High Power Focus

Power Tools
- Handheld Cordless Tools
- Gardening Tools

Light Electric Vehicles
- eBikes
- eScooters
- Pedal-Assist “Pedelec”

Battery Backup
- UPS
- Power Bank

NOTE Example photos are for illustrative purposes only
Product Categories

- Analog Front End (AFE)
- Overvoltage Protector (OVP)
- Companion Gauging
- Standalone Total Protector
OV Protectors (OVP)

- bq2945xx
  - 8-Pin; Ext Delay

- bq2947xx
  - 8-Pin; Int Delay

- bq2944x
  - 8-SON; Ext Delay

- bq2945xx
  - 6-SON; Int Delay

- bq77PL157
  - 16-TSSOP; Ext Delay; Stackable

- Stacked bq77PL157 (2-3x)


Released Q3/11

Number of Cells Supported
Comprehensive Protectors
Full Protection Features. No F/W or MCU Needed.

Stacked bq77PL900 (2x)
48V and Beyond

Stacked bq77908/910 (2x)
48V and Beyond

bq77PL900
48-SSOP

Bq77910 A
38-TSSOP

bq77908A
38-TSSOP

Number of Cells Supported
Analog Front End for Host-Control
Pair with MCU for Ultimate Flexibility.

- **bq77PL900**
  - 48-SSOP
- **bq76925 (2x)**
  - Stacking Solution
- **bq76925**
  - 20-TSSOP/24-QFN
  - Low Cost AFE

Released Q3/11

Number of Cells Supported

- PRODUCTION
- SAMPLING
- DEVELOPMENT
- FUTURE
**bq76925**

**WHAT IT IS**
- Low-Cost Analog Front End
- 3-6S
- Use with Microcontroller (MCU)
- Excellent High Accuracy

**KEY FEATURES**
- Voltage, Current, and Temperature Outputs
- Excellent Cell Voltage Accuracy
  - ±3mV @ 25°C
- Internal Cell Balancing (up to 50mA)
- Built-In Overcurrent/Short Circuit Alert
- Variable-Gain Current Sense Amplifier Supports Down To 1 mΩ Sense Resistor
- Integrated 3.3V LDO
- I2C

**ADDITIONAL DETAILS**
- Low ICC: 40uA Normal Mode, < 2uA Sleep
- 20L TSSOP or 24-pin QFN (Future)

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**Now Shipping**
Samples Available @ TI.com

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[Visit Texas Instruments website for more information](https://www.ti.com)
bq77908A & bq77910A

WHAT IT IS
- Standalone Comprehensive Protector
- 4-8S (908A) or 4-10S (910A)
- “Set It And Forget It” Convenience
- Great for Gardening Tools, Power Tools, LEV

KEY FEATURES
- Protections: OV, UV, OT, OCC, OCD, SCD
- Low-side NMOS FET Drivers
  - Parallel or Serial Configurations Both Supported
- Auto Internal Cell Balancing (up to 50mA)
- Open Wire Detection
- Integrated 3.3V LDO
- Stackable for > 10S

ADDITIONAL DETAILS
- Customer-Programmable EEPROM Configuration
- Low ICC: 50uA Normal Mode, 5uA Shutdown
- 38-Pin TSSOP

Now Shipping
EVMs, Samples Available @ TI.com
TI Enables the full Automotive Application Spectrum!

- MSA Automotive Power & Drivers
- DSP Systems Vision, Audio & Infotainment
- MSA TPMS
- Power Products Lighting & Power
- MSA Catalog
- MSA Car Information Systems
- MCU & RF Platforms & Catalog
- MSA Analog Custom
- DLP HUD & Center Stack
- Datapath Solutions LVDS-Ser/Des / Ethernet
- Battery Mgt. Solutions BMS

Texas Instruments
TI’s Value Proposition

• Complete portfolio of automotive battery management solutions

• Performance
  – Highest voltage accuracy over temperature range
  – Most reliable communications in high-noise environment

• Leading the industry in ISO26262 (ASIL) readiness
  – Only IC company with ISO26262 committee representatives
  – ASIL-D compliant today

• #1 supplier of high-volume battery management solutions

• TI + NSC: combined culture of innovation
TI Provides Passive and Active Cell Balancing Solutions for Lithium Batteries

Dissipative (Passive)
- Balance current is dissipated as heat (wasted)
- Most cost effective solution

Charge Shuffling (PowerPump™)
- Balance current is shuffled between adjacent cells
- Inductive and Capacitive options

Isolated DC-DC Balancing
- Current is moved between individual cells and module
- Can charge and discharge any cell efficiently
- Scalable to very high balance currents, fast charging
bq76PL536A-Q1
6-Channel Passive Balancing IC with Secondary Protection

