PowerLAN™ Master Gateway Battery Management Controller With PowerPump™ Cell Balancing Technology

FEATURES

- **bq78PL114 Designed for Managing 3- to 8-Series-Cell Battery Systems**
- **bq78PL114S12 Firmware Upgrade Supports 3- to 12-Series-Cell Battery Systems**
  - **Adds Support for LCD and Electronic Paper Displays or EPDs**
  - **Configurable for 11-A, 26-A, or 110-A Operating Currents**
- **Systems With More Than Four Series Cells Require External bq76PL102 Dual-Cell Monitors**
- **SmartSafety Features:**
  - **Prevention: Optimal Cell Management**
  - **Diagnosis: Improved Sensing of Cell Problems**
  - **Fail Safe: Detection of Event Precursors**
- **Rate-of-Change Detection of All Important Cell Characteristics:**
  - **Voltage**
  - **Impedance**
  - **Cell Temperature**
- **PowerPump Technology Transfers Charge Efficiently From Cell to Cell During All Operating Conditions, Resulting in Longer Run Time and Cell Life**
  - **bq78PL114S12 Adds User-Configurable PowerPump Cell-Balancing Modes**
- **High-Resolution 18-Bit Integrating Delta-Sigma Coulomb Counter for Precise Charge-Flow Measurements and Gas Gauging**
- **Multiple Independent Δ-Σ ADCs: One-per-Cell Voltage, Plus Separate Temperature, Current, and Safety**
- **Simultaneous, Synchronous Measurement of Pack Current and Individual Cell Voltages**
- **Very Low Power Consumption**
  - **bq78PL114: < 250 μA Active, < 150 μA Standby, < 40 μA Ship, and < 1 μA Undervoltage Shutdown**
  - **bq78PL114S12: < 300 μA Active, < 185 μA Standby, < 85 μA Ship, and < 1 μA Undervoltage Shutdown**
- **Accurate, Advanced Temperature Monitoring of Cells and MOSFETs With up to 12 Sensors**
- **Fail-Safe Operation of Pack Protection Circuits: Up to Three Power MOSFETs and One Secondary Safety Output (Fuse)**
- **Fully Programmable Voltage, Current, Balance, and Temperature-Protection Features**
- **External Inputs for Auxiliary MOSFET Control**
- **Smart Battery System 1.1 Compliant via SMBus**

APPLICATIONS

- **Portable Medical Instruments and Test Equipment**
- **Mobility Devices (E-Bike)**
- **Uninterruptible Power Supplies and Hand-Held Tools**

DESCRIPTION

The bq78PL114 master gateway battery controller is part of a complete Li-Ion control, monitoring, and safety solution designed for large series cell strings.

The bq78PL114 and bq78PL114S12 along with bq76PL102 PowerLAN™ dual-cell monitors provide complete battery-system control, communications, and safety functions for a structure of three up to twelve series cells. This PowerLAN system provides simultaneous, synchronized voltage and current measurements using one A/D per-cell technology. This eliminates system-induced noise from measurements and allows the precise, continuous, real-time calculation of cell impedance under all operating conditions, even during widely fluctuating load conditions.

PowerPump technology transfers charge between cells to balance their voltage and capacity. Balancing is possible during all battery modes: charge, discharge, and rest. Highly efficient charge-transfer circuitry nearly eliminates energy loss while providing true real-time balance between cells, resulting in longer run-time and improved cycle life.

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

DESCRIPTION (CONTINUED)

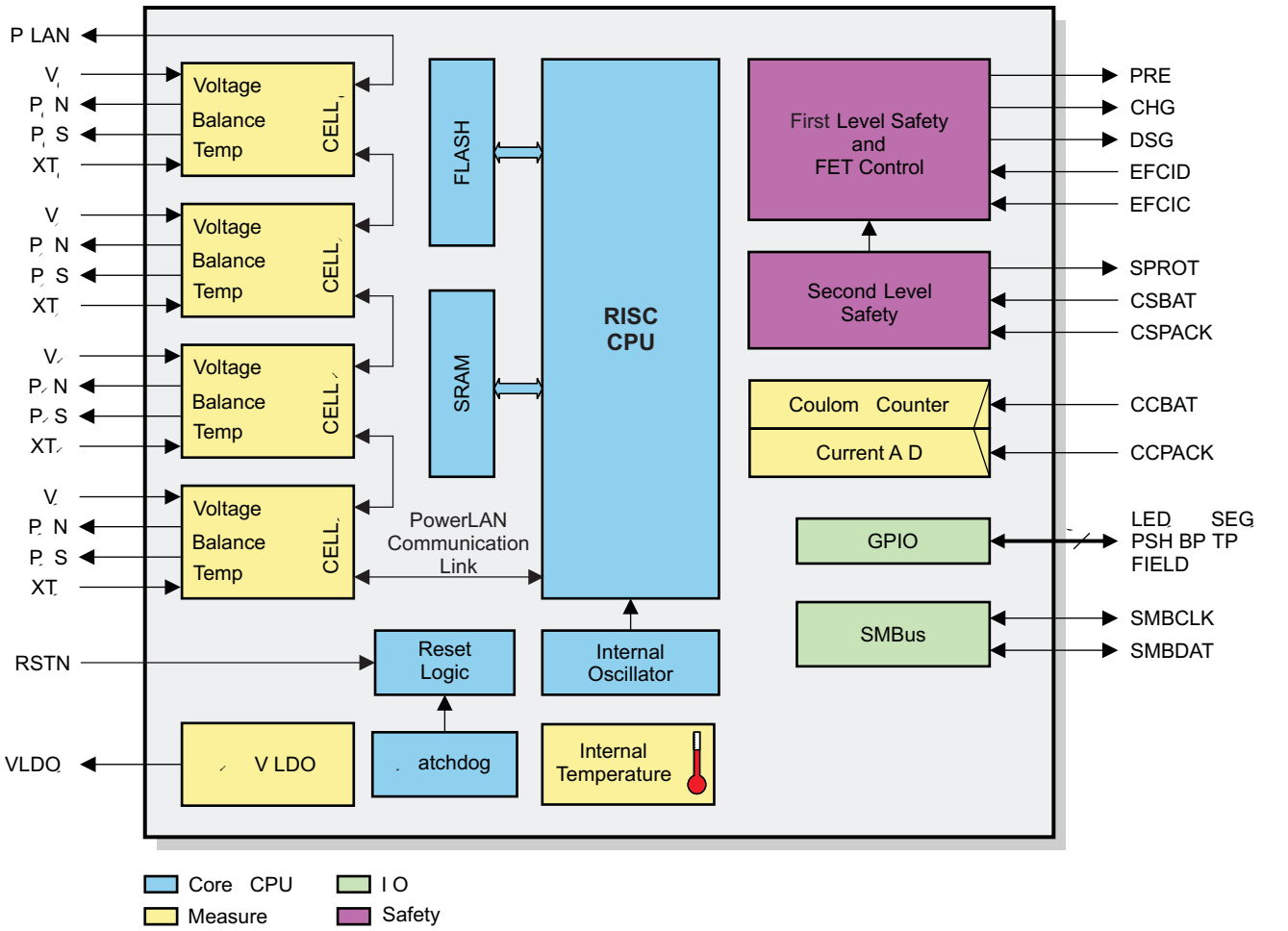
Temperature is sensed by up to 12 external sensors and one on-chip sensor. This permits accurate temperature monitoring of each cell individually. Firmware is then able to compensate for the temperature-induced effects on capacity, impedance, and OCV on a cell-by-cell basis, resulting in superior charge/ discharge and balancing control.

