Real-Life Considerations and Benefits of the AutoResponse Feature in MRI Systems with DryCool Technology

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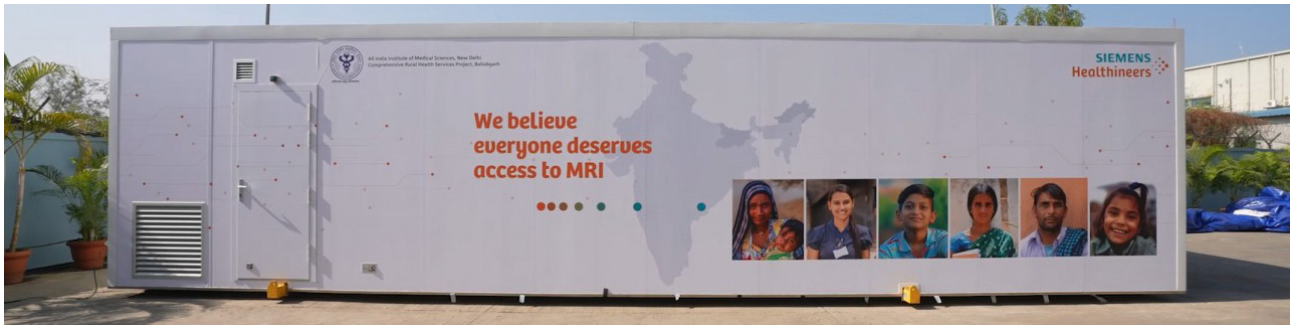
Introduction

Magnetic resonance imaging (MRI) is a cornerstone of modern diagnostic medicine, providing non-invasive insights into the human body. However, the availability of MRI services, particularly in geographically challenging or remote locations, is often restricted due to infrastructure limitations. In some countries, the most significant issue with infrastructure is the lack of a consistent and reliable electricity supply. This can range from full outages of varying duration to regular fluctuations in the available power. Conventional MRI scanners rely heavily on an uninterrupted and steady power supply to maintain the cryogenic systems that stabilize the liquid helium needed for the low temperatures that enable superconductivity in the magnet.

When electricity is interrupted for an extended period, it can disrupt the cryogenic system. This can lead to suspended cooling and, as the temperature rises, impact the superconducting capacity of the magnet. Depending on the duration and impact of the interruption, the static magnetic field may be lost entirely in a rapid event known as "magnet quench," where the entire magnetic field is converted into thermal energy. As a result, most of the helium within the magnet vessel is lost to evaporation. Recovering the magnet is highly resource-intensive: The process requires replenishing the liquid helium (which is a sparse and expensive resource with challenging logistics), and demands highly trained engineers with specialized tools to restore the functionality of the cryogenic system and the magnet. The resulting downtime, which can span multiple days, impairs patient care and escalates operational costs, rendering MRI systems less viable, especially in remote areas where access to the necessary resources is limited.

To address this shortage of resources, Siemens Healthineers introduced a revolutionary solution in the form of DryCool technology in its 0.55T MAGNETOM Free. and 1.5T MAGNETOM Flow. Platform. These systems have a cryostat with a closed magnet vessel and a practically negligible helium inventory of 0.7 liters. In addition, the low magnetic field does not cause a loss of helium, so there is no need for liquid cryogen refilling. The helium remains in the vessel and can be liquidized again once power and cooling have been reestablished. Most importantly, the system is equipped with an auto-recovery feature that reestablishes the magnetic field without the need for specialized and costly intervention. This article explores the significance of this feature, its role in improving MRI accessibility in resource-limited settings, and its potential to transform diagnostic healthcare delivery in geographically challenging regions.



