



bq78PL114S12 Extended SBS Test Commands

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1 General Operational Overview

- 1.1** The **bq78PL114S12** firmware upgrade has an extended SBS command and device status set that supports battery pack calibration and configuration during pack manufacturing. Additionally there are several commands that allow the host to manage pack operation dynamically.

This document describes the extended SBS command set and how it is used. The command set uses reserved SBS locations 0x50 and 0x51. Address 0x50 is used to write a command word or read the device status.

These commands are operational only when the board is in wired mode. The wired bit is normally set as part of the pack parameter configuration process. Manufactured packs should be loaded with a dat file that already has the wired bit set. If an access error occurs the pack configuration should be checked using the TI-supplied application bqWizard.

The bit and byte ordering is the same as for the standard SBS commands. Packet error checking (PEC) must be enabled when using any of the extended SBS test commands below to communicate with the bq78PL114S12.

1.2 Extended SBS Command and Status Words

Table 1. bq78PL114S12 Manufacturing Test Extended SBS Commands

SBS Cmd.	Mode	Name	Format	Size in Bytes	Description
0x50	R	Device Status	Unsigned Integer	2	An SBS read of this location returns the device status. See Table 2 for description of status words.
0x50	W	Device Command	Unsigned Integer	2	Command word is written to this location. See Table 3 for the list of commands.
0x51	R	Returned Data	Unsigned Integer	2	
0x51	W	Command Parameter	Unsigned Integer	2	Parameter value associated with command or safety rule. Units depend on specific command.

Table 2. bq78PL114S12 Device Status Words

Returned Device Status Value	Description
0x0000	READY
0x8001	BUSY
0x8081	INVALID_CMD, Locked
0x808A	INVALID_CMD, un-Locked
0x8101	READ Error, SAFETY_TIMER
0x8102	READ Error, SAFETY_LIMITS
0x8103	READ Error, PACK_CONFIG
0x8104	READ Error, USER_COMMAND
0x8105	WRITE Error, SAFETY_TIMER
0x8106	WRITE Error, SAFETY_LIMITS
0x8107	WRITE Error, SAFETY_TIMER
0x8200 to 0x82FF	SMB layer errors. Contact TI for assistance.

Table 3. bq78PL114S12 Manufacturing Test Commands

Command	Description	Parameter Units	Available When Locked
0x180n	Clear bit n of Safety_Limit.System_Control, n = 0x0 to 0xF. See Table 5 .	—	Yes
0x190n	Sets bit n of Safety_Limit.System_Control, n = 0x0 to 0xF. See Table 5 .	—	Yes
0x1A91	Unlock command. Unlocks device for 60 seconds.	—	Yes ⁽¹⁾
0x1A19	Lock command	—	Yes
0x2000	Calibrate Current Zero (offset)	—	No
0x2001	Calibrate Current Gain to adjust measured value to the parameter value.	16 bit, 2's complement number	No
0x2002	Calibrates temperature to the value of the parameter	0.1°K	No
0x2003	Commits (writes) calibration data to flash.	—	No
0x2007	Initialize/Relearn	—	No
0x21ii	Write_Safety_Timer[ii] = parameter 0x00pp.	See Table 5	No
0x22jj	Write_Safety_Limit[jj] = parameter PPpp.	See Table 6	No
0x23ii	Read Safety_Timer[ii] through DATA_word_low_byte.	See Table 5	No
0x24jj	Read Safety_Limit[jj] through DATA_word.	See Table 6	No
0x25kk	Read a word from Pack_Config[kk] through DATA_word.	See Table 7	No

⁽¹⁾ The unlocked state timer is automatically renewed for 60 seconds upon reception of any command as long as the timer has not expired. It is not necessary for an external host to periodically reissue the unlock command. If no manufacturing test command is received within the 60s timeout period the bq78PL114S12 firmware reverts to locked mode.

Table 4. bq78PL114S12 Safety Limit System Control Register

Bit#	Description	Details
[14:0]	Reserved, not used	Cleared to 0.
15	Pump Disable	When = 0, cell balancing (pumping) is enabled. When = 1, disables all cell balancing (default).

Note: This register is also described in section 8 of the bq78PL114 and bq78PL114S12 Technical Reference Manual, [SLUU330](#).