External MOSFET control inputs provide user- definable direct hardware control over MOSFET states. Smart control prevents excessive current through MOSFET body diodes. Auxiliary inputs can be used for enhanced safety and control in large multicell arrays.

The bq78PL114 is completely user-configurable, with parametric tables in flash memory to suit a variety of cell chemistries, operating conditions, safety controls, and data reporting needs. It is easily configured using the supplied bqWizard™ graphical user interface (GUI). The device is fully programmed and requires no algorithm or firmware development.

The bq78PL114 can be upgraded to the bq78PL114S12 by downloading the bq78PL114S12 firmware. The firmware can be downloaded using the bqWizard application or during manufacturing. Upgrading to the bq78Pl114S12 changes the functionality of the LED1–LED5, LEDEN, and N/C pin #29. The bq78PL114S12 pin functions of LED1/SEG1–LED5/SEG5, PSH/BP/TP, and FIELD support LED, LCD, and electronic paper displays (EPDs). The user can configure the bq78PL114S12 for the desired display type.

In this document all descriptions for the bq78PL114 apply to the bq78PL114S12 except where different bq78PL114S12 functionality is specifically described.


P LAN
V
P N
P S
XT
V
P N
P S
XT
V
P N
P S
XT
V
P N
P S
XT
Voltage
Balance
Temp
CELL
Voltage
Balance
Temp
CELL
Voltage
Balance
Temp
CELL
Voltage
Balance
Temp
CELL
FLASH
SRAM
RISC
CPU
PowerLAN
Communication
Link
First Level Safety
and
FET Control
Second Level
Safety
Coulom Counter
Current A D
GPIO
SMBus
PRE
CHG
DSG
EFCID
EFCIC
SPROT
CSBAT
CSPACK
CCBAT
CCPACK
LED SEG
PSH BP TP
FIELD
SMBCLK
SMBDAT
RSTN
Reset
Logic
Internal
Oscillator
VLDO
V LDO
atchdog
Internal
Temperature
Core CPU
Measure
I O
Safety

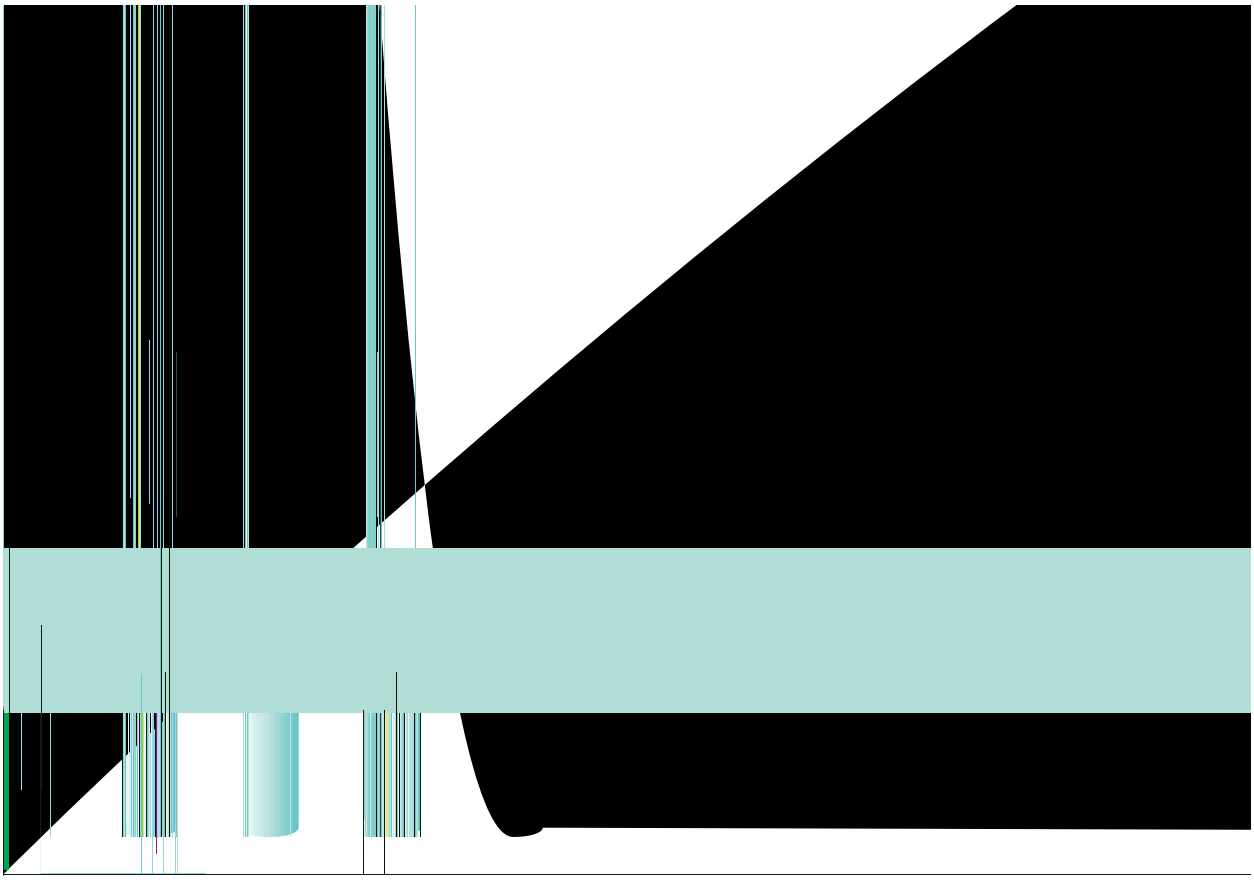


Figure 3. Example bq78PL114 PowerLAN Multicell System Implementation (8 Cells)