Released
‘536A-Q1 Key Features

• Highly integrated
  – Built-in passive balancing control with programmable safety timer
  – Built-in secondary protection

• Supports 3-6 cells per device
  – All common chemistries – Cobalt, Iron-Phosphate, NCA, NMC, Titanates, Blends
  – Max stack height = 32 devices (192 cells)

• ASIL D achieved

• ±1mV typ. accuracy
  – 14 bit ADC with 9 input MUX
  – 6 Cell inputs, 1 “brick” (stack) input, 2 temperature inputs

• 1 Mb/s SPI communications
  – Individual device addressing or broadcast messages
  – Vertical bus (daisy chain) with no additional isolation components required

• Low power consumption

• Built-in 5V LDO + GPIO for user circuits
‘536A-Q1 Built-in Protector

- Fully independent – does NOT use ADC
- Independent bandgap reference circuit
- Fully programmable trip points, 50mV steps
- Built-in programmable filter – no false alarms!
- FAULT & ALERT pin outputs
- Parameters stored in OTP-EPROM
- 6 Cell over-voltage (OV) comparators
- 6 Cell under-voltage (UV) comparators
- 2 over-temperature (OT) comparators
- Full functionality using only 45µA
‘536A-Q1 Evaluation Board Available

- 18-cell (3 IC’s stacked) evaluation module
- Includes 2.5kV galvanic isolation for host CPU / PC
- Available now!
'536A-Q1 Evaluation Software
EM1454
14-Channel Passive Balancing Chipset
Released
EM1454 Key Features

- 14-channel monitor + passive balancing chipset
  - ±1mV typ voltage accuracy
  - 100mA balancing current
  - Each channel measures from -2V to 5.5V
  - Each module supports up to 60V max

- 8 channel temperature sensing

- Stackable

- 7 IC’s in chipset:

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMB1432</td>
<td>High-accuracy 14-channel AFE (AECQ-100)</td>
<td>Core IC</td>
</tr>
<tr>
<td>EMB1426</td>
<td>14-bit ADC (AECQ-100)</td>
<td></td>
</tr>
<tr>
<td>EMB1441</td>
<td>Precision voltage reference</td>
<td></td>
</tr>
<tr>
<td>EMB1485</td>
<td>Low-noise LDO</td>
<td>Power supply</td>
</tr>
<tr>
<td>EMB1408</td>
<td>Switching regulator</td>
<td></td>
</tr>
<tr>
<td>EMB1402</td>
<td>12-bit, 8-channel ADC for temp. sensing (AECQ-100)</td>
<td>Optional</td>
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<tr>
<td>EMB1472</td>
<td>Microprocessor reset IC</td>
<td></td>
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</table>
# Benefits of EM1454 Passive Balancing Solution

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Accuracy Cell Voltage Measurement</td>
<td>• Accurate battery cell measurement for SOH and SOC calculation and balancing</td>
<td>Improved Cell Capacity and lifetime</td>
</tr>
<tr>
<td>Low Voltage Error Drift Over Temperature</td>
<td>• Improved performance in harsh temperature environments</td>
<td>Increased safety and reliability due to precise cell data over temperature</td>
</tr>
<tr>
<td>Measures up to 14 Cells</td>
<td>• Larger battery stacks can be monitored from one IC</td>
<td>System flexibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreased system cost</td>
</tr>
</tbody>
</table>
Passive Balancing Block Diagram
EM1454 Passive Balancing Evaluation Board

- Reset
- 8 Thermistor Connector
- Stack/Ext Power Select
- 14 cell battery connector
- 12b ADC 8 input
- 8 bit MCU
- 8 bit Isolation
- UART to USB
- 14 ch AFE + 14b ADC + VREF
- Input low pass filters
- Protection Diodes
- PTC Fuses
- Shunt Resistors
- Shunt FET switches
- Input low pass filters
- 2.5kV isolation trench
- Comm Connectors (above + below)
- Config Switches
- USB Port

4 layer evaluation board
EM1454 Evaluation Software
EM1451
14-Channel Bi-Directional Active Cell Balancing + Protection Chipset

