## Application Note **BQ** 产品入门指南

# TEXAS INSTRUMENTS

#### 摘要

TI 的电池管理器件以前缀 BQ 作为标识符。具体来说,电量监测计产品分为单电芯、多电芯和专用产品类别。根据命名规则,BQ27xxx 面向 CEDV 和传统的单电芯电池,而 BQ27Zxx 面向当前的单电芯电池。BQ20Z、30Z 和 40Z 面向采用 Impedance Track 技术的多电芯电池,而 BQ20xx、30xx 和 40xx 面向采用 CEDV 的多电芯电池。 多电芯电量监测计用于笔记本电脑、医疗应用和工业应用。示例包括电脑、无人机和电器。

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商标	

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## 1 如何开始使用 BQ 电量监测计产品

#### 1.1 开始使用时所需的项目

- 电量监测计 EVM
- EV2400 通信接口适配器
- 用于连接 EVM 与 EV2400 通信接口适配器的电缆
- 用于连接通信接口适配器与计算机的 USB 电缆。
- 装有 Windows XP 或更高版本操作系统的计算机。
- 电池电芯,或者如果使用电芯仿真器,则还需要与所选 EVM 电芯数量相匹配的 1k Ω 电阻器
- 可提供 EVM 所需电压和电流 (最好具有恒流和恒压能力)的直流电源

#### 1.1.1 选择电量计和订购 EV2400

- 1. 访问 https://www.ti.com/power-management/battery-management/fuel-gauges/overview.html,为相关应用选择合适的电量计。
- 2. 为相关应用订购所需的 EVM。若要订购 EVM,请前往器件的产品页面并点击"设计和开发"。

#### Design & development

For additional terms or required resources, click any title below to view the detail page where available.

All Hardware develop	ment Software development CAD/CAE symbols	
Hardware development		
	EVALUATION BOARDS 1 Series, 2 Series, 3 Series, and 4 Series Li-Ion Battery Pack Manager Evaluation Module	
4	BQ40Z50EVM-561	\$99.00
	🖹 User guide	Add to cart

3. 订购 EV2400。请参阅产品页面上的 EVM 用户指南,以了解是否支持 EV2400。如果不受支持,请使用 EVM 用户指南中推荐的器件。如需了解支持的器件列表,请转至 EV2400 产品页面。EV2400 是一款 HID 器件,可将来自 BQSTUDIO 的数据转换为 I2C/HDQ/SDQ/SMBus/SPI 命令并发送至 bq EVM (https://www.ti.com/tool/EV2400)。

#### Order Now

Part Number	Buy from Texas Instruments or Third Party	Buy from Authorized Distributor	Status
EV2400	\$199.00(USD)	Pricing may vary.	ACTIVE
USB-Based PC Interface Board for Battery Fuel (Gas) Gauge Evaluation Module	Download	Buy from distributor	
Contact a Distributor - Select a location -			

🖸 TI's Standard Terms and Conditions for Evaluation Modules apply.

4. EV2400 可能需要更新固件,更新步骤可参阅 EV2400 的用户指南 (https://www.ti.com/lit/ug/sluu446d/sluu446d.pdf)。

## 1.2 BQSTUDIO 使用入门

 下载最新稳定版本的 BQSTUDIO (https://www.ti.com/tool/download/BQSTUDIO-STABLE)。BQSTUDIO 提供 两个版本:稳定版本和测试版本,其中测试版本包含最新的发行版本。对于大多数开发和已发布的器件,TI 建议使用 BQSTUDIO 的稳定版本。如果器件处于预发布阶段或者不受稳定版本支持,请尝试从 https:// www.ti.com/tool/download/BQSTUDIO-TEST 中下载最新测试版本,查看电量计是否受支持。

# Battery Management Studio (bqStudio) Software – stable version downloads for bq series of TI battery fuel gauges

#### BOSTUDIO-STABLE 1.3.86.6

Release Date: 13 Jan 2020

#### View release notes Supported Platforms O What's New? O Release Information

This page contains specific information about Battery Management Studio (bqStudio) Software – stable version downloads for bq series of Ti battery fuel gauges release package. Refer to the table below for download links and related content.

#### Product downloads

Download requires export approval (1 minute)

	Title	Version	Description	Size							
Batt	ery Management Studio (bqStudio) Installers										
2	Windows Installer for Battery Management Studio (bqStudio)	1.3.86.6	Windows Installer for Battery Management Studio (bqStudio)	190501 K							
Batt	Battery Management Studio (bqStudio) chemistry update zip file										
	Chemistry update for Battery Management Studio (bqStudio)	791	Import this file with Battery Management Studio (bqStudio) Help menu for the latest chemistries.								
Batt	ery Management Studio (bqStudio) Documentation										
	Documentation Overview	1.0.0.0	Battery Management Studio (bqStudio) Documentation								

- 2. 根据所选 EVM 用户指南中的通用设置指南,在电池与 EVM 上的电池组或电池端子之间建立必要的连接。
- 3. 通常,用户需要先将电池组中最底端的电芯(电芯1)接地,然后再依次连接其余电芯(电芯2、电芯3等等),直到连接好电池组顶部的电芯或连接好所需数量的电芯为止。如果电量计中存在空的电芯槽,请将空的电芯槽从下往上短接到正极端子。对于一些 EVM,SYS PRESS 可能需要短接至 PACK-,以便设备能够正常启动。用户还需要连接热敏电阻(如果尚未连接)和达到推荐电压的电池或电源,将 I2C 或 SMBus 从电量计连接到 EV2400 并将 USB 从 EV2400 连接到 PC,具体如 EVM 用户指南所述。如果需要施加放电或充电电流,应将负载或充电器连接到适当的端子。
- 4. 示例连接如下所示。





- 5. 可以使用电芯仿真来代替电池电芯。在输入电芯槽的每一个触点之间连接一个 1kΩ 电阻器,直到达到所需数量的电芯。任何空的电芯槽均应进行短接。电芯仿真器可通过电源供电。将电源设置为"所需电芯电压×电芯数量"并将地线接至电池组的底部,将正极线接至电池组的顶部。例如,对于电芯电压为 3.6V 的 6 节电芯串联配置,将电源设置为 6 × 3.6 = 21.6V。
- 6. 下面显示了电芯仿真器的示例连接。





- 7. 建立必要的连接后,根据 EVM 用户指南唤醒设备,然后启动 BQSTUDIO,以确保可以通过 BQSTUDIO 和 bqz 容器文件自动检测相关设备。
- 8. 如果没有自动连接,用户将会看到一个包含多个产品系列的选择对话框,如下所示。

a Target Selection Wizard



 $\times$ 

#### Battery Management Studio (bqStudio) Supported Targets

Please select a device type...