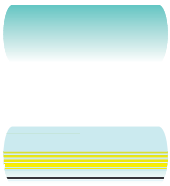
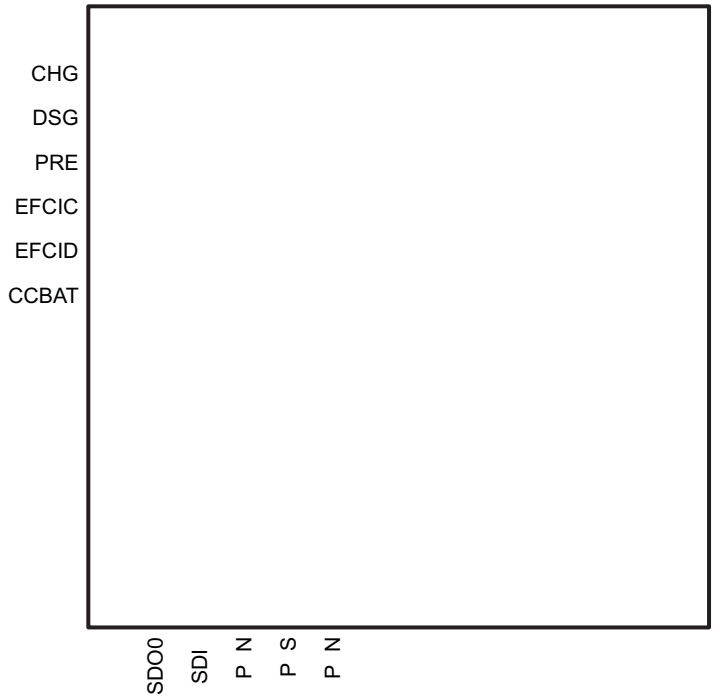


Figure 4. Example bq78PL114S12 System Implementation (12 Cells)

bq78PL114
RGZ Package
(Top View)



P00 - 6

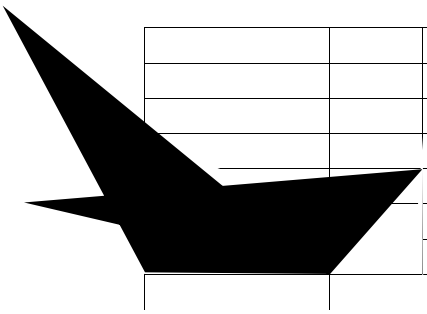
pd78LL14S15
RGZ Package
(Top View)

Figure 6. pd78LL14S15 Pinout

pd78LL14S15 TERMINAL FUNCTIONS

NAME	NO.	TYPE(1)	DESCRIPTION
CCBAT	6	IA	Coulomb counter input (sense resistor), connect to battery negative
CCPACK	7	IA	Coulomb counter input (sense resistor), connect to back negative
CHG	1	O	Charge MOSFET control (active-high, low opens MOSFET)
CSBAT	9	IA	Current sense input (safety), connect to battery negative
CSPACK	10	IA	Current sense input (safety), connect to back negative
DSG	5	O	Discharge MOSFET control (active-high, low opens MOSFET)
EFCIC	4	I	External charge MOSFET control input
EFCID	5	I	External discharge MOSFET control input
HIELD	29	O	EPD field segment
LED1\SEG1	35	O	LED1 – open-drain, active-low, LCD and EPD segment 1
LED2\SEG2	33	O	LED2 – open-drain, active-low, LCD and EPD segment 2
LED3\SEG3	34	O	LED3 – open-drain, active-low, LCD and EPD segment 3
LED4\SEG4	32	O	LED4 – open-drain, active-low, LCD and EPD segment 4
LED5\SEG5	30	O	LED5 – open-drain, active-low, LCD and EPD segment 5
N\C	27, 28	IO	Connect 1-MΩ resistor to VSS
N\C	28	O	No connect
OSCI	11	I	External oscillator input (no connect, internal oscillator used)

(1) I – input, IA – analog input, O – output, OA – analog output, P – power



ABSOLUTE MAXIMUM RATINGS(1)

over operating free-air temperature range (unless otherwise noted)

		RANGE	UNITS
T_A	Operating free-air temperature (ambient)	–40 to 85	°C
T_{stg}	Storage temperature	–65 to 150	°C
V4–V3	Maximum cell voltage	–0.5 to 5.0	V
V3–V2	Maximum cell voltage	–0.5 to 5.0	V
V2–V1	Maximum cell voltage	–0.5 to 5.0	V
V1–VSS	Maximum cell voltage	–0.5 to 5.0	V
Voltage on LEDEN, SPROT, CCBAT, CCPACK, CSBAT, CSPACK, XT1, XT2, OSCI, OSCO, P-LAN	Maximum voltage on any I/O pin with respect to VSS	–0.5 to (VLDO1 + 0.5)	V
Voltage on PSH/BP/TP (bq78PL114S12)	Maximum voltage range with respect to VSS	–0.5 to (VLDO1 + 0.5)	V
Voltage on LED1–LED5	Maximum voltage on I/O pin with respect to VSS	–0.5 to 5.5	V
Voltage on LED1/SEG1–LED5/SEG5 (bq78PL114S12)	Maximum voltage on I/O pin	–0.5 to 5.5	V
Voltage on XT3, XT4	Maximum voltage range with respect to V2	(V2 – 0.5) to (VLDO2 + 0.5)	V
EFCIC, EFCID	Maximum voltage range with respect to VSS	–0.5 to 5.5	V
Voltage on SMBCLK, SMBDAT	Maximum voltage range with respect to VSS	–0.5 to 6	V
Voltage on PRE, CHG, DSG	Maximum voltage range with respect to VSS	–0.5 to (VLDO1 + 0.5)	V
Current through PRE, CHG, DSG, LED1–LED5, P-LAN	Maximum current source/sink	20	mA
Current through LED1/SEG1–LED5/SEG5, (bq78PL114S12, LED mode)	Maximum current source/sink	20	mA
VLDO1 maximum current	Maximum current draw from VLDO	20	mA
ESD tolerance	JEDEC, JESD22-A114 human-body model, R = 1500 Ω, C = 100 pF	2	kV
Lead temperature, soldering	Total time < 3 seconds	300	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_{SUP}	Supply voltage—V1, V2, V3, V4	2.3		4.5	V
$V_{Startup}$	Minimum startup voltage—V1, V2	2.9			V
V_{IN}	Input cell voltage range—V(n+1) – V(n), n = 1, 2, 3, 4	0		4.5	V
C_{VLDO1}	VLDO 1 capacitor—VLDO1	2.2	10	47	µF
C_{VLDO2}	VLDO 2 capacitor—VLDO2	2.2	10	47	µF
C_{Vn}	Cell-voltage capacitor—Vn	1			µF

