

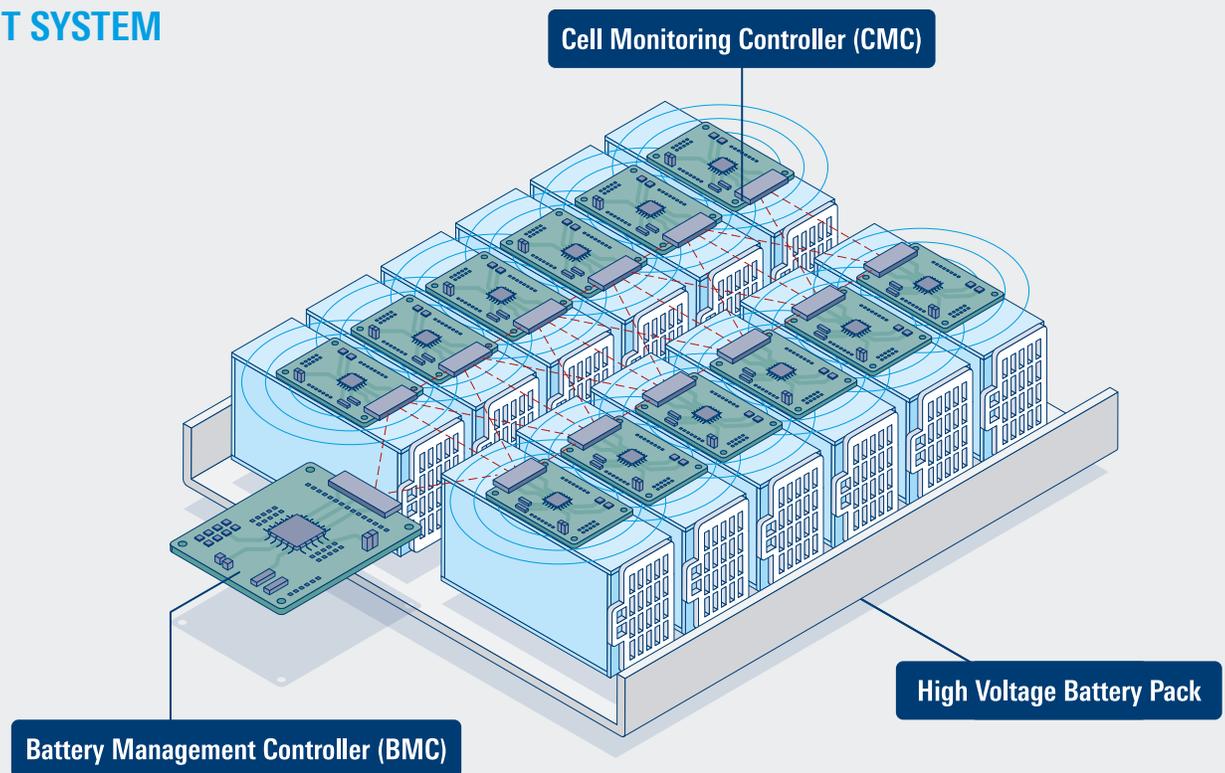
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WIRELESS ULTRA-WIDEBAND BATTERY MANAGEMENT SYSTEM PRODUCTION TEST SOLUTION FROM ROHDE & SCHWARZ