AII	
Sauce	
Charger	
ureless Charging	
Protector	
Monitor	
Reference Design	
	1
uto Detected Device : None	
the type of device is not in the list above, you may download the latest version of postudio at <u>http://www.tl.com/tool/bdstudio</u>	•
new versions add support for newer devices)	

< Back Next >	Finish	Cancel
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9. 成功连接后,位于屏幕左半部分的仪表板将会显示电压、温度和电流的值。它还会显示用于通信的协议。如果 没有显示任何信息,则表示存在通信错误。请检查连接并确保唤醒设备。



Parent							-	ىرىسى .		~		•		Commands 🕺	
roch is OEE Click to Turn On	Registers											M	0 2	Commands	
Version: 1.3.86	r togister o											Start Log	Scan Refresh	Communus	
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r	Remaining Time Alarm	10	min	Cel 5 Curren		0	mA	Cell 6 RaScale	1000		Cell 4 OMax	4400	mAh	CHEM ID	ā
	At Rate	0	mA	Cel 6 Curren		0	mA	Cell 7 RaScale	1000		Cell 5 QMax	4400	mAh	& cuewing	
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	At Rate OK	1		Cell 2 Power		0	cW	Cell 3 CompRes	0	mOhm	Cell 1 QMax DOD0	0		IAIA_SHUIDOWN	
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ba40780	Voltage	5253	mV	Cell 4 Power		0	cW	Cell 5 CompRes	0	mOhm	Cell 3 QMax DOD0	0	-		
4800.0.04	Current	0	mA	Cel 5 Power		0	cW	Cell 6 CompRes	0	mOhm	Cell 4 QMax DOD0	0		PDSG_FET_TOGGLE	
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J.	Relative State of Charge	0	%	Power		0	cW	Cell 1 Grid	0		Cell 7 QMax DOD0	0		CHG_FET_TOGGLE	
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0%	Average Time to Full	65535	min 🗡	TS4 Tempera	ture	-273.2	deoC '	Cell 7 Grid	0	- 1	Cell 2 Raw DOD	16384	. ×	LIFETIME_EN	
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500	Battery Mode (high)	0x6081	CapM		ChoM	AM		RSVD	RSVD	RSV	D PR	0	0		
1000	Battery Mode (low)		CF		RSVD	RSVI	)	RSVD	RSVD	RSV	D PBS	10	G	LT_TEST	
1500	Battery Status (high)	0x02D0	0CA		TCA	RSVE	)	OTA	TDA	RSV	D RCA	RT	A	/ DE EN	
- 1000 -	Battery Status (low)		INIT		DSG	FC		FD	EC3	EC	EC1	EC	0		
2000	Operation Status A (hi	0x2D89	SLEEP		XCHG	XDSC	3	PF	SS	SD	SEC1	SE	C0	PF_CLEAR	
0	Operation Status A (low)		BTP_N	r	RSVD	FUSE		PDSG	PCHG	CHO	DSG	PRI	ES	# DDD ENI	ā —
	Operation Status B (hi	0x0000	IATA_CTE	RM I	PSSHUT	EMSHU	л	CB	SLPCC	SLPA	D SMBLCAL	IN	п	# DDK_EIV	
	Operation Status B (lo		SLEEPI		XL	CAL_OFF	SET	CAL	AUTOCALM	AUT	H LED	SD	M.	Log Panel	
	Temp Range (high)	0x10	RSVD		RSVD	RSVE	)	RSVD	RSVD	RSV	D RSVD	RS	VD	Log Funct	
	Temp Range (low)		RSVD		OT	HT		STH	RT	STI	. ut	U	т	Transaction Log	
	Charging Status (high)	0x0001	RSVD		RSVD	RSVE	)	RSVD	NCT	00	CVR	CC	R	Name Cmd Re	asult R
	Charging Status (low)		VCT		MCHG	SU		N	HV	MV	LV	P	V		
	Gauging Status	0xD5	CF		DSG	EDV		BAL_EN	TC	TO	FC	FI	D		
	T Status (high)	0x0004	RSVD		RSVD	RSVE	)	OCVFR	LDMD	RX	QMAX	VE	DQ D		
	IT Status (low)		NSFM		RSVD	SLPQM	AX	QEN	VOK	RDI	RSVD	RE	ST		
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	Manufacturing Status (		BBR_EN		PF_EN	LF_EI	V I	FET_EN	GAUGE_EN	DSG_T	EST CHG_TEST	PCHG	TEST		
	Safety Alert A+B (high)	0x0000	RSVD		CUVC	OTD		OTC	ASCOL	RSV	D ASCCL	RS	VD		
	Safety Alert A+B (low)		AOLDL		RSVD	OCD2	2	OCD1	0002	000	1 COV	CU	IV		