ELECTRICAL CHARACTERISTICS

T_A = –40°C to 85°C (unless otherwise noted)

DC Characteristics

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{CELL} (1)	Operating range	Cells balanced	2.3		4.5	V
I_{DD}	Operating-mode current	Measure / report state, bq78PLL114		250		µA
		Measure / report state, bq78PLL114S12		300		
I_{STBY}	Standby-mode current	SMBCLK = SMBDAT = L, bq78PLL114		100		µA
		SMBCLK = SMBDAT = L, bq78PLL114S12		185		
I_{SHIP}	Ship-mode current	bq78PLL114		30		µA
		bq78PLL114S12		85		
I_{ECUV}	Extreme cell under voltage shutdown current	All cells < 2.7 V and any cell < ECUV set point			1	µA
V_{OL}	SPROT, LEDEN, PSH/BP/TP(bq78PL114S12), FIELD(bq78PL114S12)	I_{OL} < 4 mA	0		0.5	V
V_{OH} (2)	SPROT, LEDEN, PSH/BP/TP(bq78PL114S12), FIELD(bq78PL114S12)	I_{OH} < –4 mA	V_{LDO1} – 0.1			V
V_{IL}	SPROT, LEDEN, PSH/BP/TP(bq78PL114S12), FIELD(bq78PL114S12)				0.25 V_{LDO1}	V
V_{IH}	SPROT, LEDEN, PSH/BP/TP(bq78PL114S12), FIELD(bq78PL114S12)		0.75 V_{LDO1}			V

(1) Device should be configured to enter shutdown state when cell voltages are below 2.5 V.
(2) Does not apply to SMBus pins.

Voltage-Measurement Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Measurement range		2.5		4.5	V
Resolution			<1		mV
Accuracy	25°C		±5		mV
	0°C to 60°C		±10		

Current-Sense Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Measurement range(1) (bq78PL114)		–0.2		0.2	V
Measurement range(2) (bq78PL114S12, 3-mΩ sense resistor)		–0.077		0.077	V
Measurement range(2) (bq78PL114S12, 1-mΩ and 10-mΩ sense resistors)		–0.1		0.1	V
Input offset	T_A = 25°C		±50		µV
Offset drift	T_A = 0°C to 60°C		0.5		µV/°C
Resolution (bq78PL114)			18		µV
Resolution (bq78PL114S12, 3-mΩ sense resistor)			6.9		µV
Resolution (bq78PL114S12, 1-mΩ and 10-mΩ sense resistors)			10		µV
Full-scale error(3)	T_A = 25°C		±0.1%		
Full-scale error drift	T_A = 0°C to 60°C		50		PPM/°C

(1) Default range. Corresponds to ±10 A using a 5-mΩ sense resistor.
(2) The bq78PL114S12 firmware upgrade supports three sense-resistor options, 10 mΩ, 3 mΩ, and 1 mΩ.
(3) After calibration. Accuracy is dependent on system calibration and temperature coefficient of sense resistor.

Coulomb-Counter Characteristics(1) (2)

over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Resolution			5		nVh
Intergral nonlinearity			0.008%		
Snap-to-zero (deadband)			±100(3)		µV

(1) Shares common input with current-sense section
(2) After calibration. accuracy is 0 0 1 152m/F2 -8 Tf (0 0 UNIT)m.m5 -8 Tf (0 0 UNI69.06 4 481.244 404.2 239.502 281.2 Tm 1 0 0 1 228.3 2)A39.9 4zer

Current-Sense (Safety) Characteristics(1)

Internal Temperature-Sensor Characteristics(1)

LDO Voltage Characteristics(1)

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{LDO1}	LDO1 operating voltage, referenced to VSS	T_A = –40C to 85C, load = 200 µA	2.425	2.5	2.575	V
V_{LDO2}	LDO2 operating voltage, referenced to V2	T_A = –40C to 85C, load = 2 mA	2.425	2.5	2.575	V

(1) After calibration

External Temperature-Sensor(s) Typical Characteristics(1)

over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Measurement range(2)		–40		90	°C
Resolution			0.2		°C
Accuracy(3)	25°		±1		°C
	0° to 85°		±2		

(1) Typical for dual-diode (MMBD4148 or equivalent) external sensor using recommended circuit
(2) Range of diode sensors may exceed operational limits of IC and battery cells.
(3) Typical behavior after calibration, final result dependent on specific component characteristics

SMBus Characteristics(1)

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IL}	Input low voltage		0		0.8	V
V_{IH}	Input high voltage		2.1		5.5	V
V_{OL}	Output low voltage	350-µA sink current	0		0.4	V
C_I	Capacitance, each I/O pin				10	pF
f_{SCL}	SCLK nominal clock frequency	T_A = 25°C		100		kHz
R_{PU}(2)	Pullup resistors for SCLK, SDATA	V_{BUS} 5 V nominal	13.3		45.3	kΩ
		V_{BUS} 3 V nominal	2.4		6.8	

(1) SMBus timing and signals meet the SMBus 2.0 specification requirements under normal operating conditions. All signals are measured with respect to PACK-negative.
(2) Pullups are typically implemented external to the battery pack, and are selected to meet SMBus requirements.