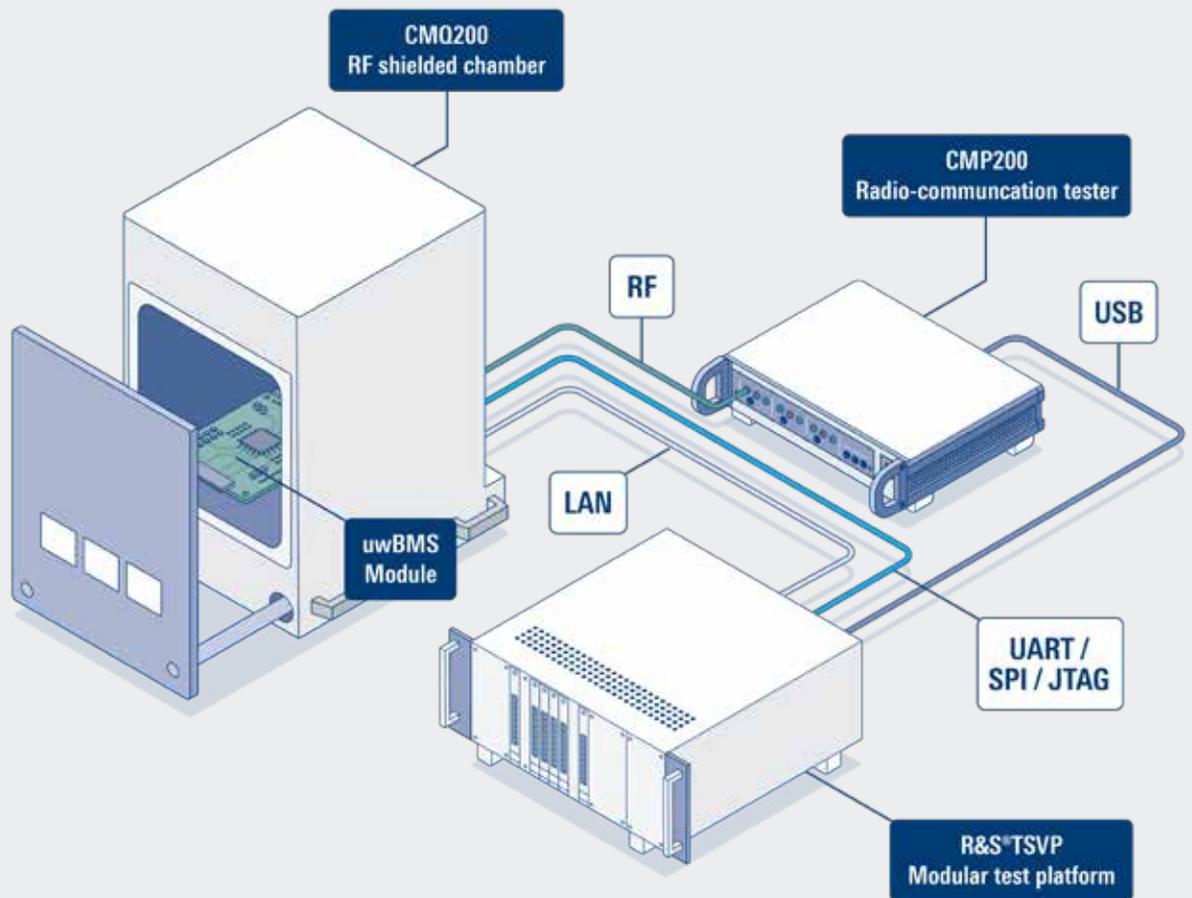
WIRELESS UWB BATTERY MANAGEMENT SYSTEM (uwBMS)



In electric vehicles (EVs), efficient sensing of the most critical cell parameters (voltage, temperature and current) is essential to ensure functional safety during charging and discharging and to optimize battery capacity. Battery Management Systems (BMS) help to control the power input and output of battery cells, modules, and packs. In conventional BMS, the communication between the battery components is based on galvanic isolated wired daisy chain communication. Wired harnessing is the current industry standard but limits the design flexibility and increases the weight of the vehicle, and the required manufacturing and servicing time.

In a wireless BMS (uwBMS), each battery module is interconnected via its Cell Monitoring Controller (CMC) to a Battery Management Controller (BMC) based on a robust pulse-modulated Ultra-Wideband (UWB) 6.0 - 8.5 GHz radio integrated circuit instead of a "galvanic isolated" bus cable. UWB provides low-latency, high-reliability communication, low average power consumption, and strong multipath robustness — which together enable lighter, more modular, easier-to-design and manufacture battery packs while keeping the safety, timing and synchronization requirements that BMS functions need.

ROHDE & SCHWARZ TEST SOLUTION FOR WIRELESS UWB BMS



A UWB based BMS (uwBMS) eliminates harnesses and reduces connectors, allowing cells and modules to be added, removed, or swapped with minimal mechanical or electrical rework — enabling modular pack architectures, battery swapping, and second life redeployment.

A uwBMS module must operate reliably and robustly in an electrically noisy, multipath rich environment while ensuring strong authentication and low latency control. Production testing compounds this challenge: Beyond RF reproducibility and sub nanosecond timing verification, test systems must account for coexistence and multiplexing/interference effects. The main requirements are creating repeatable RF conditions, validating transmission accuracy and synchronization performance, performing radiated (OTA) measurements safely and repeatably, and keeping test cycle time and fixture cost within manufacturing targets.

Automated test system, optimized for mass production

Rohde & Schwarz has developed together with NXP Semiconductors Inc. an ultra-compact automated test solution for uwBMS. With this test setup all the necessary uwBMS module calibration, receiver, transmitter and DC tests can be

conducted quickly and reliably for verification in the lab and for production tests, ensuring highest throughput and yield. The test system consists of the CMP200 Radio Communication Tester, the R&S WMT Wireless Automated Testing software framework and the R&S ExpressTSVP Universal Test and Measurement Platform. Over-the-air testing of the device-under-test (DUT) is achieved in an interference-free environment using an isolated chamber such as the R&S CMO200 RF shielded box and a linear polarized Vivaldi antenna.