10. 屏幕中间的"Register"窗口默认会报告来自电量计的数据。

Battery Management S	Studio ( bqStudio ) 1.3.86														_	o ×
File View AutoCycle	Window Help															
🚫 Registers 🦔	🎔 Data Memory 🛛 之	Commands [ Calibration f	SHA Authent	tication 🏄	Advan	ced Comm SMB 🔐	ECC Authentica	tion 🗼	Chemistry	nware [ GPCPackag	ger 📴 Wa	itch 🔚 Data Graph 🕎	Errors			
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Auto Refresh is OFF - C	ilick to Turn On	Registers											Start Log	Scan Refresh	Commands	
bq5tudio Version: 1.3.86	, ,	Desize and													DEVICE_NUMBER	^
Ω		Registers													HW VERSION	
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	Version:0.28	Manufacturer Access	0x2D89	hex	E Ce	I 3 Current	0	mA	Cell 4 RaScale	1000		Cell 2 QMax	4400	mAh		
		Remaining Cap. Alarm	300	mAh	Ce	# 4 Current	0	mA	Cell 5 RaScale	1000		Cell 3 QMax	4400	mAh	PW_BUILD	
		Remaining Time Alarm	10	min	E Ce	I 5 Current	0	mA	Cell 6 RaScale	1000		Cell 4 QMax	4400	mAh	CHEM_ID	
		At Rate	0	mA	😑 Ce	I 6 Current	0	mA	Cell 7 RaScale	1000		Cell 5 QMax	4400	mAh		
	SMB	At Rate Time To Full	65535	min	E Ce	17 Current	0	mA	Cell 1 CompRes	0	mOhm	E Cell 6 QMax	4400	mAh	SHUIDOWN	
		At Rate Time To Empty	65535	min	E Ce	I 1 Power	0	cW	Cell 2 CompRes	0	mOhm	Cell 7 QMax	4400	mAh	IATA SHUTDOWN	
		At Rate OK	1		E Ce	I 2 Power	0	cW	Cell 3 CompRes	0	mOhm	Cell 1 QMax DOD0	0			
		Temperature	27.3	degC	Ce Ce	13 Power	0	cW	Cell 4 CompRes	0	mOhm	Cell 2 QMax DOD0	0		CC_OFFSET	
12	bq40z80	Voltage	5253	mV	Ce	14 Power	0	cW	Cell 5 CompRes	0	mOhm	Cell 3 QMax DOD0	0	-	PDSG FET TOGGLE	
	4800_0_04 Adda 0x17	Gurrent	0	mA	Ce	15 Power	0	cW	Cell 6 CompRes	0	mOhm	Cell 4 QMax DOD0	0	-		
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0%		Average Time to Full	65535	min 🗸	TETS	4 Temperature	-273.2	deoC	Cell 7 Grid	0	- ~	Cell 2 Raw DOD	16384	- ×	LIEFTIME ENI	
		Bit Registers											Bit High	Bit Low RSVD	LT_RESET	
AND DODD		Name	Value	Bit7		B#6	B#5		Bit4	Bit3	Bit2	B#1	Bi	0 ^	LT FLUSH	
500 500		Battery Mode (high)	0x6081	CapM		ChoM	AM		RSVD	RSVD	RSVD	PB	0			
S-1000 1000		Battery Mode (low)		CF		RSVD	RSVE		RSVD	RSVD	RSVD	PBS	IC	c	LT_TEST	
- 1500 1500		Battery Status (high)	0x02D0	OCA		TCA	RSVE		OTA	TDA	RSVD	RCA	RT	A	🛷 PF EN	
-2000 2000 -		Battery Status (low)		INIT		DSG	FC		FD	EC3	EC2	EC1	EC	:0	-	
		Operation Status A (hi	0x2D89	SLEEP		XCHG	XDSG		PF	SS	SDV	SEC1	SE	20	PF_CLEAR	
		Operation Status A (low)		BTP_N	т	RSVD	FUSE		PDSG	PCHG	CHG	DSG	PR	IS	BBR FN	
		Dperation Status B (hi	0x0000	IATA_CTE	RM	PSSHUT	EMSHU	т	CB	SLPCC	SLPAE	) SMBLCAL	IN	π		Ŷ
		Operation Status B (lo		SLEEPI	4	XL	CAL_OFF	SET	CAL	AUTOCALM	AUTH	LED	SC	M	Log Panel	ClearLog
		Temp Range (high)	0x10	RSVD		RSVD	RSVE		RSVD	RSVD	RSVD	RSVD	RS	VD		cicor cog
		Temp Range (low)		RSVD		OT	HT		STH	RT	STL	LT	U	T	Transaction Log	
		Charging Status (high)	0x0001	RSVD		RSVD	RSVE		RSVD	NCT	CCC	CVR	CC	R	Name Cmd Result	t Read A
		Charging Status (low)		VCT		MCHG	SU		N	HV	MV	LV	P	/		
		Gauging Status	0xD5	CF		DSG	EDV		BAL_EN	TC	TD	FC	F			
		III Status (high)	0x0004	RSVD		RSVD	RSVE		OCVER	LOMD	RX	QMAX	VE	u .		
		IT Status (IOW)	0.0000	NSFM		KSVD	SLPUM	UA INT	UCN DOWN	VUK	RUIS	RSVD	RE	51		
		Manufacturing Status (	0x0090	CAL_E		DE EN	P050_11	.51	ROVU CET EN	ROVU CAUCE EN	RSVU DEC TE	EEU_EN	PUSE	TECT		
		Safety Alert A+B (blob)	0x0000	DOK_C		CUVC	070		OTC	ASCDI	DSG_IE	ASCOL	PCHG	/0		
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															<u> </u>	

11. 屏幕右侧的"Commands"窗口可用于向电量计发送命令。用户可以使用这些命令来获取电量计信息,例如 设定的化合物 ID 以及硬件或固件版本。另外,保护 FET 等很多电量计功能也可以使用这些命令来控制。用户 还可以使用这些命令来解封或密封相关设备。如需每个命令功能的相关说明,请参考电量计的技术参考手册。