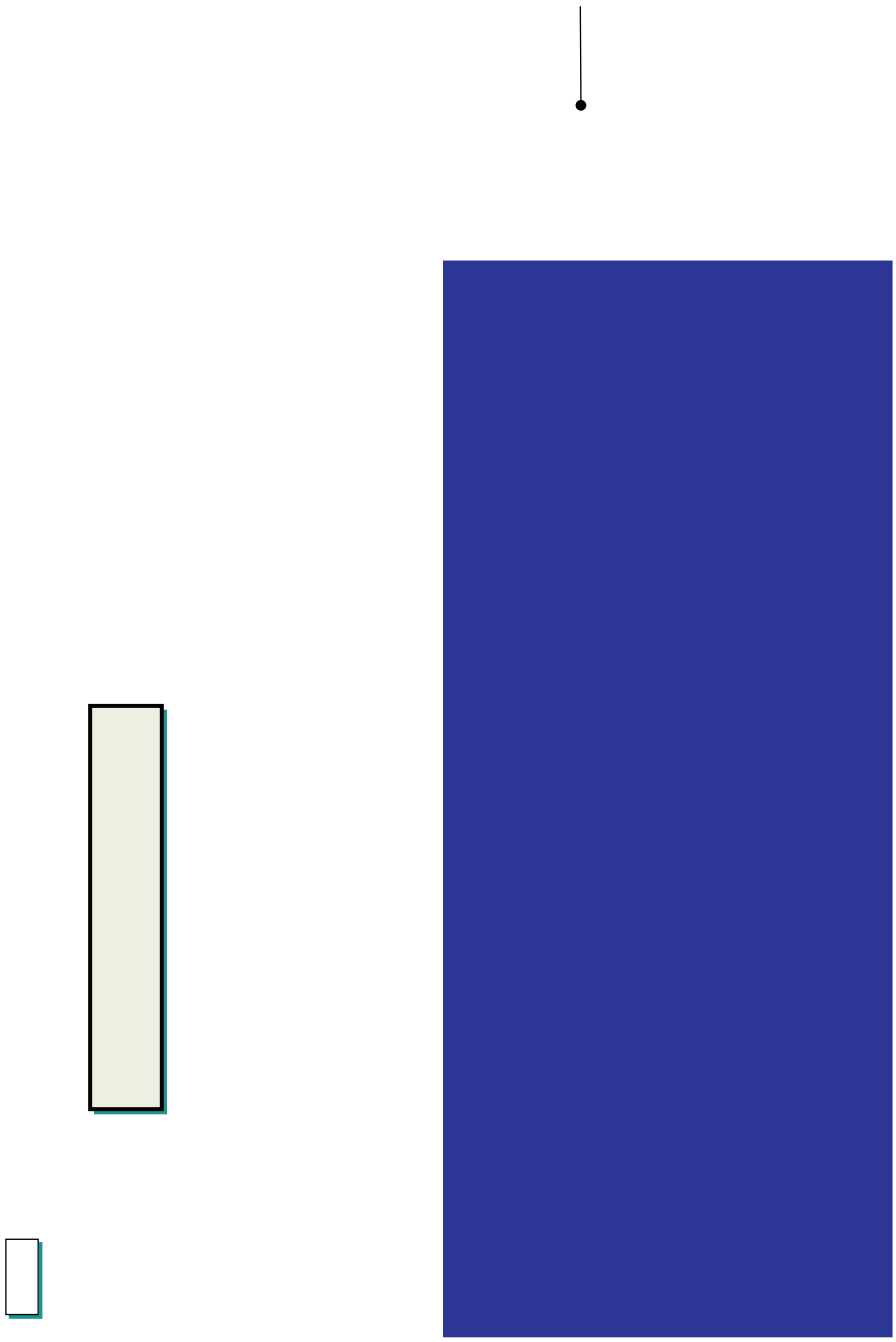


Figure 7. bq78PL114 Simplified Example Circuit Diagram

FEATURE SET

Primary (First-Level) Safety Features

The bq78PL114 implements a breadth of system protection features which are easily configured by the customer. First-level protections work by controlling the MOSFET switches. These include:

- Battery cell over/undervoltage protection
- Pack over/undervoltage protection
- Charge and discharge overcurrent protection
- Short-circuit protection
- External MOSFET control inputs (EFCIx) with programmable polarity
- Up to 12 external temperature inputs for accurate cell and MOSFET monitoring
- Watchdog timer protection
- Brownout detection and protection against extreme pack undervoltage

Secondary (Second-Level) Safety Features

The bq78PL114 can detect more serious system faults and activate the SPROT pin, which can be used to open an in-line chemical fuse to permanently disable the pack. Secondary optional features include

- Fully independent of first-level protections
- SmartSafety algorithms for early detection of potential faults
  - Temperature abnormalities (variances, extremes, rate of change, etc.)
  - Disconnected cell voltage inputs
  - Cell imbalance exceeds safety limits
  - Impedance rise due to cell or weld strap fault
- MOSFET failure or loss of MOSFET control
- Safety overvoltage, pack and cell
- Safety overtemperature, limits for both charge and discharge
- Safety overcurrent, charge and discharge
- Failed current measurement, voltage measurement, or temperature measurement

Charge Control Features

- Meets SMBus 2.0 and Smart Battery System (SBS) Specification 1.1 requirements
- Active cell balancing using patented PowerPump technology, which eliminates unrecoverable capacity loss due to normal cell imbalance
- Balancing-current monitoring to detect cell problems
- Simultaneous, synchronous measurement of all cell voltages in a pack
- Simultaneous, synchronous measurement of pack current with cell voltages
- Reports target charging current and/or voltage to an SBS Smart Charger
- Reports the chemical state-of-charge for each cell and pack
- Supports precharging and zero-volt charging with separate MOSFET control
- Programmable, Chemistry-specific parameters
- Fault reporting

Gas Gauging

- The bq78PL114 accurately reports battery cell and pack state-of-charge (SOC). No full charge/discharge cycle is required for accurate reporting.
- State-of-charge is reported via SMBus and optional display.
- 18-bit integrating delta-sigma ADC coulomb counter, with programmable snap-to-zero value

Display Types

- The bq78PL114 drives a three- to five-segment LED display in response to a pushbutton (LEDEN) input signal. Each LED pin can sink up to 10 mA.

- The bq78PL114S12 drives a three- to five-segment static liquid-crystal display.
- [illegible] drives a three- to five-segment electronic paper display. An external [illegible]

Lifetime Logging (Readable via SMBus)

Forensic Data Logging (Readable via SMBus)

Power Modes

OPERATION

PowerLAN Communication

Outputs

Charge Control

The CHG and PRE outputs are ordinarily used to drive MOSFET transistors controlling charge to the cell stack. Charge or precharge mode is selected based on the present cell voltage compared to the user-definable cell precharge, undervoltage, and temperature thresholds. When below these limits, the PRE signal is active and the CHG signal is inactive. This turns on the precharge MOSFET and is used to charge a depleted system through a current-limiting series resistor. When all cell voltages are above the limit and the temperature is above the charge temperature minimum, then the CHG output also becomes active and enables the charge MOSFET to turn on, providing a high-current path between charger and battery cells.

