



Intelligent Battery Management: The Motorola IMPRES™ Smart Energy System



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Abstract

First responders and other mission critical workers demand ready and reliable two-way radio batteries. To ensure mission success, two-way radio batteries require recharging and reconditioning for optimal performance. While in the field, two-way radio users need to know exactly how much usage they can expect from their equipment, eliminating the worry about being caught on an 8-hour shift with a 4-hour battery.

Motorola introduces the concept of intelligent, automated battery maintenance with the IMPRES™ Smart Energy System of batteries and chargers. Exclusive technology only from Motorola, IMPRES allows departments to maintain their two-way radio batteries at the most optimal performance. Designed and tested to operate in extreme conditions while providing the assurance of high battery charge capacity throughout a full shift, the IMPRES Smart Energy system boosts workforce productivity and departmental efficiency.



PMNN4066A
7.2V Li-ion IMPRESS
Battery

The Need for Reliable Batteries is Real

Shock, vibration, and electrostatic discharge (ESD) wreak havoc on electronic systems—including two-way radio batteries. Many workers depend on their two-way radios to keep them in touch and in control of their tasks. First responders, such as police and fire professionals, need radio batteries that will withstand the hazards they experience in the field. In all lines of work, equipment reliability can make the difference between success and failure.

Mission Critical Tasks Benefit From Intelligent Energy Systems

Professionals in all fields expect their equipment to be ready and reliable. Dependable two-way radio communications are a vital tool for saving lives, protecting property, and providing rapid response. In reality, improperly maintained batteries provide less than expected performance—jeopardizing the team and their mission.

Manually maintaining and reconditioning batteries stand as a time-consuming and costly chore. Mission critical radios can benefit from intelligent batteries that store usage information that the battery charger can use to determine proper reconditioning intervals. To make this possible, the battery and charger must have the ability to “talk” to each other.

Motorola – A Pioneer in Two-Way Communication Systems

With over 65 years of experience developing wireless technologies and two-way radio systems, Motorola knows what it takes to power reliable, productive, and cost-effective communication systems.

- Unmatched leadership and experience in the communications industry
- Decades of expertise in providing secure systems for mission critical and government customers
- World’s leading provider of mission critical communications networks implemented at over 100,000 sites globally
- Trusted advisor in the public safety industry
- History of supporting industry standards

Motorola’s communications solutions help customers in all markets optimize processes, improve service, and reduce downtime. Motorola has decades of expertise in building reliable communications solutions for the rigorous demands of a mission critical workforce.

The IMPRES Smart Energy System Optimizes Battery Charging and Enhances Radio Reliability

Motorola's exclusive IMPRES technology provides a communication interface between radios, batteries and chargers, which automates battery maintenance and enhances the capabilities of two-way radio systems. Batteries that are charged and maintained at their optimal levels benefit from longer life, ensuring the reliability of the radio and the safety of the mission critical worker and community.

Conventional Battery Maintenance

Optimizing battery performance requires an intelligent approach to battery maintenance. Inappropriate maintenance and overcharging are two of the leading reasons for premature battery failure.

Most apparent in Nickel-Cadmium (NiCd) batteries, but also relevant to Nickel-Metal Hydride (NiMH) batteries, "memory effect" occurs when batteries are frequently or repeatedly charged without allowing the battery to fully discharge prior to subsequent charge cycles. Memory effect manifests itself as a condition wherein the battery loses its ability to accept a full charge. This results in shorter usage time and the need to recharge more frequently. To minimize this problem, NiCd and NiMH batteries require periodic reconditioning for optimal performance.

Maintenance technicians who use conventional batteries, chargers, and reconditioners must guess at the correct reconditioning intervals, which vary due to usage patterns and may be unknown to the maintenance technician. Reconditioning too frequently wastes battery cycles, while reconditioning not often enough results in diminished battery performance and shorter lifespan—driving up equipment costs.

Leverage Motorola's Exclusive IMPRES Technology

IMPRES batteries and charging systems provide the ability to communicate through a proprietary, one-wire protocol. Each IMPRES battery contains memory to store battery historical charge and recondition/recalibration data. IMPRES chargers contain a microcontroller that manages communication between the battery and charger. Placing an IMPRES battery into an IMPRES charger triggers the charger to write data into the battery's memory listing the charge event details.

Adaptive Reconditioning Automates Battery Maintenance

During IMPRES charging, periodic automatic reconditioning and recalibration serves three purposes:

- Recalibrates batteries of all three chemistries: NiCd, NiMH, Lithium-Ion (Li-ion)
- Helps to minimize the memory effect in NiCd and NiMH batteries
- Utilizes battery data to optimally charge Lithium-Ion batteries

Motorola's IMPRES chargers evaluate the actual usage pattern of each IMPRES battery. This allows the charger to adapt to that individual battery's usage pattern and establish the optimal reconditioning and recalibration interval for that battery. IMPRES uses an adaptive algorithm, which relies on several factors to evaluate the need for reconditioning/recalibration. The system then automatically reconditions/recalibrates the battery as required. The intelligence within the IMPRES system automates the process—removing guesswork from determining the optimal reconditioning/recalibration interval.