Table 5. Command Indices for Write_Safety_Timer (0x21ii)

Index (ii)	Name	SLUU330 Reference	Section Title	Parameter Units ⁽¹⁾
0x00	COV Time	1.1	Cell Overvoltage	seconds
0x01	CUV Time	1.2	Cell Undervoltage	seconds
0x02	POV Time	1.4	Pack Overvoltage	seconds
0x03	PUV Time	1.5	Pack Undervoltage	seconds
0x04	OC Charge Tier 1 Recovery	1.6	Charge Overcurrent – Tier 1	seconds
0x05	OC Charge Tier 1 Time	1.6	Charge Overcurrent– Tier 1	seconds
0x06	OC Discharge Tier 1 Recovery	1.7	Discharge Overcurrent – Tier 1	seconds
0x07	OC Discharge Tier 1 Time	1.7	Discharge Overcurrent – Tier 1	seconds
0x08	OC Charge Tier 2 Recovery	1.8	Charge Overcurrent – Tier 2	seconds
0x09	OC Charge Tier 2 Time	1.8	Charge Overcurrent – Tier 2	seconds
0x0A	OC Discharge Tier 2 Recovery	1.9	Discharge Overcurrent – Tier 2	seconds
0x0B	OC Discharge Tier 2 Time	1.9	Discharge Overcurrent – Tier 2	seconds
0x0C	Hardware OC Charge Recovery	1.10	Hardware Overcurrent Charge	seconds
0x0D	Hardware OC Discharge Recovery	1.11	Hardware Overcurrent Discharge	seconds
0x0E	Hardware Short Circuit Recovery	1.12	Hardware Short Circuit	seconds
0x0F	EUV Time	1.3	Extreme Cell Undervoltage	seconds
0x10	OT Charge Time	1.13	Overtemperature Charge	seconds RDTE
0x11	OT Discharge Time	1.14	Overtemperature Discharge	seconds RDTE
0x12	Host Watchdog Timeout	1.15	Host Watchdog Timeout	seconds RDTE
0x13	SOV Time	2.1	Safety Cell Overvoltage (SOV)	seconds RDTE
0x14	Reserved	—	—	—
0x15	SOC Charge Time	2.2	Safety Overcurrent (SOC) Charge	seconds RDTE
0x16	SOC Discharge Time	2.3	Safety Overcurrent (SOC) Discharge	seconds RDTE
0x17	SOT Charge Time	2.4	Safety Overtemperature (SOT) Charge	seconds RDTE
0x18	SOT Discharge Time	2.5	Safety Overtemperature (SOT) Discharge	seconds RDTE
0x19	Open Temperature Sensor Time	2.7	Open Temperature Sensor	seconds RDTE
0x1A	FET Fail Time	2.8 & 2.9	Discharge Protection MOSFET Verification and Charge Protection MOSFET Verification	seconds RDTE
0x1B	Fuse Fail Time	2.11	Fuse Failure	seconds RDTE
0x1C	PowerLAN Communications Bus Fail Time	1.18	PowerLAN™ Communications Bus Failure	seconds RDTE
0x1D	Current Measurement Fail Time	2.10	Current Measurement Failure	seconds RDTE
0x1E	Charge Completion Time	3.7	Charge Completion	seconds
0x1F	Charge Completion FET Activation Time	3.7	Charge Completion	seconds
0x20	Discharge Completion Time	3.10	Discharge Completion	seconds

⁽¹⁾ The seconds value range is 0 to 255 and is in the low byte of the returned data or write parameter word. When writing the parameter the upper byte must be all zeros.

Table 5. Command Indices for Write_Safety_Timer (0x21ii) (continued)

Index (ii)	Name	SLUU330 Reference	Section Title	Parameter Units ⁽¹⁾
0x21	Discharge Completion FET Activation Time	3.10	Discharge Completion	seconds
0x22	Board Over Temperature Time	1.16	Board Overtemperature	seconds RDTE
0x23	Reserved	—	—	—
0x24	FD Set Voltage Time	3.12	Fully Discharged (FD) Bit Control	seconds
0x25	TDA Set Voltage Time	3.11	Terminate Discharge Alarm (TDA) Control	seconds
0x26	Discharge Under Temperature Time	1.17	Discharge Undertemperature	seconds RDTE
0x27	OCA Activation Time	3.13	Overcharge Alarm (OCA) Control	seconds RDTE

Table 6. Command Indices for Write_Safety_Limit (0x22jj)