The CHG and PRE MOSFET control outputs are both disabled (low) when any cell reaches the safety cutoff limit or temperature threshold. During active charging modes (and above cell voltage thresholds), the discharge MOSFET is also enabled to avoid excessive heating of the body diode. Similarly, the charge MOSFET is active during discharge, provided current flow is in the correct direction and no safety violations are present.

The bq78PL114S12 firmware upgrade supports the following configurable cell-balancing features:

- Super-pump mode. When enabled this allows 60%–70% pump availability when there are no active safety events and current is not flowing. While in super-pump mode, temperature rate-of-rise features are not available.
- Option to disable cell balancing during discharge
- Option to disable cell balancing during charge

The CHG and PRE outputs are intended to drive buffer transistors acting as inverting level shifters.

Discharge Control

The DSG output operates similarly to control-system discharging. It is enabled (high) by default. If a cell voltage falls below a programmable threshold, or excessive current or other safety related fault is sensed, the DSG output is disabled (low) to prevent damage to the cells.

All facets of safely charging and discharging the cell stack are controlled by user-definable parameters which provide precise control over MOSFET states. Both system and cell over- and undervoltage limits are provided, as well as programmable hysteresis to prevent oscillation. Temperature and current thresholds are also provided, each with independent timers to prevent nuisance activations.

The DSG output is intended to drive a buffer transistor acting as an inverting level-shifter.

Display

The bq78PL114 shows state-of-charge indication on a five-LED display in a bar-graph format. LEDEN is a dual-function pin. One function is to control current to the LED display array. It also serves as an input that monitors for closure of a state-of-charge indicator (SOCi) push-button switch.

The bq78PL114S12 shows state-of-charge indication on LED, static liquid crystal, and electronic paper displays or EPDs in a bar-graph-type format. The parameter set allows selection of display type and configuration. PSH/BP/TP is a multifunction pin. In LED display mode, PSH serves as an input that monitors for closure of a state-of-charge indicator (SOCi) push-button switch. In LCD mode, this pin is used to drive the LCD backplane. In EPD mode, this pin drives the top plane common signal of the display.

For both the bq78PL114 and bq78PL114S12, in LED display mode the signals LED1/SEG1–LED5/SEG5 are current-sinking outputs designed to drive low-current LEDs.

For the bq78PL114S12 firmware in LCD and EPD modes, the LED1/SEG1–LED5/SEG5 pins drive the active segments through external buffer transistors. In EPD mode, the FIELD pin drives the display background field.

Electronic paper displays require an external power supply, typically 15 V, to power the display. In EPD, mode the bq78PL114S12 strobes the display outputs for a user- programmable period of milliseconds to drive an external voltage multiplier or charge pump to the required display supply voltage. The display segments are then updated in a manner that ensures the required 0-Vdc segment voltage offset is maintained and keeps the external power supply at its nominal voltage.

Inputs

Current Measurement

Current is monitored by four separai01820 0 1 .2 Tm BT 1 0 0 1 465 42 Tm 1 0 0 4ej 1 1 1 RG 1 248 122.2 Tm /F2 -10

COMMUNICATIONS

SMBus

The bq78PL114 uses the industry-standard Smart Battery System's two-wire System Management Bus (SMBus) communications protocol for all external communication. SMBus version 2.0 is supported by the bq78PL114, and includes clock stretching, bus fault time-out detection, and optional packet error checking (PEC). For additional information, see the www.smbus.org and www.sbs-forum.org Web sites.

Smart Battery Data (SBData)

The data content and formatting of the bq78PL114 information conforms to the Smart Battery System's (SBS) Smart Battery Data specification, version 1.1. See the SBS/SMBus site at www.sbs-forum.com for further information regarding these specifications.

This SBS Data (SBData) specification defines read/write commands for accessing data commonly required in laptop computer applications. The commands are generic enough to be useful in most applications.

Because the bq78PL114 provides a wealth of control and battery information beyond the SBData standard, new command codes have been defined by Texas Instruments. In addition, new battery data features, such as state-of-health, use newly defined extended SBData command codes. Standard SMBus protocols are used, although additional data values beyond those defined by the Smart Battery Data specification are employed. (For th example, the bq78PL114 typically is used in a multicell battery system and may report individual cell voltages for up to computer

SBS Standard Data Parameter List (Abridged)(1)

Command	Data Type	Description
00	R/W word (unsigned)	Manufacturer Access
01	R/W word (unsigned)	Remaining Capacity Alarm Level
02	R/W word (unsigned)	Remaining Time Alarm Level
03	R/W word (unsigned)	Battery Mode
04	R/W word (unsigned)	At Rate value used in AtRate calculations
05	Read word (unsigned)	At Rate Time to Full
06	Read word (unsigned)	At Rate Time to Empty
07	Read word (Boolean)	At Rate OK
08	Read word (unsigned)	Pack Temperature (maximum of all individual cells)
09	Read word (unsigned)	Pack Voltage (sum of individual cell readings)
0A	Read word (unsigned)	Pack Current
0B	Read word (unsigned)	Average Pack Current
0C	Read word (unsigned)	Max Error
0D	Read word (unsigned)	Relative State of Charge
0E	Read word (unsigned)	Absolute State of Charge
0F	Read word (unsigned)	Remaining Pack Capacity
10	Read word (unsigned)	Full Charge Capacity
11	Read word (unsigned)	Run Time to Empty
12	Read word (unsigned)	Average Time to Empty
13	Read word (unsigned)	Average Time to Full
14	Read word (unsigned)	Charging Current
15	Read word (unsigned)	Charging Voltage
16	Read word (unsigned)	Battery Status
17	Read word (unsigned)	Cycle Count
18	Read word (unsigned)	Design Capacity
19	Read word (unsigned)	Design Voltage
1A	Read word (unsigned)	Specification Information
1B	Read word (unsigned)	Manufacture Date
1C	Read word (unsigned)	Serial Number
1D–1F	Reserved	
20	Read block (string)	Pack Manufacturer Name (31 characters maximum)
21	Read block (string)	Pack Device Name (31 characters maximum)
22	Read block (string)	Pack Chemistry
23	Read block (string)	Manufacturer Data
24–2E	Reserved	
2F	R/W Block	Optional Manufacturer Function 5
30–3B	Reserved	
3C	R/W word (unsigned)	Optional Manufacturer Option 4 (Vcell 1)
3D	R/W word (unsigned)	Optional Manufacturer Option 3 (Vcell 2)
3E	R/W word (unsigned)	Optional Manufacturer Option 2 (Vcell 3)
3F	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 4)
40	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 5)
41	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 6)
42	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 7)
43	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 8)
44	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 9, bq78PL114S12 only)

(1) Parameters 0x00–0x3F are compatible with the SBDATA specification.

