Test Conditions	Min	Typ	Max	Units
Input dc voltage, V_{DC}			4.9	5.0	†	V
Battery charge current, I_{CHG}		J4 shorted, J3 open	0.4	0.5	0.6	A
		J3 shorted, J4 open	0.9	1	1.1	
Battery voltage regulation, V_{REG}		J6 set to V_{CC}	4.15	4.20	4.25	V
		J6 set to GND	4.05	4.1	4.15	
Therm fault	High, T_{BATMAX}	J2 set to Therm	43	48	53	°C
	Low, T_{BATMIN}	J2 set to Therm	0	5	10	
APG (user defined, see data sheet)		J2 set to APG		‡		
Power dissipation, P_D		$(V_I\text{-}V_O) \times I_{load}$			2.3	W

† V_I, for a single-cell, should not exceed 5.3 VDC for the 1-A charge rate and 7.6 V for the 0.5-A charge rate. (V_I is the input voltage to the bq2400x IC, pins 2 and 3. The power supply source voltage, at J1, is 0.1 V larger than V_I because of the regulated voltage drop across the current sense resistor, during constant current regulation.)

‡ If J2 is set to APG, then the chip will be disabled when the input is outside of this range: 4.02 V±0.07 V and 10.76 V ±0.09 V.

Table 1–2. Performance Specification Summary (Two Cell)

Specification		Test Conditions	Min	Typ	Max	Units
Input dc voltage, V_{DC}			9.1	9.5	†	V
Battery charge current, I_{CHG}		J4 shorted, J3 open	0.4	0.5	0.6	A
		J3 shorted, J4 open	0.9	1	1.1	
Battery voltage regulation, V_{REG}		J6 set to V_{CC}	8.35	8.40	8.45	V
		J6 set to GND	8.15	8.20	8.25	
Therm fault	High, T_{BATMAX}	J2 set to Therm	43	48	53	°C
	Low, T_{BATMIN}	J2 set to Therm	0	5	10	
APG (user defined, see data sheet)		J2 set to APG		‡		
Power dissipation, P_D		$(V_I\text{-}V_O) \times I_{load}$			2.3	W

† V_I, for a 2-cell, should not exceed 9.1 VDC for the 1-A charge rate and 10.6 V for the 0.5-A charge rate. (V_I is the input voltage to the bq2400x IC, pins 2 and 3. The power supply source voltage, at J1, is 0.1 V larger than V_I because of the regulated voltage drop across the current sense resistor, during constant current regulation.)

‡ If J2 is set to APG, then the chip will be disabled when the input is outside of this range: 4.02 V±0.07 V and 10.76 V ±0.09 V.

Chapter 2

Test Summary

This chapter shows the test setups used, and the tests performed, in designing the bq2400xEVM.

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2.1 Setup

The bq2400X EVM board requires a DC power source to provide input power and a single-cell lithium-ion or lithium-polymer battery to charge.

Note:

Other versions of the bq2400x IC can charge two-cell battery packs.

The test setup connections and jumper setting selections are listed below.

2.1.1 I/O Connections

Jack	Connect to:
J1–VCC	Power source positive output
J1–GND	Power source negative output
J9–+	Positive lead of single lithium cell
J9– –	Negative lead of single lithium cell
J9 – VSENSE	Tie to battery's positive terminal
J10 – THERM	Tie to thermistor lead in battery pack
J10 – GND	Tie to other thermistor lead (may be GND)

2.1.2 Jumper-Selectable Configuration

Jumper	Selection
J3	1-A charge, use two jumpers placed horizontally; no jumpers on J4
J4	0.5-A charge, use two jumpers placed horizontally, no jumpers on J3
J2	Adapter power good (APD) or battery's thermistor
J5†	Enable, on or off
J6	Regulation voltage, 4.2 V or 4.1 V (single cell), 8.4 V or 8.2 V (double cell)
J7	Timer, 3-hour (float, no jumper), 4.5-hour, or 6-hour
J8	Stat2 green diode, connect for bq24002/3/5/6/8‡

† This jumper enables/disables the IC for bq24001/2/3/4/5/6. For bq24007/8, this jumper enables/disables the change timer.

‡ For bq24003/6/8 the evaluation board used two LED (red and green) in place of a single dull-color LED. Therefore, when both LEDs are lit a yellow status is indicated.