Key features and discussion

1. The role of AutoResponse

AutoResponse is an automatic ramp-up feature in all systems with DryCool technology, including the MAGNETOM Flow. Platform at 1.5T and the MAGNETOM Free. Platform at 0.55T. It eliminates the dependence on manual intervention for restoring magnet functionality after a ramp-down event caused by a severe interruption to the power supply. In conventional MRI systems, this event would require replenishing of the liquid helium, specialized tools, and engineers. Systems with DryCool technology employ an innovative mechanism to automatically restore the magnetic field. Key benefits include:

No need for helium refilling: The system operates with a small amount of helium (0.7 liters). The helium deposit is sealed for life, so evaporating helium can be captured and recondensed upon restoration of the power supply.

Self-sufficient operation: Even in the event of extended power outages, the system can autonomously return to operational status once power is restored, without requiring specialized engineers or equipment.

Case study:
Power outage at AIIMS in Ballabhgarh, India
At the All India Institute of Medical Sciences (AIIMS) campus in Ballabhgarh, India, the 0.55T MAGNETOM Free.Star system demonstrated its resilience during a prolonged power outage.

Ballabhgarh is a regional center, located approximately two hours from New Delhi. There, AIIMS has established a comprehensive rural health services project (CRHSP), which is supplied with staff from the main campus in Delhi to provide a basic healthcare service to the population of Ballabhgarh.

Around five or six extended power cuts were recorded at AIIMS Ballabhgarh during an observation window in the peak summer months: A 16-hour power cut was recorded from roughly 3:50 p.m. on Sunday, July 7, 2024, to 8:10 a.m. on Monday, July 8, 2024. In general, MRI systems are backed up with a diesel generator to maintain the electricity supply, and this setup was in place during the outage. However, the diesel generator ceased operation after consuming all its diesel, cutting all power to the MRI system and causing it to ramp down at approximately 2:00 a.m. on July 8. This type of scenario can result in significant downtime for conventional MRI systems that require manual ramp-up.

However, once power was restored, the AutoResponse ramp-up mechanism on our MAGNETOM Free.Star system seamlessly activated, autonomously restoring the magnet to full operational status within roughly 4.5 hours as per the log file (Fig. 1).

```
**********EVENT LOG**********
08-07-24 12:58:48.0000  ==>  Event_Power_Software(18)
08-07-24 12:59:02.0488  ==>  Event_Compressor_Comm_Fault(33)
08-07-24 12:59:07.0855  ==>  Event_Compressor_ON(2)
08-07-24 12:59:07.0945  ==>  Event_supply_3V3_Okay(58)
08-07-24 12:59:07.0949  ==>  Event_supply_5V_Okay(60)
08-07-24 12:59:07.0949  ==>  Event_supply_15V_Okay(62)
08-07-24 12:59:07.0953  ==>  Event_supply_24V_Okay(64)
08-07-24 12:59:07.0953  ==>  Event_At_Field(66)
08-07-24 12:59:07.0957  ==>  Event_ERDU_Clear(6)
08-07-24 12:59:07.0957  ==>  Event_AutoRamp_Dbg_Mag_Ready_For_Scan_Set(74)
08-07-24 12:59:07.0957  ==>  Event_MonitorMagnetFailure_Thread_Created(100)
08-07-24 12:59:08.0230  ==>  Event_eMMC_4bit_to_1bit_Switch(96)
08-07-24 12:59:09.0402  ==>  Event_Power_Software(18)
08-07-24 13:00:24.0179  ==>  Event_RTCM_Pause_Failed(117)
```

Figure 1: Log file showing AutoResponse.

This automatic recovery to operational state happened without liquid helium refilling, specialized tools, or expert intervention. As a result, patient imaging services resumed on the same day, minimizing disruption to the clinical workflow. The event highlighted the system's efficiency in mitigating operational challenges, making it a possible MRI solution for healthcare facilities in regions prone to power outages.