A myth exists that suggests that IMPRES provides no value to Li-ion batteries used in two-way radios. Batteries using Li-ion cells provide significant improvements over conventional NiCd or NiMH batteries, particularly in relation to capacity vs. weight and capacity vs. volume. Two-way radios commonly require two cells in series to achieve the necessary voltage and two or more cells in parallel to accommodate the discharge rates of the higher-powered two-way radios. This requires additional attention from the charger to optimize the charge process and maintain the accuracy of the IMPRES fuel gauge. To address these needs, the IMPRES battery provides the charger the necessary information to guarantee that the system automatically manages IMPRES Li-ion batteries for optimal performance.

Common Battery Charging Realities

Critical applications demand optimal capacity to ensure that batteries meet application needs over time. Batteries require proper maintenance in order to deliver optimal service. However, each of the three primary cell technologies, NiCd, NiMH, and Li-ion, has slightly different charging requirements.

Heat is one of the key contributors to premature capacity loss, particularly in NiCd and NiMH, because they generate heat as a by-product of the charge process. The charge process generates heat either in the battery, in the charger, or both. Heat accelerates the drying of the cell electrolyte and the longer that the heat remains, the greater the effect on the battery. Minimizing unnecessary heat helps prevent this loss from occurring.

Matching the charge rate to the battery capacity helps minimize capacity loss. Conventional chargers have no way of knowing the battery capacity and, therefore, cannot distinguish between very high capacity batteries and lower capacity batteries. Conventional systems charge all batteries at the same rate (Rapid Charge), potentially leading to elevated temperatures and early capacity loss. Rapid Charging at lower rates can result in missed Rapid Charge termination, over-charge, and cell damage. After completion of Rapid Charge, conventional chargers generally trickle charge batteries as long as they remain in the charger in an attempt to prevent self-discharge or stand-loss. This frequently results in heat generation within the battery. Maintaining even low current (Trickle and/or Maintenance) after the battery is fully charged may result in overcharging the battery and prevent the battery from cooling.

As two-way radio manufacturers move toward greater use of Li-ion batteries to satisfy the needs of higher capacity and lower self-discharge, the IMPRES system stands ready to answer this vital need with smarter charging.

Long-Term Safe Charging is the Best Approach to Battery Readiness

Like conventional chargers, the IMPRES Smart Energy System uses both a rapid and a trickle/maintenance charge sequence. That is where the similarities end. IMPRES systems contain Motorola's most advanced charging algorithm, which brings many benefits associated with IMPRES, including long-term safe charging. The charger more appropriately matches the charge currents to each battery by using the charge parameter data directly from the battery. This translates to optimal charging and continuous battery monitoring once Rapid Charge completes.

Long-term safe charging allows a battery to remain in an IMPRES charger for extended periods without heat damage. Unlike conventional chargers, the IMPRES charger shuts off charge current after trickle charge, yet continues to periodically monitor the battery status. Rapid Charging restarts if the battery capacity drops below a level predetermined for each battery and stored in the battery memory.

Using this approach, the IMPRES system maintains a high state of charge without heating up and damaging the battery.



**WPLN4211A
Multi-Unit Charger**

What does “Fully Charged” Really Mean?

At manufacturing time, every battery contains a fixed amount of energy, all of which remains available for use when the battery is fully charged. Fully charging a battery generally means that the battery has completed both the Rapid Charge and Trickle charge phases of the charge process and now contains all of the energy that the battery is capable of producing.

As a battery cycles through repeated charge and discharge phases, the amount of available energy decreases. The battery remains fully charged, but will ultimately contain less energy over time. For example, a new battery when fully charged contains 100% of its initial available capacity, whereas an old battery when fully charged contains only 60% of the original capacity.

Most conventional chargers feature an indicator to display charge status. These displays vary among charger suppliers, but Motorola typically chooses red to indicate Rapid Charging and green to indicate charge complete, or fully charged. However, the user has no way of knowing battery capacity with a basic visual indicator by itself. The resulting battery capacity after charging for an old or defective battery may be far less than the capacity when the battery was new, but still indicates fully charged.

IMPRES Makes it Easier to Understand what “Fully Charged” Really Means

When lives are at stake, first responders must have more assurance than just a “still charging” or “charge completed” light. Meeting this challenge, the IMPRES Smart Energy System contains analysis capabilities typically found only in battery analyzers. With the IMPRES system, radio users can know exactly how much usage they can expect from each battery, eliminating the worry about being stuck on an 8-hour shift with a 4-hour battery.