Board	~ <b>D</b>	🗆 🔕 Registers 🛛											- 0	😂 Commands 🗧	22	
esh is OFF -	- Click to Turn On	Registers										Start Log	Scan Refresh	Commands	3	
Version: 1.3.	.86	Paristan										Start Log	Jean Nenean	DEVICE_	NUMBER	
Λ		Registers												🖉 HW_VE	ERSION	
	EV2400	Name	Value	Units ^	Name	Value	Units ^	Name	Value	Units ^	Name	Value	Units ^	🖉 FW VE	ERSION	
	Version:0.28	Manufacturer Access	0x2D89	hex	Cell 3 Current	0	mA	Cell 4 RaScale	1000		Cell 2 QMax	4400	mAh			
r		Remaining Cap. Alarm	300	mAh	Cell 4 Current	0	mA	Cell 5 RaScale	1000		Cell 3 QMax	4400	mAh	🌮 FW_E	BUILD	
		Remaining Time Alarm	10	min	Cell 5 Current	0	mA	Cell 6 RaScale	1000		Cell 4 QMax	4400	mAh	🔮 CHE	M ID	
		At Rate	0	mA	Cell 6 Current	0	mA	Cell 7 RaScale	1000		Cell 5 QMax	4400	mAh		-	
	SMB	At Rate Time To Full	65535	min	Cell 7 Current	0	mA	Cell 1 CompRes	0	mOhm	Cell 6 QMax	4400	mAh	SHUTE	DOWN	
		At Rate Time To Empty	65535	min	Cell 1 Power	0	cW	Cell 2 CompRes	0	mOhm	Cell 7 QMax	4400	mAh		UTDOWN	
		At Rate OK	1		Cell 2 Power	0	cW	Cell 3 CompRes	0	mOhm	Cell 1 QMax DOD0	0		- magain	0.00.00	
<b>b</b> .		Temperature	27.3	degC	Cell 3 Power	0	cW	Cell 4 CompRes	0	mOhm	Cell 2 QMax DOD0	0		CC_0	OFFSET	
	bq40z80	■ Voltage	5253	mV	Cell 4 Power	0	cW	Cell 5 CompRes	0	mOhm	Cell 3 QMax DOD0	0	-	# DDCC EE	TTOCCLE	
	4800_0_04	Current	0	mA	Cell 5 Power	0	cW	Cell 6 CompRes	0	mOhm	Cell 4 QMax DOD0	0	-	* PD30_PE	1_100012	
$\sim \lambda$	Addr: 0x17	Average Current	0	mA	Cell 6 Power	0	cW	Cell 7 CompRes	0	mOhm	Cell 5 QMax DOD0	0		PCHG_FE	T_TOGGLE	
	27.5 degu	Max Error	100	%	Cell 7 Power	0	cW	PackGrid	0	-	Cell 6 QMax DOD0	0	-			
,		Relative State of Charge	0	%	Power	0	cW	Cell 1 Grid	0	-	Cell 7 QMax DOD0	0		CHG_FEI	I_IOGGLE	
		Absolute State of Charge	0	%	Average Power	0	cW	Cell 2 Grid	0	-	QMax Passed Q	0	mAH	DSG_FET	TOGGLE	
		Remaining Capacity	0	mAh	iii Int Temperature	26.9	degC	Cell 3 Grid	0	-	GMax Time	0	h/16			
		Full charge Capacity	3976	mAn	IS1 lemperature	27.3 0	degC	Cell 4 Grid	0		iii lemp k	1.0		✓ GAUG	GE_EN	
2		Run time To Empty	65535	min	IS2 Temperature	27.4 0	degC	Cell's Grid	0	-	iei lemp a	1000	-	🛷 FET	I EN	
3 mv		Average Time to Empty	65535	min Y	TS4 Temperature	-273.2	degC degC Y	Cell 7 Grid	0	. ~	Cell 2 Raw DOD	16384	- v	# UEETI	-	
-		Disp. 14										Da Ulas	ne en	* LIFE II		
1177		bit Registers	Mahua	047	940	Pat		Pat	842	820	Pat	Di Tigli Di			LUCH	
<u>i</u>		Romer Hade (kink)	value	Dit	Dio	DED		00.4	015	012	BEI	Bitt		* uga	LUSH	
500	4	Dattery Mode (high)	UXOUO1	Capm	Crigs	AM		RSVD	RSVD	RSVD	PD	00		🖉 U ()	TEST	
1000		Battery Mode (low)	0+0200	OCA.	KSVU	RSVD		KSVU	KSVU	RSVD	PDS	00		- 05	C 11	
1500 -	8	Battery Status (high)	0X0200	INIT	DEC	KSVD EC		ED	EC2	RSVD EC2	RUA EC1	RIA	<u> </u>	✓ PF.	TEM	
2000	7	Concertion Status A (b)	0x2089	SI FFP	ХСНО	XDSG		PF	55	SDV	SEC1	SEC	0	PF_C	LEAR	
0		Operation Status A (low)	010.000	BTP INT	RSVD	FUSE		PDSG	PCHG	CHG	DSG	PRE	s			
		Operation Status B (hi	0×0000	IATA CTER	M PSSHUT	EMSHUT		CB	SLPCC	SLPAD	SMBLCAL	INIT	r i i i i i i i i i i i i i i i i i i i	- BBH	CEN .	
		Operation Status B (lo		SLEEPM	XL	CAL OFFSET	r 🛛	CAL	AUTOCALM	AUTH	LED	SDI	A. C.			
		Temp Range (high)	0x10	RSVD	RSVD	RSVD		RSVD	RSVD	RSVD	RSVD	RSV	(D	Logitunei		
		Temp Range (low)		RSVD	OT	HT		STH	RT	STL	LT	UT		Transaction Lo	q	
		Charging Status (high)	0x0001	RSVD	RSVD	RSVD		RSVD	NCT	000	CVR	CCF	R	Name Cn	nd Result	
		Charging Status (low)		VCT	MCHG	SU		N	HV	MV	LV	PV				
		Gauging Status	0xD5	CF	DSG	EDV		BAL_EN	TC	TD	FC	FD	1			
		T Status (high)	0x0004	RSVD	RSVD	RSVD		OCVFR	LDMD	RX	QMAX	VDC	۵.			
		IT Status (low)		NSFM	RSVD	SLPQMAX		QEN	VOK	RDIS	RSVD	RES	π			
		Manufacturing Status (	0x0090	CAL_EN	LT_TEST	PDSG_TEST		RSVD	RSVD	RSVD	LED_EN	FUSE	EN			
		Manufacturing Status (		BBR_EN	PF_EN	LF_EN		FET_EN	GAUGE_EN	DSG_TES	T CHG_TEST	PCHG_1	TEST			
		Safety Alert A+B (high)	0x0000	RSVD	CUVC	OTD		OTC	ASCOL	RSVD	ASCCL	RSV	O			
		Safety Alert A+B (low)		AOLDL	RSVD	OCD2		OCD1	0002	0001	COV	CUV	V			
		Safety Status A+B (hig	0x4001	RSVD	CUVC	OTD		OTC	ASCOL	ASCD	ASCCL	ASC	C			