Command	Data Type	Description
45	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 10, bq78PL114S12 only)
46	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 11, bq78PL114S12 only)
47	R/W word (unsigned)	Optional Manufacturer Option 1 (Vcell 12, bq78PL114S12 only)
48–4F	Unused	
50–55	Reserved	
56–57	Unused	
58–5A	Reserved	
5B–5F	Unused	
60–62	Reserved	
63–6F	Unused	
70	Reserved	
71–FF	Unused	

NOTE:

The bq78PL114 allows mapping of the eight cell voltage SBS locations to be different than its base address of 0x3C. The bq78PL114S12 does not support this feature.

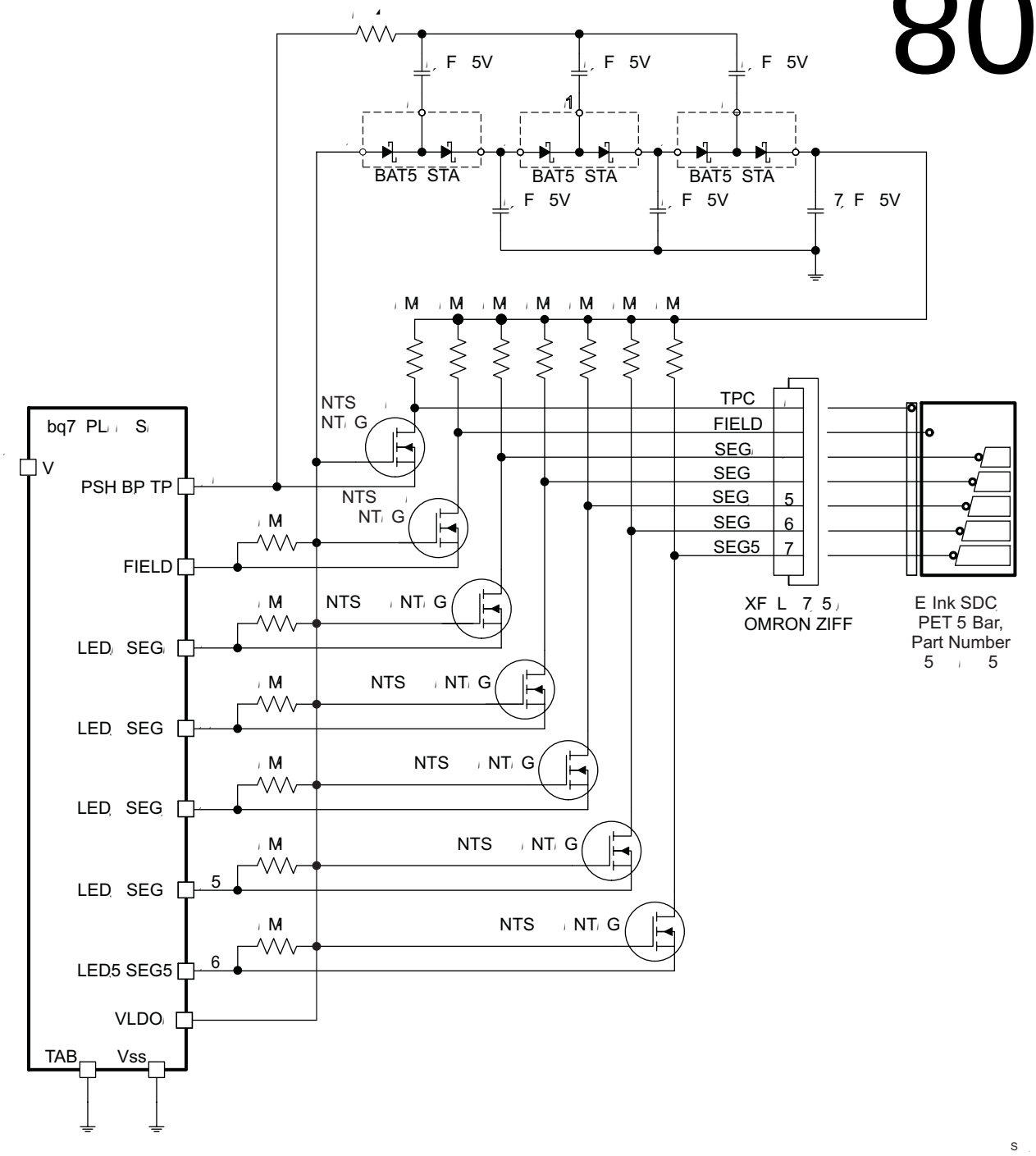
REFERENCE SCHEMATICS

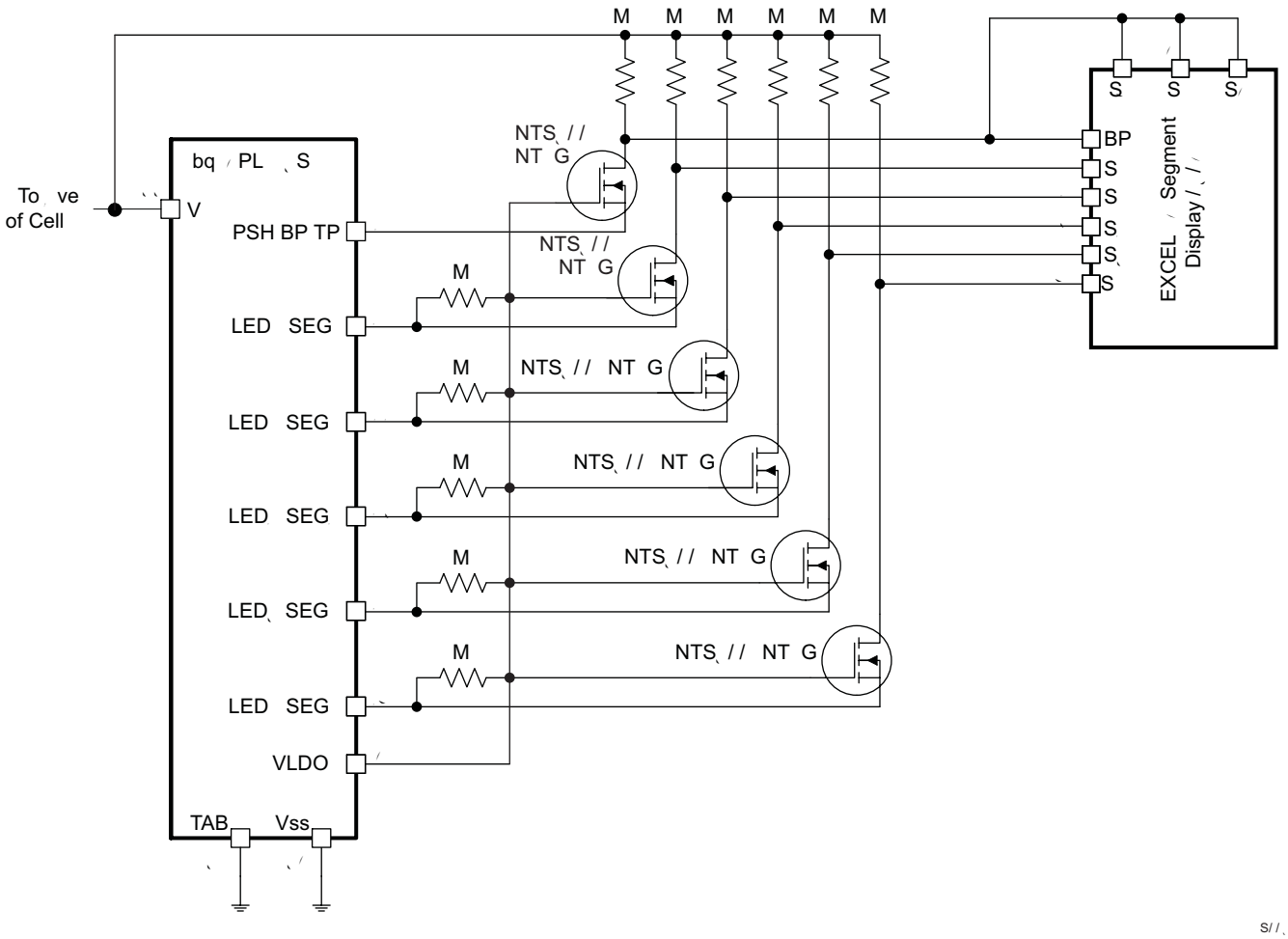
This configuration applies to the bq78PL114 only. The bq78PL114S12 has a different configuration for three-cell operation.

Figure 8. bq78PL114 Reference Schematic (3 Series Cells)

bq78PL114S12 Reference Schematic (10 Series Cells) (Sheet 2 of 2)

2008


F 5V
F 5V
F 5V
BAT5 STA
BAT5 STA
BAT5 STA
F 5V
F 5V
7 F 5V
TPC
FIELD
SEG
SEG
SEG 5
SEG 6
SEG5 7
XF L 7 5
OMRON ZIFF
E Ink SDC
PET 5 Bar,
Part Number
5 5
bq7 PL S
V
PSH BP TP
FIELD
LED SEG
LED SEG
LED SEG
LED SEG 5