The CMP200 is a one-box mobile radio communication tester suitable for parallel testing of multiple UWB DUTs in non-signaling mode. It combines vector signal analyzer and arbitrary waveform (ARB) based generator functions. The CMP200 supports replay of predefined waveforms with frequency range from 6 - 20 GHz. Three switchable ports with 1 GHz bandwidth each accelerate the measurement speed.

The R&S ExpressTSVP versatile test platform architecture supports chipset interface protocols including RS232, JTAG and all relevant electrical test methods: Analog In-circuit Test (ICT), Boundary Scan Test (BS) and Functional Test (FCT) within one instrument.

This compact set up covers the UWB Tx, Rx, and DC test requirements on a production line:

Transmitter tests	Receiver tests	DC tests
Crystal Freq/Power calibration	Rx sensitivity sweep	Doze current
Tx frequency error	Rx sensitivity verify	Rx current consumption
Tx output power		Tx current consumption
Tx spectral mask		Battery cell emulation
Tx pulse mask		
Tx harmonics		

CMP200 Tx Test Automation Measurement Results

VERTX SPO BMA606s
Channel: 9, Nominal Power: 0.0, Pkt Mode: NPKI, SM Type: 1, Pkx Data Rate: DRPM_LR, Preset Code Index: 9, Pulse Shape: SymmetricdBRC

Measurement	Result	Value	Unit	Min	Max	Match	Verdict
Modulation	Reliability	0		0	0		Pass
Modulation	FreqErrorHz	-546.2225	Hz				
Modulation	FreqErrorPPM	-0.08090727	ppm				
Modulation	ChipClockError	-0.1027057	µps	-20.0	20.0		Pass
Modulation	NormalizedMeanSquareError	-13.51888	dB				
Modulation	SymbolModulationAccuracy	0.9788694					
Modulation	SidelobePeak	0.2113094			0.3		Pass
Modulation	PulseMainlobeWidth	1.334501e-09	sec	5e-11			Pass
Modulation	SymbolTime jitterRms	5.750647e-12	sec				
Modulation	SymbolPhase jitterRms	3.610758	deg				
Modulation	ChipTime jitterRms	1.160797e-11	sec				
Modulation	ChipPhase jitterRms	4.056419	deg				
Modulation	SymbolErrorRms	0	%				
Modulation	ChipErrorRms	0	%				
Modulation	Marker	5.304807e-05	sec				
Modulation	NRMSE_SRR	7.814342	%		25.0		Pass
Modulation	NRMSE_PRR	10.44346	%		30.0		Pass
Modulation	NRMSE_PSDU	11.29881	%		30.0		Pass
Modulation	NRMSE_STS	NCAP	%		25.0		
Modulation	SVCPulseCheck	NW					
Modulation	SFDPulseCheck	NW					
Modulation	SVCPulseCheck	NW					