12. BQSTUDIO 提供了记录功能,可记录"Log"复选框(在"Register"部分中每个参数的旁边)选择的值。若要启用此功能,请选择"Log"按钮,此时会选中"Scan"按钮。记录停止后,"Scan"按钮仍处于选中状态,需要手动取消选择。

legisters												Start Log	Scan Re	2 fres
egisters														
Name	Value	Units	^	Name	Value	Units	Name	Value	Units	^ N	ame	Value	Units	^
Manufacturer Access	0x6D81	hex		Cell 3 Current	0	mA	Cell 4 RaScale	1000	-		Cell 2 QMax	4400	mAh	
Remaining Cap. Alarm	300	mAh		Cell 4 Current	0	mA	Cell 5 RaScale	1000			Cell 3 QMax	4400	mAh	
Remaining Time Alarm	10	min		Cell 5 Current	0	mA	Cell 6 RaScale	1000			Cell 4 QMax	4400	mAh	
At Rate	0	mA		Cell 6 Current	0	mA	Cell 7 RaScale	1000	-		Cell 5 QMax	4400	mAh	
At Rate Time To Full	65535	min		Cell 7 Current	0	mA	Cell 1 CompRes	0	mOhm		Cell 6 QMax	4400	mAh	
At Rate Time To Empty	65535	min		Cell 1 Power	0	cW	Cell 2 CompRes	0	mOhm		Cell 7 QMax	4400	mAh	
At Rate OK	1	-		Cell 2 Power	0	cW	Cell 3 CompRes	0	mOhm		Cell 1 QMax DOD0	0	_	
Temperature	28.4	deoC		Cell 3 Power	0	cW	Cell 4 CompRes	0	mOhm		Cell 2 QMax DOD0	0		
Voltage	5154	mV		Cell 4 Power	0	cW	Cell 5 CompRes	0	mOhm		Cell 3 QMax DOD0	0	-	
Current	0	mA		Cell 5 Power	0	cW	Cell 6 CompRes	0	mOhm		Cell 4 QMax DOD0	0	-	
Average Current	0	mA		Cell 6 Power	0	cW	Cell 7 CompRes	0	mOhm		Cell 5 OMax DOD0	0		
Max Error	100	%		Cell 7 Power	0	cW	PackGrid	0	-		Cell 6 QMax DOD0	0		
Relative State of Charge	0	%		Power	0	cW	Cell 1 Grid	0			Cell 7 OMax DOD0	0		
Absolute State of Charge	0	%		Average Power	0	cW	Cell 2 Grid	0			OMax Passed O	0	mAH	
Remaining Capacity	0	mAh		Int Temperature	27.7	deoC	Cell 3 Grid	0			OMax Time	16	h/16	
Eull charge Canacity	1414	mΔh		TS1 Temperature	28.4	denC	Cell 4 Grid	0			Temp k	1.0		
Run time To Empty	65535	min		TS2 Temperature	28.5	deoC	Cell 5 Grid	0			Temp a	1000		
Average Time to Empty	65535	min		TS3 Temperature	-273.2	deoC	Cell 6 Grid	0			Cell 1 Raw DOD	16384	-	
Average Time to Full	65535	min	~	TS4 Temperature	-273.2	degC	Cell 7 Grid	0		v	Cell 2 Raw DOD	16384		~
it Registers												Bit High B	It Low	łsv
Name	Value	E	Bit7	Bit6	Bit5		Bit4	Bit3	В	it2	Bit1	Bit	)	_
Battery Mode (high)	0x6081	Ca	арМ	ChgM	AM		RSVD	RSVD	RS	VD	PB	CC		
Battery Mode (low)			CF	RSVD	RSVE	)	RSVD	RSVD	RS	VD	PBS	ICC	:	
Battery Status (high)	0x02D0	0	CA	TCA	RSVE	)	OTA	TDA	RS	VD	RCA	RT4	λ	
Battery Status (low)			NIT	DSG	FC		FD	EC3	E	22	EC1	ECI	)	
Operation Status A (hi	0x6D81	SL	EEP.	XCHG	XDSG	;	PF	SS	Si	V	SEC1	SEC	0	
Operation Status A (low)		BTR	P_INT	RSVD	FUSE		PDSG	PCHG	CI	IG	DSG	PRE	S	
Operation Status B (hi	0x0000	IATA_	CTERI	M PSSHUT	EMSHU	JT	CB	SLPCC	SL	PAD	SMBLCAL	INΠ	Г 	
Operation Status B (lo		SLI	EEPM	XL	CAL_OFF	SET	CAL	AUTOCALM	AL	TH	LED	SDI	4	
Temp Range (high)	0x10	R	SVD	RSVD	RSVE	)	RSVD	RSVD	RS	VD	RSVD	RSV	D	
Temp Range (low)		R	SVD	от	нт		STH	RT	s	TL	LT	UT		
Charging Status (high)	0x0001	R	SVD	RSVD	RSVE	)	RSVD	NCT	C	00	CVR	CCI	२ -	
Charging Status (low)		V	TT	MCHG	SU		IN	HV	N	V	LV	PV		
Gauging Status	0xC5		CF	DSG	EDV		BAL_EN	TC		D	FC	FD		
II Status (high)	0x0014	R	SVD	RSVD	ŔSVE	,	OCVFR	LDMD	R	X	QMAX	VDI	2 -	
IT Status (low)		NS	SFM	RSVD	SLPQM/	4X	QEN	VOK	R	JIS	RSVD	RES	1	
Manufacturing Status (	0x0288	CA	L_EN	LT_TEST	PDSG_TI	EST	RSVD	RSVD	RS	VD	LED_EN	FUSE	EN	
Manufacturing Status (		BBI	R_EN	PF_EN	LF_EN	4	FET_EN	GAUGE_EN	DSG	TEST	CHG_TEST	PCHG_	TEST	
Safety Alert A+B (high)	0x0000	R	SVD	CUVC	OTD		OTC	ASCDL	RS	RSVD ASCCL		RSV	D	
Safety Alert A+B (low)		AC	DLDL	RSVD	ÖCD2		OCD1	0002	00	:C1	COV	CUV		
			CIVIC)	CUNC	OTD		OTC	10001		CD .	48001	100	0	_