2.2 Test Procedures

2.2.1 For Single-Cell Applications

Set up the evaluation board as described above, by making the necessary I/O connections and jumper selections.

Note:

Before test and evaluation, it is important to verify that the maximum power dissipation on the IC is not exceeded. Pmax = 2.3 W.

$$P_{diss,\ single\ cell} = (V_I - 3\ V) \times I_{CHG} \qquad \text{where } V_I = V_{CC} - 0.1\ V$$

Note:

V_I for a single cell should not exceed 5.3 VDC for the 1-A charge rate and 7.6 V for the .5-A charge rate.

Adjust the input power supply for 5 V. The red LED should illuminate to indicate charging, unless there is a fault or the battery is fully charged.

The bq2400x enters preconditioning mode if the battery is below the LowV threshold. In this mode, the bq2400x trickle-charges with approximately 65 mA for approximately 23 minutes. If the battery does not reach the LowV threshold after this period, then the charge current is terminated and the bq2400x enters fault mode. The red LED flashes when in fault mode. This feature may be tested in the .5-A charge mode by using a 5-Ω, 3-W resistor in place of the battery. Fault mode is reset by toggling input power or enable pin.

Once the battery charges to the LowV-stop threshold, the battery enters fast charge mode and charges at the selected I_{CHG} level (0.5-1 A).

The battery remains at the fast-charge mode until either the selected time expires or the battery charges to the selected regulation voltage.

The time-out feature may be tested in the 0.5-A charge mode by using a 7 Ω, 3-W resistor in place of the battery. Apply the resistor after the unit is powered.

If the battery discharges down to the HighV threshold, the charger starts fast charging. The refresh feature may be tested in the 0.5-A charge mode by using a 7-Ω, 3-W resistor in parallel with a fully charged battery.

The circuit has an overvoltage comparator for added protection. If the battery voltage exceeds this threshold for 330 ms, then the charger goes into fault mode. This may be tested by connecting an external power supply in place of the battery and adjusting the voltage above the threshold.

2.2.2 For Two-Cell Applications

Set up the evaluation board as described above, by making the necessary I/O connections and jumper selections.

Note:

Before test and evaluation, it is important to verify that the maximum power dissipation on the IC is not exceeded. P_{max} = 2.3 W.

$$P_{diss,\ 2\ cell} = (V_I - 6.8\ V) \times I_{CHG} \qquad \text{where } V_I = V_{CC} - 0.1\ V$$

Note:

With a two-cell battery pack at 6 V, charging at 1 A, the IC power dissipation is temporarily as high as 3.1 W until the pack charges to 6.8 V. This condition is acceptable for the short time before the pack reaches 6.8 V.

Adjust the input power supply for 9.1 V. The red LED should illuminate to indicate charging, unless there is a fault or the battery is fully charged.

The bq2400x enters preconditioning mode if the battery is below the LowV threshold. In this mode, the bq2400x trickle-charges with approximately 65 mA for approximately 23 minutes. If the battery does not reach the LowV threshold after this period, then the charge current is terminated and the bq2400x enters fault mode. The red LED flashes in fault mode. This feature is tested in the 0.5-A charge mode by using a 10-Ω, 5-W resistor in place of the battery. Fault mode is reset by toggling input power or enable pin.

Once the battery charges to the LowV-stop threshold, the battery enters fast charge mode and charges at the selected Ichg level (0.5 A/1 A).

The battery remains at the fast charge mode until either the selected time expires or the battery charges to the selected regulation voltage.

The timeout feature is tested in the 0.5-A charge mode by using a 14-Ω, 5-W resistor in place of the battery. Apply the resistor after the unit is powered up.

Once the battery voltage reaches voltage regulation (8.2 or 8.4 VDC), the charge current tapers off as the battery charges.

If the battery discharges down to the HighV threshold, the charger starts fast charging. The refresh feature is tested, in the 0.5-A charge mode, by using a 14-Ω 5-W resistor in parallel with a fully charged battery.

The circuit has an overvoltage comparator for added protection. If the battery voltage exceeds this threshold for 330 ms, then the charger goes into fault mode. This process may be tested by connecting an external power supply in place of the battery and adjusting the voltage above the threshold.

Chapter 3

Physical Layouts

This chapter contains the board layout and assembly drawings for the SLUP051 EVM.