Index (jj)	Name	SLUU330 Reference	Section Title	Parameter Units
0x00	COV Threshold	1.1	Cell Overvoltage	mV
0x01	COV Recovery 1.1 Cell Overvoltage			mV
0x02	COV High-Temperature Adjust	1.1	Cell Overvoltage	mV
0x03	COV High-Temperature Adjust	1.1	Cell Overvoltage	0.1°K
0x04	CUV Threshold	1.2	Cell Undervoltage	mV
0x05	CUV Recovery	1.2	Cell Undervoltage	mV
0x06	POV Threshold	1.4	Pack Overvoltage	mV
0x07	POV Recovery	1.4	Pack Overvoltage	mV
0x08	PUV Threshold	1.5	Pack Undervoltage	mV
0x09	PUV Recovery	1.5	Pack Undervoltage	mV
0x0A	OC Charge Tier 1 Threshold	1.6	Charge Overcurrent – Tier 1	mA ⁽¹⁾
0x0B	OC Discharge Tier 1 Threshold	1.7	Discharge Overcurrent – Tier 1	mA ⁽¹⁾
0x0C	OC Charge Tier 2 Threshold	1.8	Charge Overcurrent – Tier 2	mA ⁽¹⁾
0x0D	OC Discharge Tier 2 Threshold	1.9	Discharge Overcurrent – Tier 2	mA ⁽¹⁾
0x0E	HSC Max Attempts	1.12	Hardware Short Circuit	number
0x0F	HOC Max Attempts	1.10, 1.11	Hardware Overcurrent Charge, Hardware Overcurrent Discharge	number
0x10	Hardware OC Charge Threshold	1.10	Hardware Overcurrent Charge	number
0x11	Hardware OC Charge Time	1.10	Hardware Overcurrent Charge	number
0x12	Hardware OC Discharge Threshold	1.11	Hardware Overcurrent Discharge	number
0x13	Hardware OC Discharge Time	1.11	Hardware Overcurrent Discharge	number
0x14	Hardware OC Discharge Threshold	1.12	Hardware Short Circuit	number
0x15	Hardware OC Discharge Time	1.12	Hardware Short Circuit	number
0x16	EUV Threshold	1.3	Extreme Cell Undervoltage	mV
0x17	EUV Recovery	1.3	Extreme Cell Undervoltage	mV
0x18	OT Charge Threshold	1.13	Overtemperature Charge	0.1°K
0x19	OT Charge Recovery	1.13	Overtemperature Charge	0.1°K
0x1A	OT Discharge Threshold	1.14	Overtemperature Discharge	0.1°K
0x1B	OT Discharge Recovery	1.14	Overtemperature Discharge	0.1°K
0x1C	SOV Threshold	2.1	Safety Cell Overvoltage (SOV)	mV
0x1D	Cell Imbalance Current	2.6	Cell Imbalance	mA
0x1E	Cell Imbalance Fail Voltage	2.6	Cell Imbalance	mV
0x1F	Cell Imbalance Time	2.6	Cell Imbalance	seconds RDTE

⁽¹⁾ When the bq78PL114S12 is configured for 100A operation this current parameter is in units of 10mA.

Table 6. Command Indices for Write_Safety_Limit (0x22jj) (continued)

Index (jj)	Name	SLUU330 Reference	Section Title	Parameter Units
0x20	Cell Imbalance SOC Inhibit	2.6	Cell Imbalance	%
0x21	SOC Charge Threshold	2.2	Safety Overcurrent (SOC) Charge	mA ⁽¹⁾
0x22	SOC Discharge Threshold	2.3	Safety Overcurrent (SOC) Discharge	mA ⁽¹⁾
0x23	SOT Charge Threshold	2.4	Safety Overtemperature (SOT) Charge	0.1°K
0x24	SOT Discharge Threshold	2.5	Safety Overtemperature (SOT) Discharge	0.1°K
0x25	Open Temperature Sensor Threshold	2.7	Open Temperature Sensor	0.1°K
0x26	Reserved	–	–	–
0x27	Fuse Fail Limit	2.11	Fuse Failure	mA
0x28	IGR Limit	2.12	Impedance Growth	number
0x29	IGR Fail Count	2.12	Impedance Growth	number
0x2A	IGR Ratio Limit	2.13	Impedance Growth Ratio	number
0x2B	IGR Ratio Fail Count	2.13	Impedance Growth Ratio	number
0x2C	Rate Limit Threshold	2.14	Cell	0.1°K/minute
0x2D	Rate Limit Activation Count	2.14	Cell	number
0x2E	Charge Inhibit Temperature Low	3.3	Charge	0.1°K
0x2F	Charge Inhibit Recovery Temperature Low	3.3	Charge	0.1°K
0x30	Charge Inhibit Temperature High	3.3	Charge	0.1°K
0x31	Charge Inhibit Recovery Temperature High	3.3	Charge	0.1°K
0x32	Precharge Temperature	3.5	Precharge Temperature	0.1°K
0x33	Precharge Voltage	3.4	Precharge Voltage and Current	mV
0x34	Precharge Timeout	3.1	Precharge Timeout	seconds
0x35	Charge Suspend Temperature Low	3.6	Charge Suspend –Temperature	0.1°K
0x36	Charge Suspend Recovery Temperature Low	3.6	Charge Suspend –Temperature	0.1°K
0x37	Charge Suspend Temperature High	3.6	Charge Suspend –Temperature	0.1°K
0x38	Charge Suspend Recovery Temperature High	3.6	Charge Suspend –Temperature	0.1°K
0x39	HOC Max Attempts	1.10	Hardware Overcurrent Charge	number
0x3A	Charge Duration Timeout	3.2	Charge Timeout	Seconds RDTE
0x3B	Reserved	–	–	–
0x3C	Reserved	–	–	–
0x3D	Reserved	–	–	–
0x3E	Reserved	–	–	–
0x3F	Reserved	–	–	–
0x40	Reserved	–	–	–
0x41	Charge Completion Pack Voltage Qualifier	3.7	Charge Completion	mV
0x42	Charge Completion Taper Current	3.7	Charge Completion	mA ⁽¹⁾
0x43	Discharge Completion Pack Voltage Qualifier	3.10	Discharge Completion	mV
0x44	FD Clear SOC Threshold	3.12	Fully Discharged (FD) Bit Control	%
0x45	FD Clear Voltage	3.12	Fully Discharged (FD) Bit Control	mV
0x46	FC Clear SOC Threshold	3.9	Fully Charged (FC) Bit Control	%
0x47	FC Set SOC Threshold	3.9	Fully Charged (FC) Bit Control	%
0x48	HW_Config (Hardware Configuration) Register	8.3	Configuration Registers	number
0x49	Algorithm Register	8.3	Configuration Registers	number
0x4A	Minimum Cell Differential for Balancing	8.2	Cell Balancing	mV