Released
# EM1451 Key Features

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active bi-directional, multi-cell balancing for 6 to 14 cells (up to 60V)</td>
<td>Reduced system BOM</td>
</tr>
<tr>
<td>±1mV typ accuracy</td>
<td>Better state-of-charge accuracy</td>
</tr>
<tr>
<td>5A bi-directional balancing current</td>
<td>Fast balancing and ability to compensate mismatches in big cells</td>
</tr>
<tr>
<td>750V stacking capability</td>
<td>Supports high voltage light-duty and heavy-duty battery packs</td>
</tr>
<tr>
<td>Up to 8 thermistor temperature inputs</td>
<td>System-level temperature sensing</td>
</tr>
<tr>
<td>Secondary protection IC</td>
<td>Independent comparator IC for secondary protection: over-voltage (OV), under-voltage (UV), and AUX (e.g., for over-temperature)</td>
</tr>
</tbody>
</table>
EM1451 Chipset

Total number of IC’s per module: 14
- 9 “core” and 5 housekeeping power supply IC’s

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Number</th>
<th>Qty/System</th>
<th>AECQ-100</th>
<th>Description</th>
<th>Category</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>EMB1432QSQ</td>
<td>1</td>
<td>Yes</td>
<td>14-channel AFE</td>
<td>Core BMS IC’s</td>
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<tr>
<td>2</td>
<td>EMB1426QMM</td>
<td>1</td>
<td>Yes</td>
<td>14-bit ADC</td>
<td>Core BMS IC’s</td>
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<td>3</td>
<td>EMB1428QSQ</td>
<td>2</td>
<td>Yes</td>
<td>7-channel gate controller</td>
<td>Core BMS IC’s</td>
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<tr>
<td>4</td>
<td>EMB1499QMH</td>
<td>2</td>
<td>Yes</td>
<td>7-channel PWM controller</td>
<td>Core BMS IC’s</td>
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<tr>
<td>5</td>
<td>EMB1412MY</td>
<td>2</td>
<td></td>
<td>Gate driver</td>
<td>Housekeeping Power Supply</td>
</tr>
<tr>
<td>6</td>
<td>EMB1433QSQ</td>
<td>1</td>
<td>Yes</td>
<td>Secondary protection IC</td>
<td>Housekeeping Power Supply</td>
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<tr>
<td>7</td>
<td>EMB1420MM</td>
<td>1</td>
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<td>Flyback controller</td>
<td>Housekeeping Power Supply</td>
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<tr>
<td>8</td>
<td>EMB1487MM</td>
<td>1</td>
<td></td>
<td>Charge pump</td>
<td>Housekeeping Power Supply</td>
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<tr>
<td>9</td>
<td>EMB1437MP</td>
<td>2</td>
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<td>12V linear regulators</td>
<td>Housekeeping Power Supply</td>
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<tr>
<td>10</td>
<td>EMB1464MH</td>
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<td>Dual switching regulator (5V)</td>
<td>Housekeeping Power Supply</td>
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<tr>
<td>11</td>
<td>EMB1402QMT</td>
<td>1</td>
<td>Yes</td>
<td>12-bit temp sense ADC</td>
<td>Optional: implementation-specific</td>
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<tr>
<td>12</td>
<td>EMB1424MF</td>
<td>1</td>
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<td>MCU reset IC</td>
<td>Optional: implementation-specific</td>
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<tr>
<td>13</td>
<td>ISO7521</td>
<td>1</td>
<td></td>
<td>Isolator IC for communications</td>
<td>Implementation-specific</td>
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<tr>
<td>14</td>
<td>SN65HVDA1040</td>
<td>1</td>
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<td>CAN transceiver</td>
<td>Implementation-specific</td>
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</tbody>
</table>
EM1401 BMS Module Architecture

Isolated DC-DC Balancing
- Current is moved between individual cells and module
- Can charge and discharge any cell efficiently
- Scalable to very high balance currents, fast charging

Balance up to 14 cells
- Current source/sink
- Precise voltage, temperature measurements
- Powered from stack
- Full software control

Multiple battery modules stack to form a larger pack

Battery Module
- 14 Channel AFE
- Active Cell Balancing
- Secondary Protection

Stack <750V

High Speed Isolated CAN Bus
Protection/Safety Comms
Protocol Comms
EM1401 BMS Pack Architecture

- Scalable to 750V+ pack
- Standard CAN bus interface between modules and pack controller
  - Basic commands and enumeration based on J1939
- Dual safety/protection layers

Number of Packs is Pack Voltage Limited

Battery Pack Controller

- Pack SOH, SOC, History
- I/O
- CAN Bus

Stack Current Sense

Vehicle Comms

Contactor
EM1401 Active Balancing Eval Board

- Battery harness connector
- Temp sense connector
- CAN connector
- Ext power supply
- Converter Circuit
- Switch Matrix
- Isolated Comms
- Housekeeping Power
- AFE
- Battery harness connector (upstream & downstream, secondary protection)
- PING connectors
EM1401 Evaluation Software
Thank You!