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3.1 Board Layout

Figure 3-1 shows the top layer of the SLUP051. Figure 3-2 shows the bottom layer. Figure 3-3 shows the SLUP051 top assembly view.

Figure 3–1. SLUP051 Board Layout Top Layer

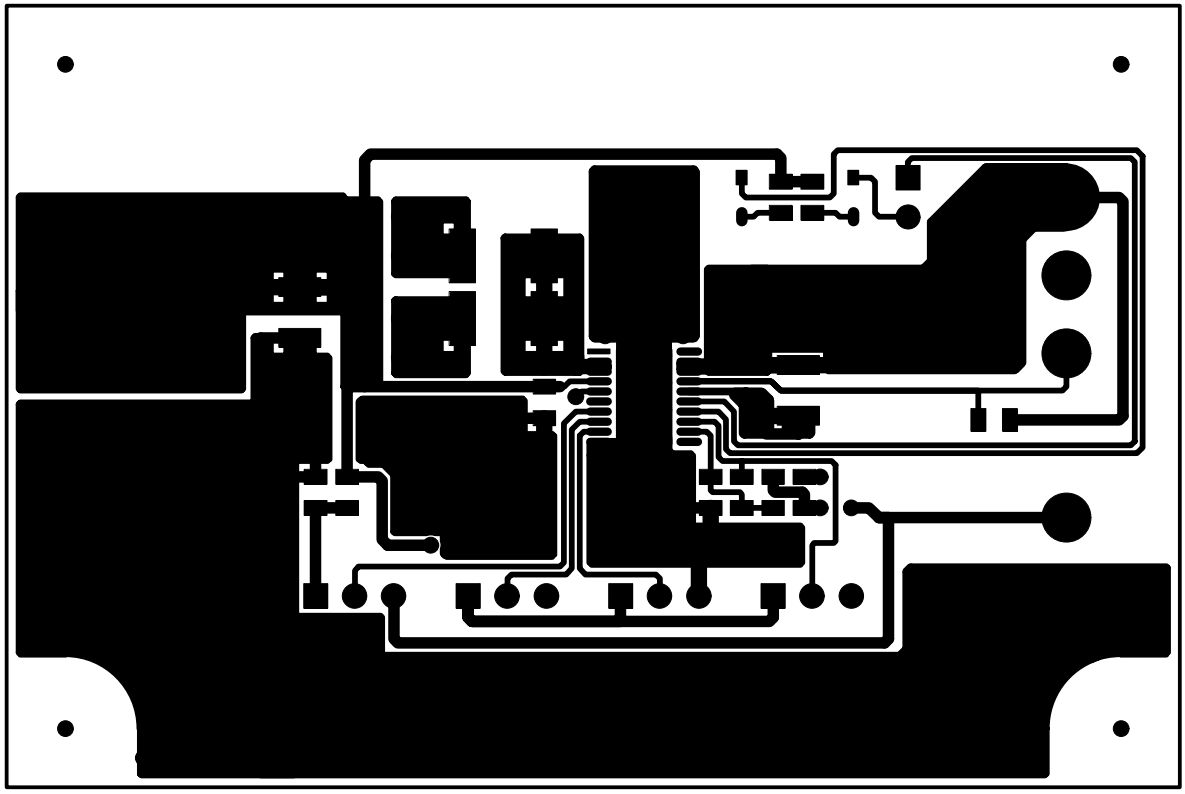


Figure 3–2. SLUP051 Board Layout Bottom Layer

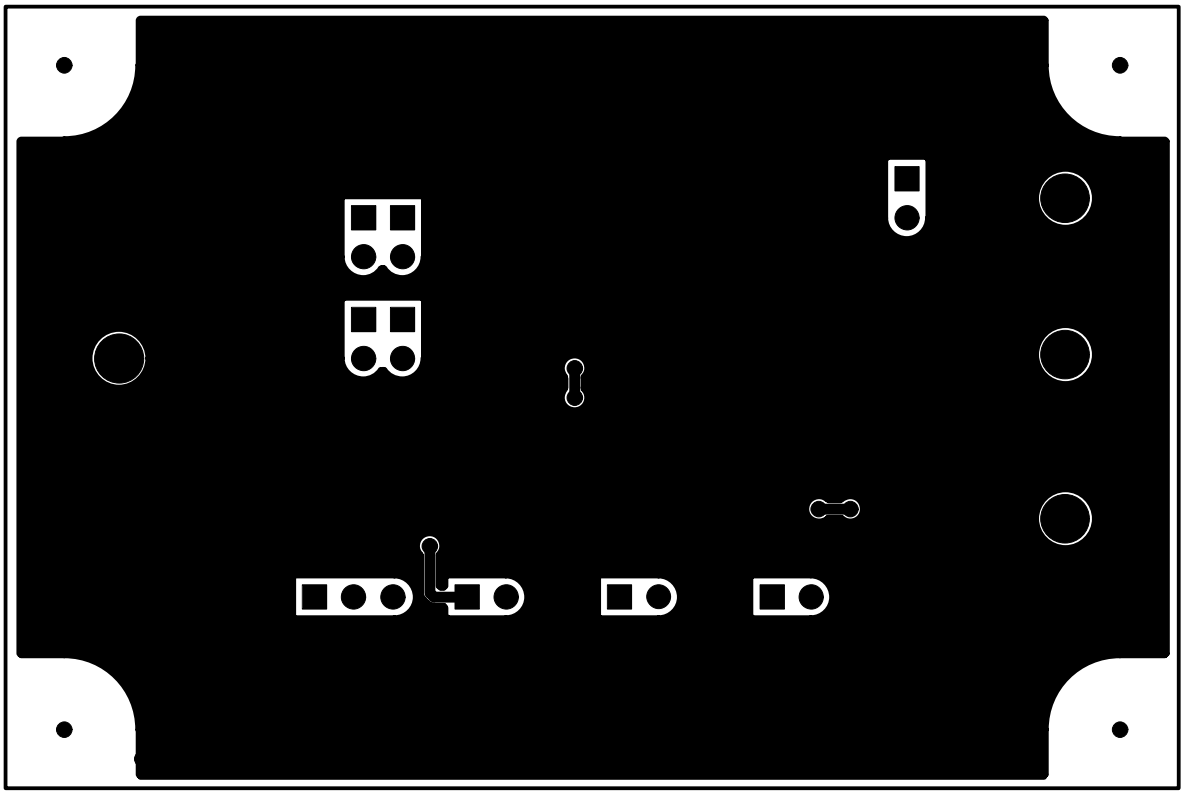
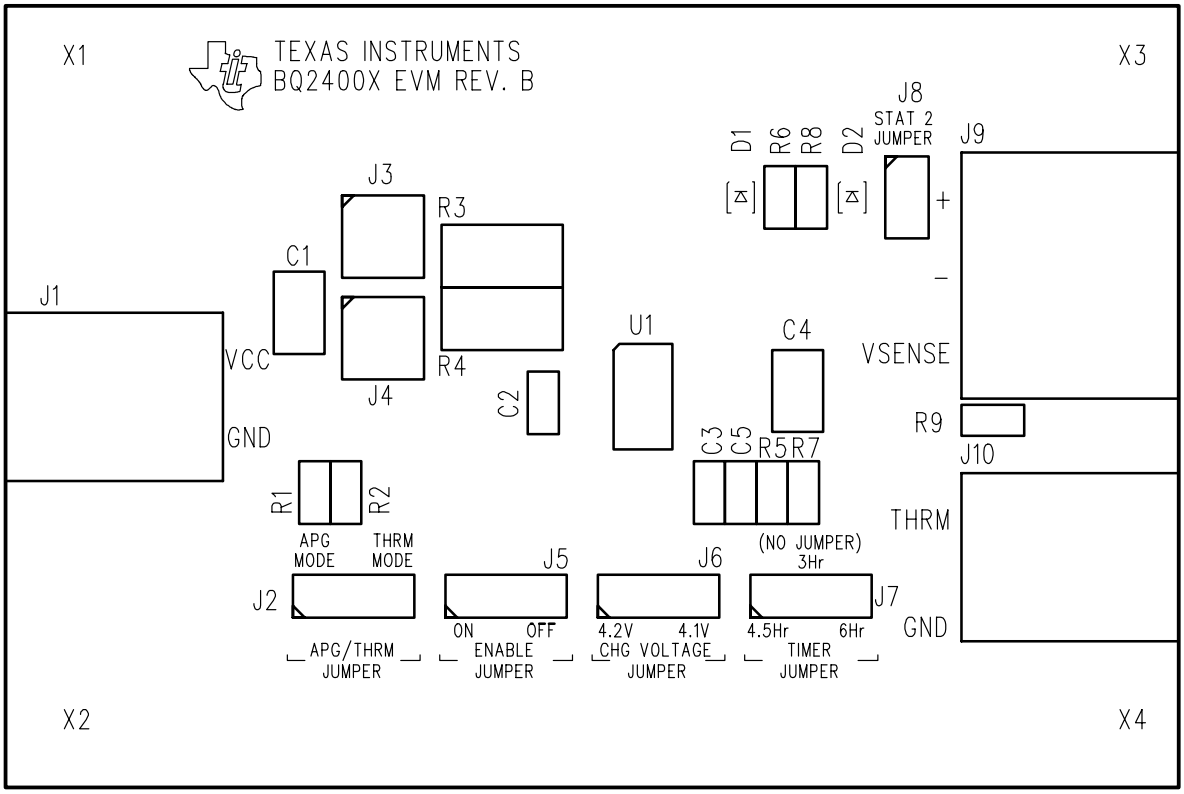