13. "Log Interval"可以通过打开"Windows"选项卡并接着选择"Preferences">"Registers"来进行调整。 小于 1000 毫秒的任何值均无法提供任何有用的信息,因为这类数据大多只会每秒更新一次。请勿将该值设为 大于 10 秒,因为这样可能会丢失有用的信息。理想情况下,应该将该值保持在 2,000 毫秒至 8,000 毫秒之 间,也就是 2 秒至 8 秒之间。我们建议将记录间隔保留为 4000 ms 的默认值。

#### 1.2.1 使用 BQSTUDIO 配置电量计

1.	导航	到'	"Data Memory"	0
File Vie	Window	Help		

Registers	🐜 Data Memory	2	Commands	Q	Calibration	SHA Authentication	Advanced Comm SMB	ECC Authentication	-	Chemistry	Firmware	GPCPackager	Watch	Data Graph	Errors
🖋 DashBoard	D	ata Flas	h View Comr	mand 8											

#### 2. 用户可以从这里配置各种电量计参数。

egisters 🥗 Data Memory 🕅				
ta Memory	Filter/Search			
1/Write Data Memory Content	s	Addo Ex	on export import write_Air i	
write bata memory content				
Calibration	Name	Value	Unit	
	✓ Voltage			
Settings	Cell Gain	12135	-	
Protections	Pack Gain	44470	-	
Trotections	Vc6-Vss Gain	32868	-	
Permanent Fail	✓ Current			
1.00	CC Gain	2.076	mOhm	
anced Charge Algorithm	Capacity Gain	2.076	mOhm	
Gas Gauging	✓ Current Offset			
	CC Offset	0	-	
Power	Coulomb Counter Offset Samples	64	-	
	Board Offset	0	-	
PF Status	CC Auto Config	07	hex	
System Data	CC Auto Offset	9	-	
System bata	✓ Temperature			
SBS Configuration	Internal Temp Offset	3.1	°C	
	External1 Temp Offset	0.1	°C	
LED Support	External2 Temp Offset	0.3	°C	
Black Box	External3 Temp Offset	0	°C	
DIDCK DOX	External4 Temp Offset	0	°C	
Lifetimes	✓ Ext Cell Voltage			
	VC7 Sense Gain	41660	-	
Ra Table	✓ Internal Temp Model			
	Int Gain	-12143	-	
	Int base offset	6232	-	
	Int Minimum AD	0	-	
	Int Maximum Temp	6232	0.1°K	
	✓ Cell Temperature Model			
	Coeff a1	-11130	-	
	Coeff a2	19142	-	
	Coeff a3	-19262	-	
	Coeff a4	28203	-	
	Coeff a5	892	-	
	Coeff b1	328	-	
	Coeff b2	-605	-	
	Coeff b3	-2443	-	
	Coeff b4	4696	-	
	Rc0	11703	-	
	Adc0	11703	-	
	Rpad	0	-	
	Rint	0	-	
	✓ Fet Temperature Model			
	Coeff a1	-11130	-	
	Coeff a2	19142		

- 3. 若要读取电量计非易失性闪存中的所有数据,请点击"Data Memory"窗口中的 Read All 按钮。器件不得处 于密封状态并且必须处于完全访问模式,才能读取或写入数据存储器。
- 4. 按照 EVM 用户指南所示校准电量计并配置应用的所有值。务必要更改 DA Configuration 以设置串联电芯数量,从而匹配实际的电池组配置。这是在 | Data Memory | Settings | DA Configuration 寄存器中进行设置的。这样便完成了基本设置。
- 5. 为了满足 TI Impedance Track 电量计的学习循环要求,用户需要调整"Design Capacity"、"Design Voltage"、"Charge Term Taper Current"、"Discharge Current Threshold"、"Charge Current threshold"、"Quit Current"和"Term Voltage"。对于其他参数,请参阅电量计的技术参考手册和 EVM 用户指南中的详细说明。
- 6. 若要保存或查看配置设置,用户可以使用"Data Memory"右上角的导出按钮来导出.GG.CSV 文件。
- 7. 用户还可以使用"Data Memory"右上角的导入按钮来导入现有的 .GG.CSV 文件;然后,用户必须使用 "Data Memory"右上角的"Write All"按钮将其写入存储器。这会将所有导入的信息写入电量计的数据闪存 中。



ta Memory		Filter/Search	oort Export Import Write_All Re
d/Write Data Memory Content	ş		
Calibration	Name	Value	Unit
	✓ Voltage		
Settings	Cell Gain	12135	-
Protections	Pack Gain	44470	-
Protections	Vc6-Vss Gain	32868	-
Permanent Fail	✓ Current		
	CC Gain	2.076	mOhm
dvanced Charge Algorithm	Capacity Gain	2.076	mOhm
Gas Gauging	✓ Current Offset		
Gas Gauging	CC Offset	0	-
Power	Coulomb Counter Offset Samples	64	-
	Board Offset	0	-
PF Status	CC Auto Config	07	hex
Custom Data	CC Auto Offset	9	-
System Data	✓ Temperature		
SBS Configuration	Internal Temp Offset	3.1	°C
	External1 Temp Offset	0.1	°C
LED Support	External2 Temp Offset	0.3	°C
	External3 Temp Offset	0	°C
Black Box	External4 Temp Offset	0	°C
Lifetimes	✓ Ext Cell Voltage		
Enclines	VC7 Sense Gain	41660	
Ra Table	✓ Internal Temp Model		
	Int Gain	-12143	-
	Int base offset	6232	-
	Int Minimum AD	0	
	Int Maximum Temp	6232	0.1%
	Cell Temperature Model	ULUL VLUL	0.1 K
	Coeff a1	-11130	
	Coeff a?	10142	
	Coeff a3	-10262	
	Coeff a4	- 19202	
	Coeff as	20203	-
	Coeff b1	220	-
	Coeff b2	528	-
		-000	-
		-2443	-
	D-0	4090	-
	RCU ALLO	11/03	-
	Addu	11/03	-
	Kpad	0	-
	Kint	0	-
	✓ Fet lemperature Model		
	Coett a1	-11130	-
	Coeff a2	19142	-