IMPRES chargers report the following information for all chemistries in a two-line display:

- Battery serial number, kit number, and chemistry
- Battery charge capacity in milliamp hours (mAh)
- Battery charge capacity as a percentage of rated capacity
- Battery voltage
- Estimated battery capacity at end of charge in mAh
- Time remaining to complete rapid charge cycle (NiCd and NiMH only)
- Notification when a battery is approaching reconditioning

Because first responders need quick access to their equipment and may not have time to read battery status, IMPRES chargers contain an alternating red/green LED indicator warning users that batteries have fallen below a defined capacity threshold, typically 60% of rated capacity.

Motorola Radios and IMPRES Batteries Can Communicate

With this Motorola exclusive technology, IMPRES batteries can also communicate to MOTOTRBO™, XTS5000™, and XTS2500™ radios providing a migration path for future enhancements and reporting within Motorola two-way radios and accessories. The above radios contain a “fuel gauge” within the radio display that reports accurate IMPRES battery capacity information—giving workers the confidence and peace of mind they need to accomplish their mission.

Battery Compatibility Enhances Migration

IMPRES chargers are compatible with non-IMPRES batteries, making the migration to all IMPRES batteries much easier. However, adaptive reconditioning and all other IMPRES feature benefits only become a reality when using both IMPRES batteries and IMPRES chargers. In addition, IMPRES systems can charge a battery alone or while still attached to a radio.

Extended Warranty Improves Cost-Effectiveness

Because the adaptive, automatic reconditioning/re-calibration technology works only with the combination of IMPRES batteries and IMPRES chargers, IMPRES batteries charged exclusively in IMPRES chargers carry extended capacity warranties that continue six months longer than Motorola standard battery warranties.

Motorola Standard Batteries and IMPRES Batteries are Proven Tough for the Real World

Battery failure caused by adverse conditions may jeopardize a mission and its success. Shock, vibration, and electrostatic discharge (ESD) wreak havoc on electronic systems, including two-way radio batteries.

To ensure Motorola standard batteries and IMPRES batteries can withstand the toughest work environments; Motorola designs, engineers, and manufactures Motorola standard batteries and IMPRES batteries using some of the most stringent specifications and criteria in the industry. Motorola standard batteries and IMPRES batteries must pass a rigorous Accelerated Life Testing (ALT) process that simulates an estimated five years of product use by subjecting the batteries to five weeks of grueling tests.

ALT testing includes, but is not limited to, exposure to repeated cycles of humidity, vibration, temperature cycle, temperature shock, electrostatic discharge, drop, and mechanical actuations.

Proven Tough Test Results

To measure how well Motorola batteries stand up to the competition, Motorola hired an independent, outside testing service to select competitor batteries considered comparable to Motorola batteries. The testing service evaluated 30 samples of each battery type installed within Motorola's most popular two-way radios.

Motorola chose to conduct three tests representing real-world situations that occur most often during normal battery use¹:

- Being dropped on a hard surface – Drop Test
 - ▶ **Results:**88% of the Motorola batteries passed while the best competitor suffered a 67% failure rate.
- Being subjected to long periods of vibration – Vibration Test
 - ▶ **Results:**100% of the Motorola batteries passed while one competitor suffered a failure rate as high as 43%.
- Being shocked by static electricity – Electrostatic Discharge (ESD) Test
 - ▶ **Results:**100% of the Motorola batteries passed while the nearest competitor suffered a 43% failure rate.

The results of the Drop, Vibration, and ESD tests clearly demonstrate that Motorola batteries dramatically outperform competing batteries. In fact, the averages for all three tests reported a Motorola success rate of 96%, while the nearest competitor achieved only a 56% success rate.

Intrinsically Safe Batteries Help Ensure Mission Safety

First responders and fire crews routinely operate in environments that contain flammable gasses, combustible dusts, and flammable fibers. In these conditions, workers must rely on equipment that will never cause sparks or electrical discharges. Motorola's IMPRES batteries labeled as Intrinsically Safe prevent potential sparking, which could ignite flammable gasses or combustible materials. Only Motorola batteries are tested and certified with Motorola radios as a complete system—giving users complete confidence and peace of mind that the system will perform as promised.

IMPRES Meets the Public Safety Challenge

Motorola's IMPRES Smart Energy system delivers the reliability and optimal performance that today's mission critical workforce requires. Through the power of innovation and a smart communication interface, the IMPRES Smart Energy system meets the challenge of automating battery maintenance while diminishing charge memory effects and optimizing the battery life cycle. Intelligent battery management with IMPRES allows workers in the field to maintain dependable two-way communication throughout their shift—along with the peace of mind that their device will operate reliably even in tough environments.



WPLN4226A
Single Unit Charger

¹ Motorola, *How Tough Are Your Batteries?*, 2006



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