Figure 3–3. SLUP051 Top Assembly View



Chapter 4

Bill of Materials

This chapter contains the bill of materials required for the SLUP051 EVM. It also specifies the charge status configurations for the bq2400x.

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4.1 Bill of Materials

Table 4-1 lists materials required for the SLUP051 EVM.

Table 4–1. SLUP051 Bill of Materials

Qty	Reference Designator	Part Number	Description	MFG	Size
2	C1, C4	TAJC106M016R	Capacitor, 10 μF tantalum, 16 V, ±20%, 6032	AVX-Future	1210
1	C2	C0805X7R250-104KNE	Capacitor, 0.1 μF ceramic, X7R, 25 V, ±10%, 805	Venkel	805
1	C3	ECJ-2YB1E224K	Capacitor, 0.22 μF ceramic, X7R, 25 V, ±10%, 0805	Panasonic	805
1	C5	ECJ-2VCH100F	Capacitor, 10 pF ceramic, NPO, 50 V, ±10%, 0805	Panasonic	805
1	D1	LN1361C(UY)-(TR)	LED, green, GW type	Panasonic	
	D2	LN1261CAL-(TR)	LED, red, GW type	Panasonic	
2	J1, J10	AKZ500/2WP	Terminal block, 2 pin	Altech	
4	J2, J5-J7	2340-6111TG	Pin strip header, 3 pin	3M	
5	J3a/b, J4a/b,J8	2380-6221TG	Pin strip header, 2 pin	3M	
1	J9	ED350/3 (ED1610-ND)	Terminal block, 3-pin	On shore	
1	R1	CR0805-105113F	Resistor, 51.1 kΩ, 1%, 1/10W, see Note 1	Venkel	805
1	R2	CR0805-10W3163JT	Resistor, 316 Ω, 1%, 1/10W, see Note 1	Venkel	805
1	R3	LR2512-01-R100-G	Resistor, 0.10 Ω, 2%, 1W	IRC	2512
1	R4	LR2512-01-R200-G	Resistor, 0.20 Ω, 2%, 1W	IRC	2512
1	R5	CR0805-10W1872F	Resistor, 18.7 kΩ, 1%, 1/10W, see Note 1	Venkel	805
2	R6, R8 (see Note 3)	CR0805-10W5110F	Resistor, 511 Ω, 1%, 1/10W, see Note 1	Venkel	805
1	R7	CR0805-10W9532F	Resistor, 95.3 kΩ, 1%, 1/10W, see Note 1	Venkel	805
1	R9	CR0805-10W1000F	Resistor, 100 Ω, 1%, 1/10W, see Note 1	Venkel	805
1	U1	bq2400x (see Note 2)	Battery charger, linear, lithium-ion	TI	HTSSOP-20
1	PWB	bq2400x EVM REV B	PWB, bq2400x EVM REV B	TI	

Notes: 1) 5% tolerance rsistors may be used in place of 1% resistors if the application allows for it.

2) See Table 4.2 for 2400x charge stuatus configuration.

3) For bq24004/5/6 resistor value should be 1K.

4.2 bq2400x Charge Status Configurations

Table 4–2 lists the charge status configurations for the bq2400x.