Table 6. Command Indices for Write_Safety_Limit (0x22jj) (continued)

Index (jj)	Name	SLUU330 Reference	Section Title	Parameter Units
0x4B	Transition to Idle Current	3.14	Misc. Control Parameters	mA ⁽¹⁾
0x4C	Transition to Idle Time	3.14	Misc. Control Parameters	seconds
0x4D	Transition to Discharge Current	3.14	Misc. Control Parameters	mA ⁽¹⁾
0x4E	Transition to Charge Current	3.14	Misc. Control Parameters	mA ⁽¹⁾
0x4F	Reserved	–	–	–
0x50			abs change in current to be used for impedance	mA
0x51			abs resistance of sense resistor in mOhms	mΩ
0x52	FCC Learn Qualifier	8.6.9	FCC Learn Qualifier	% of SOC
0x53	Cycle Fade	8.6.10	Cycle Fade	% per cycle
0x54	Min OCV Slope	8.6.11	Min OCV Slope	mV/%RSOC
0x55	OCV Idle Qualifier	8.6.12	OCV Idle Qualifier	minutes
0x56	Stale FCC Timeout	8.6.13	Stale FCC Timeout	minutes
0x57	Reserved	–	–	–
0x58	Low Power HW Overcurrent Discharge Threshold	1.11	Hardware Overcurrent Discharge	number
0x59	Low Power HW Overcurrent Discharge Time	1.11	Hardware Overcurrent Discharge	number
0x5A	Low Power HW Overcurrent Charge Threshold	1.10	Hardware Overcurrent Charge	number
0x5B	Low Power HW Overcurrent Charge Time	1.10	Hardware Overcurrent Charge	number
0x5C	EPD Pump Time	8.4	Display Operation	Cycle counts
0x5D			100–1000 mS	number
0x5E	Default Charging Current	8.6.15	Default Charging Current	mA
0x5F	Default Charging Voltage	8.6.14	Default Charging Voltage	mV
0x60	Capacity Algorithm	8.6.16	Capacity Algorithm	number
0x61	User Rate	8.6.17	User Rate	mA ⁽¹⁾
0x62	Pre-Charge Current	3.4	Precharge Voltage and Current	mA ⁽¹⁾
0x63	Reserved	–	–	–
0x64		TBD	cells in parallel, default going to be 2 (for 2P3S)	number
0x65	Design Capacity	7.3.3	Design Capacity	mAh
0x66	Design Capacity	7.3.3	Design Capacity	10mWh
0x67	Board Over Temperature	1.16	Board Overtemperature	0.1°K
0x68	Board Over Temperature Recovery	1.16	Board Overtemperature	0.1°K
0x69	TDA Clear SOC Threshold	3.11	Terminate Discharge Alarm (TDA) Control	%
0x6A	TCA Clear SOC Threshold	3.8	Terminate Charge Alarm (TCA) Control	%
0x6B	Precharge Recovery	3.4	Precharge Voltage	mV
0x6C	FD Set SOC Threshold	3.12	Fully Discharged (FD) Bit Control	%
0x6D	FD Set Voltage	3.12	Fully Discharged (FD) Bit Control	mV
0x6E	TDA Set SOC Threshold	3.11	Terminate Discharge Alarm (TDA) Control	%
0x6F	TCA Set SOC Threshold	3.8	Terminate Charge Alarm (TCA) Control	%
0x70	TDA Set Voltage Threshold	3.11	Terminate Discharge Alarm (TDA) Control	mV
0x71	TDA Clear Voltage	3.11	Terminate Discharge Alarm (TDA) Control	mV
0x72	Discharge Under Temperature	1.17	Discharge Undertemperature	0.1°K
0x73	Discharge Under Temperature Recovery	1.17	Discharge Undertemperature	0.1°K
0x74	OCA Set Voltage	3.13	Overcharge Alarm (OCA) Control	mV