### 1.3 化合物 ID

使用 Impedance Track™ 电量计时,选择适当的化合物 ID 对于实现良好的性能至关重要。化合物 ID 是指一组包 含电芯特性和行为相关信息的表格。BQSTUDIO 提供了大量的化合物 ID,这些是德州仪器 (TI) 针对各种各样的 电芯创建的。

1. 导航到"Chemistry"

File View AutoCycle Window	Help								
💮 Registers 🐲 Data Me	mory 🕏 Commands 🔲 Calibratio	SHA Authentication	Advanced Comm SMB	ECC Authentication	Chemistry	Firmware	GPCPackager	Watch 🔤 Da	ata Graph
S DashBoard	🗢 🗖 🔘 Registers 🛛 🖜 Data	Memory			Cł	nemistry			

2. 根据所需电芯的型号在表格中找到匹配项(若适用)并选择匹配的化合物 ID。



Registers 🍽 Data Memory 🛓 Chemistry	×					
nemistry Programming						
ogram Battery Chemistry						
lost Li-ion cells use LiCoO2 cathode and grap his tool allows the fuel gauge to be set up for	phitized carbon anode, which is supported by the default firmware various alternate battery chemistries.	in the Impedance track fu	uel gauges.			
Include chemistry IDs that do not support T	furbo Mode 2	interent chemistry than L	icoo2 cathode and graphice anode.			
Manufacturer	Model	Chemistry ID	Description	Supports Turbo Mode	^	
360FLY	PR-693231 (815mAh)	1318	LiCoO2/carbon 11	Yes		
A&TB	LGR18650OU	0100	LiCoO2/graphitized carbon (default)	No		
A01	ALPBA002 (3430mAh)	0207	NiCoMn/carbon 2	No		
A123	APR18650M1 (1100 mAh)	0404	LiFePO4/carbon	No		
A123	26650M1B (2500mAh)	0434	LiFePO4/carbon	Yes		
A123	ANR26650M1-B (2500mAh)	0440	LiFePO4/carbon	No		
A123	ANR26650M1-B Consult TI before use (2500mAh)	0453	LiFePO4/carbon	Yes		
A123 Systems	26650A	0400	LiFePO4/carbon	No		
A123Systems	ANR26650M1-B (2500mAh)	0465	LiFePO4/carbon	Yes		
A123Systens	A123_Pack (20000mAh)	6105	NIMH	No		
A123Systens	A123 (2000mAh)	6111	NIMH	No		
AA Portable Power	LFP-18650-1500 (1500 mAh)	0439	LiFePO4/carbon	Yes		
AAPortable	26650 (3300mAh)	0451	LiFePO4/carbon	No		
AAPortable	8790160 (10000mAh)	0456	LiFePO4/carbon	No		
ABS	62D12000_InVista (12000mAh)	6116	NIMH	No		
ABS	BPI-50C5500_InVista (5500mAh)	6117	NIMH	No		
Acebel	ECFV1260 (60Ah)	0807	Lead Acid	Yes		
Advanced Electronics Energy	AE18650C-26 (2600mAh)	2151	NiCoMn/carbon	Yes		
AEenergy	AE1004765 (3500mAh)	0131	LiCoO2/carbon 4	No		
AEenergy	AE583696PM1HR (2150 mAh)	0222	PSS, LiNiO2 with Co, Mn doping	No		
AESC	295B9-3NK0B (16500mAh)	1554	LiCoO2/carbon 11	Yes		
AESC	295B9-4NN0A (10425mAh)	1561	LiCoO2/carbon 11	Yes		
AESC	ModuleHC3 (120Ah)	1785	LiMn2O4 (Co,Ni)/carbon, 4.4V	No		
AET	TP2000-1SPL (2000mAh)	0190	LiCoO2/carbon 11	No		
AGM	INR34600K2 (7500mAh)	0210	NiCoMn/carbon	No		
AISIPU	3872C8 (5100mAh)	1335	LiCoO2/carbon 11	Yes		
AISIPU	723292 (3080mA)	1363	LiCoO2/carbon 11	Yes		
AISIPU	856360 (4750mAh)	3636	LiMn2O4 (Co,Ni)/carbon, 4.35V	Yes		
ALE	045062 (2300 mAh)	1254	LiNiCoMnO2/SGenNo1, 4.2V	Yes		
ALE	ALE073470 (1700mAh)	2047	NiCoMn/carbon	Yes		
Alees	26700FE (3300mAh)	0411	LiFePO4/carbon	No	1.	
1 A I	A 3770402 (12000 AL)	0.410	LE BOW I	A1		

Program selected chemistry Program from GPCRB file...

Chemistry Version : 791 Check for a newer chemistry update on ti.com

- 3. 如果表格中没有型号与电芯匹配,请基于 GPCCHEM 工具 (http://www.ti.com/tool/GPCCHEM) 创建日志并获 取 GPCCHEM 报告。根据 GPCCHEM 报告,选择误差最小的化合物 ID。这将确保学习循环不会失败。若要 为电量计确定合适的化合物 ID,最佳方法是运行 GPCCHEM 测试。
- 4. 如果不存在合适的 ID,请联系您当地的 TI 代表,或者将 GPCCHEM 日志和您的电量计设置发布到 e2e.ti.com 上。
- 5. 获得合适的化合物 ID 后,对所选的化合物 ID 进行编程



- -

🚳 Registers 🗢 Data Memory 🚡 Chemistry 🛛

#### **Chemistry Programming**

Program Battery Ch

Most Li-ion cells use LiCoO2 cathode and graphitized carbon anode, which is supported by the default firmware in the Impedance track fuel gauges. This tool allows the fuel gauge to be set up for various alternate battery chemistries. Use this tool to load settings for any alternate chemistry if your cell manufacturer indicates that their cells use a different chemistry than LiCoO2 cathode and graphite anode.