Table 4–2. Charge Status Configurations

Part Number	Number of Cells	Charge Status Configuration
bq24001	Single cell	Single LED
bq24002	Single cell	2 LED
bq24003	Single cell	Bicolor LED
bq24004	Two cell	Single LED
bq24005	Two cell	2 LED
bq24006	Two cell	Bicolor LED
bq24007	Single cell	Single LED
bq24008	Single cell	Bicolor LED

Appendix A

Schematic

This chapter contains the schematic diagram for the EVM.

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REVISIONS				
LTR	ZONE	DESCRIPTION	DATE	APPROVED
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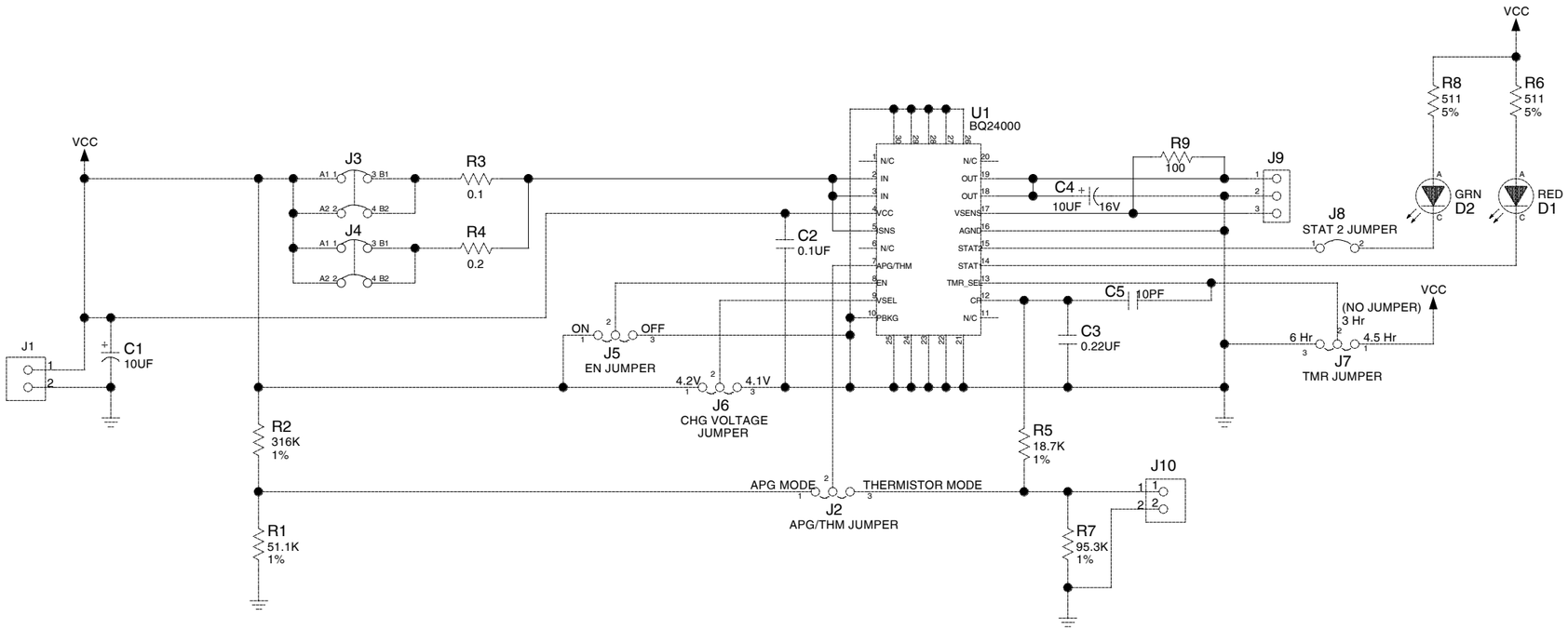

				TEXAS INSTRUMENTS
		DRAWN S. MCGEE	DATE 05/23/2000	TITLE SCHEMATIC BQ2400X EVM
		ENGR		
		CHK		
NEXT ASSY	USED ON	RELEASE		SIZE C / CODE / DRAWING NO: BQ2400X / REV: D
APPLICATION		FILE NAME:		SCALE: NONE / DRAWING DATE 01/11/2001 / SHEET 1 OF1