Table 6. Command Indices for Write_Safety_Limit (0x22jj) (continued)

Index (jj)	Name	SLUU330 Reference	Section Title	Parameter Units
0x75		TBD	xxxx122 assigned by marketing or the customer and tied in the bqWizard to a data set name	number
0x76	System Control Register	8.3	Configuration Registers	number
0x77	Display Driver Frequency	8.4	Display Operation	Hz

Table 7. Pack Config (Read Only)

Index (kk)	Element name	type
0x00	Product_ID	unsigned int
0x02	format	unsigned int
0x04	FW_Build	unsigned int
0x0E	Sense_uOhm	unsigned int
0x10	Report_Scaling	char
0x11	Hardware_gain_bits	char
0x12	Sense_uOhm	unsigned int
0x14	Report_Scaling	char
0x15	Hardware_gain_bits	char
0x16	Sense_uOhm	unsigned int
0x18	Report_Scaling	char
0x19	Hardware_gain_bits	char
0x1A	EPD_Refresh_Period	unsigned int
0x1C	RSOC Threshold 5	char
0x1D	LED Pattern 5	char
0x1E	RSOC Threshold 4	char
0x1F	LED Pattern 4	char
0x20	RSOC Threshold 3	char
0x21	LED Pattern 3	char
0x22	RSOC Threshold 2	char
0x23	LED Pattern 2	char
0x24	RSOC Threshold 1	char
0x25	LED Pattern 1	char
0x83	Local_SMB_address	unsigned int
0x85	SMB_Base	unsigned int

2 Usage Examples

This section provides examples of how to use the bq78PL114S12 manufacturing test extended SBS commands. These commands only operate when the board is in Wired mode.

2.1 Current Calibration Example

```
/* Unlock the unit */
{
wait while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear, before doing something */
SMB_Write_Word(0x50, 0x1A91); /* Send Unlock command*/
wait while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */
}

/* Calibrate Current Zero */
/* Ensure there is no external load or charge current present, before send this step */
{
SMB_Write_Word(0x50, 0x2000); /* Send Calibrate Current Zero command*/
wait while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */
}

/* Calibrate Current Gain */
/* Apply external load of -2000 mA and wait a few seconds for it to stabilize, < 60s */.
{
SMB_Write_Word(0x51, 0xf830); /* Send parameter -2000mA*/
wait while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */

SMB_Write_Word(0x50, 0x2001); /* Send Calibrate Current Gain command*/
wait while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */
}

/* Remove external load of -2000 mA and wait a few seconds for it to stabilize, < 60s */.
```

2.2 Set Bit in System Control Register

```
{
while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear, before doing something */
SMB_Write_Word(0x50, 0x190F); /* Send command to set bit 15 of the System Control Register*/
while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */
}
```

2.3 Clear Bit in System Control Register

```
{
while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear, before doing something */
SMB_Write_Word(0x50, 0x180F); /* Send command to clear bit 15 of the System Control Register*/
while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */
}
```

2.4 Write Safety Timer

```
{
while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear, before doing something */
SMB_Write_Word(0x50, 0x1A91); /* Send Unlock command*/
while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */
}

/* Write the timer */
{
SMB_Write_Word(0x51, 0x0020); /* Write time parameter =32s*/
wait while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */

SMB_Write_Word(0x50, 0x2100); /* Write Safety Timer, COV command*/
wait while(SMB_Read(0x50) ==0x8001); /* Wait for busy status to clear */
if(SMB_Read(0x50) != 0) then handle_error(); /* The unit returned error, handle it */
}
```