Include chemistry IDs that do not support Turbo Mode 2

Manufacturer	Model	Chemistry ID	Description	Supports Turbo Mode
360FLY	PR-693231 (815mAh)	1318	LiCoO2/carbon 11	Yes
A&TB	LGR18650OU	0100	LiCoO2/graphitized carbon (default)	No
🔜 A01	ALPBA002 (3430mAh)	0207	NiCoMn/carbon 2	No
🔜 A123	APR18650M1 (1100 mAh)	0404	LiFePO4/carbon	No
🔜 A123	26650M1B (2500mAh)	0434	LiFePO4/carbon	Yes
🔜 A123	ANR26650M1-B (2500mAh)	0440	LiFePO4/carbon	No
🔜 A123	ANR26650M1-B Consult TI before use (2500mAh)	0453	LiFePO4/carbon	Yes
🔝 A123 Systems	26650A	0400	LiFePO4/carbon	No
🔝 A123Systems	ANR26650M1-B (2500mAh)	0465	LiFePO4/carbon	Yes
🔝 A123Systens	A123_Pack (20000mAh)	6105	NiMH	No
🔝 A123Systens	A123 (20000mAh)	6111	NiMH	No
🔜 AA Portable Power	LFP-18650-1500 (1500 mAh)	0439	LiFePO4/carbon	Yes
🔝 AAPortable	26650 (3300mAh)	0451	LiFePO4/carbon	No
🔝 AAPortable	8790160 (10000mAh)	0456	LiFePO4/carbon	No
🔀 ABS	62D12000_InVista (12000mAh)	6116	NiMH	No
👪 ABS	BPI-50C5500_InVista (5500mAh)	6117	NiMH	No
🐻 Acebel	ECFV1260 (60Ah)	0807	Lead Acid	Yes
🔝 Advanced Electronics Energy	AE18650C-26 (2600mAh)	2151	NiCoMn/carbon	Yes
🔝 AEenergy	AE1004765 (3500mAh)	0131	LiCoO2/carbon 4	No
🔜 AEenergy	AE583696PM1HR (2150 mAh)	0222	PSS, LiNiO2 with Co, Mn doping	No
AESC	295B9-3NK0B (16500mAh)	1554	LiCoO2/carbon 11	Yes
AESC	295B9-4NN0A (10425mAh)	1561	LiCoO2/carbon 11	Yes
AESC	ModuleHC3 (120Ah)	1785	LiMn2O4 (Co,Ni)/carbon, 4.4V	No
🔜 AET	TP2000-1SPL (2000mAh)	0190	LiCoO2/carbon 11	No
🔜 AGM	INR34600K2 (7500mAh)	0210	NiCoMn/carbon	No
🔜 AISIPU	3872C8 (5100mAh)	1335	LiCoO2/carbon 11	Yes
🔜 AISIPU	723292 (3080mA)	1363	LiCoO2/carbon 11	Yes
🔜 AISIPU	856360 (4750mAh)	3636	LiMn2O4 (Co,Ni)/carbon, 4.35V	Yes
🔜 ALE	045062 (2300 mAh)	1254	LiNiCoMnO2/SGenNo1, 4.2V	Yes
🔜 ALE	ALE073470 (1700mAh)	2047	NiCoMn/carbon	Yes
Alees	26700FE (3300mAh)	0411	LiFePO4/carbon	No



Chemistry Version : 791 Check for a newer chemistry update on ti.com

#### 1.4 学习周期

在 golden 文件创建过程中,Impedance Track 电量计必须完成一个学习周期流程。学习周期要求用户对电池组执 行几个周期,确保在所学电阻中考虑到电芯制造商工艺中的可能变化,以及板接触点和布线电阻,后两者可能影 响电量计的充电状态报告和精度。

- 1. 在开始学习周期之前,必须先选择匹配的化合物 ID。
- 2. 在设备上执行学习周期。有多个学习周期指南,请参阅下面适用于单节电芯和多节电芯电量计的学习周期应用 手册("成功实现学习周期")。(https://www.ti.com/lit/slua903)。
- 3. 运行精度周期并确定学习周期/化合物是否成功 (https://e2e.ti.com/blogs\_/archives/b/fullycharged/archive/ 2016/11/04/how-accurate-is-your-battery-fuel-gauge-part-2-2)。

#### 1.5 补偿放电终止电压 (CEDV) 电量计

使用 TI 基于 CEDV 算法的电量计时,用户必须获得匹配特定电池曲线的 CEDV 系数。这些系数让用户可以提高 电量计 IC 在温度范围内的准确度。用户可利用我们适用于 CEDV 电量计的在线 Gauging Parameter Calculator (GPC) 工具来 (http://www.ti.com/tool/GPCCEDV) 获取 CEDV 参数。将设计参数编程到电量计后,可以使用 EVM 来获取计算 CEDV 系数所需的实验数据。





有关 CEDV 系数数据采集过程和 GPC 工具配置的详细说明,请参阅 (*Gauging Parameter Calculator (GPC)*)的 CEDV 数据采集简易指南。



## 2 BQ40Z50-R3 评估示例

- 1. 请通过 samples.ti.com 订购 BQ40Z50-R3 EVM。EVM 用户指南中讨论了用于连接该电路板的选项 (http:// www.ti.com/lit/ug/sluuav7b/sluuav7b.pdf)。
- 2. 请通过 samples.ti.com 订购 EV2400 电路板
- **3**. 安装 BQSTUDIO: http://www.ti.com/tool/BQSTUDIO,并有稳定版本和测试版本可供选择。如果用户是首次 使用,TI 建议其使用稳定版本。
- 4. 安装 BQSTUDIO 后,确保可以通过点击 "start log"来记录 SBS 寄存器。确保知道如何使用 "data memory" 选项卡来导出 gg.csv 文件。
- 5. 遵循适用于 GPCCHEM 工具的说明。将输入日志文件提交到 GPCCHEM 后,使用化学插件并将 chemID 编 程到 BQ40Z50-R3 中。
- 6. 执行学习循环。

## 3 Linux 和 Windows 驱动程序

支持 SMBus 通信协议的 TI 电量监测计符合智能电池规范 (SBS) 标准。Windows 和 Linux 通过内置驱动程序从符 合 SBS 标准的电池电量监测计中读取数据。

采用 I2C 通信协议的 TI 电量监测计大多在 Linux 内核中集成了驱动程序。TI 会定期推送更新,向 Linux 内核中添加对新款 I2C 电量监测计的支持。

如果使用的不是上文介绍的操作系统与电量监测计组合,则可能需要开发定制驱动程序。

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