LED5 SEG5 6
VLDO
TAB Vss
NTS
NTS
NTS
NTS
NTS
NTS
NTS

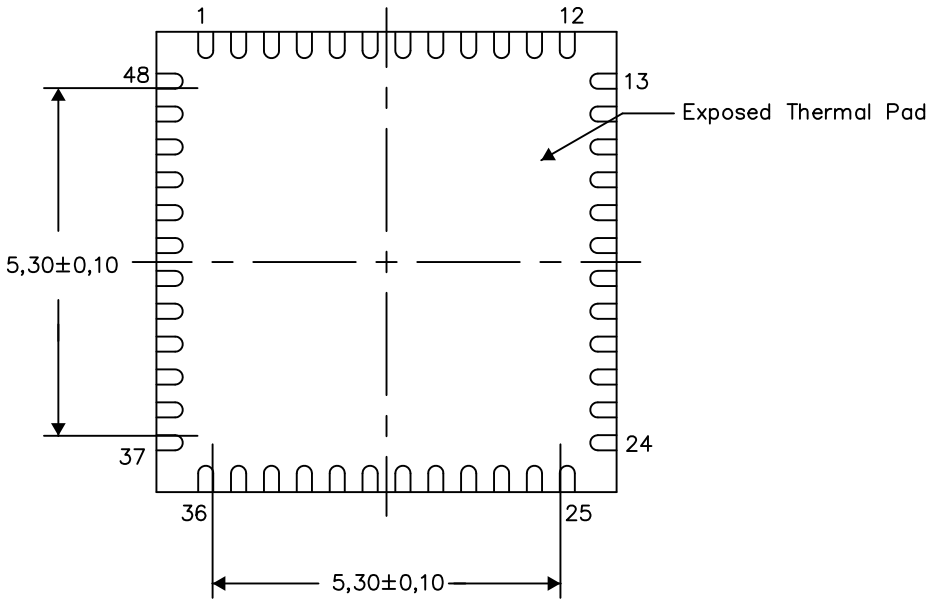

M
M
M
M
M
M
S
S
S
BP
S
S
S
S
S
EXCEL Segment Display
NTS
NT G
bq PL S
To ve
of Cell
V
PSH BP TP
LED SEG
LED SEG
LED SEG
LED SEG
LED SEG
VLDO
TAB
Vss

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
BQ78PL114RGZR	NRND	VQFN	RGZ	48	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	78PL114 BQ	
BQ78PL114RGZT	NRND	VQFN	RGZ	48	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	78PL114 BQ	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent



4206354–9/T 03/13

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale

TIasspecillyight4Tj 38.07 0 Td (described)1.5 Td (Buyer)Tj 26.41 0 Td (components)Tj 45.98 0 Td(its)Tj 22.85 0 meetgarding)0j 42.86 0 ISO/TS16949ress50j 25.97 0

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms

a.e (TI)Td (chroduatd)Tj 13.52 0 Td (equipmentss53.45 0 Td (products)Tj 9.07 0 Td (and)Tj 30.41 0 Td (technicquestoa)Tj 9.07 0 Td (the)Tj 15.74 0 Td (the

to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitu 0 Td (a.e (TI)Tjs Td BT /F3 8 T4.8 0 2nimize)a1 re 1 1 1 rg f 54 53 0 Td Td (or)T