PASS

Test Cases	Failed
1	0

Verdicts: 13 Failed: 0
Test Time: 1.43 s

Logs

```

2025-12-19 14:40:31.231 INFO: Send CORE_GET_DEVICE_INFO_CMD (GID: 0, DID: 2) packet with 0 payload byte(s)
2025-12-19 14:40:31.243 INFO: Received CORE_GET_DEVICE_INFO_RSP (GID: 0, DID: 2) packet with 62 payload byte(s)
2025-12-19 14:40:31.248 INFO: DUT_FIRMWARE_VERSION (F, 7, 2)
2025-12-19 14:40:31.248 INFO: Send CORE_SET_CONFIG_CMD (GID: 0, DID: 4) packet with 3 payload byte(s)
2025-12-19 14:40:31.248 INFO: Received CORE_SET_CONFIG_RSP (GID: 0, DID: 4) packet with 2 payload byte(s)
2025-12-19 14:40:31.248 INFO: Send GET_TRIM_VALUES_CMD (GID: 14, DID: 80) packet with 6 payload byte(s)
2025-12-19 14:40:31.254 INFO: Received GET_TRIM_VALUES_RSP (GID: 14, DID: 80) packet with 233 payload byte(s)
2025-12-19 14:40:31.255 INFO: Executing test case
2025-12-19 14:40:31.255 INFO: Configure instrument
2025-12-19 14:40:31.562 INFO: Send SESSION_INIT_CMD (GID: 1, DID: 0) packet with 5 payload byte(s)
2025-12-19 14:40:31.562 INFO: Received CORE_SET_CONFIG_RSP (GID: 0, DID: 4) packet with 2 payload byte(s)
2025-12-19 14:40:31.567 INFO: Received SESSION_INIT_RSP (GID: 1, DID: 0) packet with 1 payload byte(s)
2025-12-19 14:40:31.567 INFO: Received SESSION_STATUS_NOTIFY (GID: 1, DID: 2) packet with 6 payload byte(s)
2025-12-19 14:40:31.577 INFO: Send SESSION_SET_APP_CONFIG_RSP (GID: 1, DID: 3) packet with 26 payload byte(s)
2025-12-19 14:40:31.577 INFO: Received SESSION_SET_APP_CONFIG_RSP (GID: 1, DID: 3) packet with 2 payload byte(s)
2025-12-19 14:40:31.577 INFO: Received SESSION_STATUS_NOTIFY (GID: 1, DID: 2) packet with 6 payload byte(s)
2025-12-19 14:40:31.581 INFO: Send TEST_START_CMD (GID: 14, DID: 32) packet with 17 payload byte(s)
2025-12-19 14:40:31.581 INFO: Received TEST_START_RSP (GID: 14, DID: 32) packet with 2 payload byte(s)
2025-12-19 14:40:31.582 INFO: Initiate measurement
2025-12-19 14:40:31.591 INFO: Send TEST_STOP_CMD (GID: 14, DID: 33) packet with 0 payload byte(s)
2025-12-19 14:40:31.595 INFO: Received TEST_STOP_RSP (GID: 14, DID: 33) packet with 1 payload byte(s)
    
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CMP200 Rx Test Automation Measurement Results

VERTX SPO BMA606s
Channel: 9, Nominal Power: 0.0, Sx Packet Structure: 0, SM Type: 1, Ardlife: Library/NXP_dccLaw

Measurement	Result	Value	Unit	Min	Max	Match	Verdict
Receiver	PER	0.0	%		10		Pass
Receiver	RSSI	-256.0	dBm				

VERTX SENS PER SEARCH BMA606s
Channel: 9, Nominal Power: 40.0, Sx Packet Structure: 0, SM Type: 1, Ardlife: Library/NXP_dccLaw

Measurement	Result	Value	Unit	Min	Max	Match	Verdict
Receiver	Sensitivity	-89.53125	dBm				
Receiver	PER@Sensitivity	0.0	%				
Receiver	RSSI@Sensitivity	-256.0	dBm				
Receiver	PER@-75.00	0.0	%				
Receiver	PER@-82.50	0.0	%				
Receiver	PER@-88.25	0.0	%				
Receiver	PER@-88.12	0.0	%				
Receiver	PER@-88.06	0.0	%				
Receiver	PER@-85.53	0.0	%				

VERTX SWEEP BMA606s
Channel: 9, Nominal Power: 40.0, Sx Packet Structure: 0, SM Type: 1, Ardlife: Library/NXP_dccLaw

Measurement	Result	Value	Unit	Min	Max	Match	Verdict
Receiver	PER @-90.00dBm	0.0	%		50		Pass

PASS

Test Cases	Failed
3	0

Verdicts: 5 Failed: 0
Test Time: 11.05 s

Logs

```

2025-12-19 14:42:50.562 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.564 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.566 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.568 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.570 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.571 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.572 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.573 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.575 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.577 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.579 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.582 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.584 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.585 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.586 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.588 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.589 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.591 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.593 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.595 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.597 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.599 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.600 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.601 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.606 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.609 INFO: Received LOG_NOTIFY (GID: 14, DID: 0) packet with 29 payload byte(s)
2025-12-19 14:42:50.611 INFO: Received SESSION_STATUS_NOTIFY (GID: 1, DID: 2) packet with 6 payload byte(s)
2025-12-19 14:42:50.613 INFO: Received TEST_STOP_NOTIFY (GID: 14, DID: 33) packet with 0 payload byte(s)
    
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Features

- ▶ R&S®ExpressTSVP cPCIe/PXIe-based modular instrument platform covering all non-RF uwBMS interfaces and controlling the entire test bench including executing the test automation software
- ▶ Parallel testing on up to 3 bidirectional RF ports of the CMP200 to further optimize asynchronous Tx and Rx tests and multi-module testing
- ▶ Complete crystal calibration & Tx/Rx tests
- ▶ R&S®CMQ200 RF shielded chamber with isolation of up to 80dB
- ▶ Python based R&S®WMT wireless test automation framework optimized for production testing with easy customizable web-based GUI for sequencing and test plan creation
- ▶ Easy 1-button test execution and automated HTML report generation

Benefits

- ▶ Easy integration of solution due to the use of standard R&S instruments
- ▶ Shorter test times through very fast DC and RF tests by the R&S®TSVP in combination with the smart channeling function (multi-port / up to 8-fold asynchronous parallel testing) of the CMP200
- ▶ Reduced maintenance effort due to in-system self-test and in-system calibration capabilities of R&S modular instruments
- ▶ Faceless, dust protected, space and energy efficient 19-inch ultra-small footprint
- ▶ World-wide service based on local application engineering support and customizable service level agreements

The solution built of proven test technology from Rohde&Schwarz, provides complete test coverage across all test cases and offers the speed and scalability necessary to ensure efficient testing from validation to production of highly complex uwBMS modules.



To find out more, please get in contact with your local R&S representative.
www.rohde-schwarz.com/automotive/BMS