2. Impact on resource-limited settings

Geographically challenging regions
Many remote and rural areas, particularly in low income countries, suffer from unstable electricity supply. Operating traditional MRI systems in these areas often requires investment in expensive and extensive power-backup solutions to safeguard the operation of the magnet. As well as adding to the cost, these measures provide no guarantee that a magnet quench and loss of helium can be avoided entirely. The helium safety combined with the AutoResponse ramp-up feature ensures that scanners with DryCool technology can maintain continuity in operations, providing reliable diagnostic imaging to underserved populations.

Cost savings and time efficiency
Cost savings: Avoiding the need for cryogen refills and reducing costly service needs translates into substantial upfront operational savings, planning certainty, and investment security.
Time efficiency: The AutoResponse feature reduces system downtime even in areas with an unstable power supply, ensuring that diagnostic services are available when needed. This is particularly vital in time-sensitive scenarios such as trauma or stroke cases.

3. Comparison with conventional systems

Downtime and service continuity
In conventional MRI systems, magnet quenches result in significant downtime due to the complexity of restoring the magnet. This downtime disrupts patient care and creates bottlenecks in diagnostic workflows due to cost and time. By contrast, DryCool technology and the AutoResponse feature minimize service interruptions, enabling practically continuous scanning and maximizing patient throughput.

Impact on the environment and resources
In conventional systems, the reliance on liquid helium not only imposes logistical challenges but also contributes to environmental concerns and costs. Liquid helium is a finite resource, and its extraction and transportation are resource intensive with a large carbon footprint. In addition, helium is a common by-product of fossil gas production. The ability of systems with DryCool technology to operate without the need for helium refills aligns with sustainable healthcare practices, reducing the ecological footprint of MRI operations and making MRI more sustainable.

4. Advancing diagnostic equity

The introduction of the MAGNETOM Free. Platform with AutoResponse has far-reaching implications for healthcare equity. By enabling reliable diagnostic imaging in areas with unreliable infrastructure, the platform bridges the gap between urban and rural healthcare access. Patients in remote areas can now benefit from timely diagnoses, which can improve health outcomes and reduce the need for costly referrals to distant healthcare facilities. Availability of and access to MRI are key factors in improving healthcare in developing countries.

Conclusion

The 0.55T MAGNETOM Free. and 1.5T MAGNETOM Flow. Platforms with AutoResponse and a sealed-for-life helium deposit that requires no refilling represent a significant leap forward in MRI technology. By addressing the challenges of power dependency, cryogen management, and operational downtime, these systems are uniquely suited for deployment in resource-constrained and geographically challenging settings.

The ability to autonomously restore magnet functionality without requiring specialized tools, engineers, or cryogen refills ensures cost-effectiveness, sustainability, and reliability. These attributes not only enhance the feasibility of MRI operations in underserved regions, but also contribute to the broader goal of equitable healthcare delivery and access to MRI for everyone, everywhere.

As healthcare systems worldwide strive to extend diagnostic services to the most remote areas, innovations to deal with infrastructural challenges are needed. By reducing costs, improving operational efficiency, and ensuring consistent service delivery, the MAGNETOM Free. Platform has the potential to transform diagnostic imaging, bringing the benefits of MRI closer to those who need it most.

Probability case for power outages in a remote MRI installation	
Frequency of power outages	Assume long power outages occur three to four times per month, or seven to eight times per quarter.
Probability of system ramp-down during long power outages	Estimate that **20%** of these outages last long enough to trigger a ramp-down event. Note that it is possible to safeguard against longer outages, but this comes at the expense of managing fuel supply to the generator.
Probability of cryogen refill and manual intervention	With conventional MRI systems (at AIIMS Ballabhgarh), every ramp-down requires a manual ramp-up that involves helium refilling, specialized tools, and trained engineers. Assume that all ramp-down cases require cryogen refilling for traditional systems.
Costs and downtime	
Helium refilling cost	Approx. $40,000 per incident (including helium and labor).
Engineering cost, and downtime	$2,000 per incident; average downtime of one to two days.
Calculation	
Incidents per quarter	Total power outages: Seven to eight times per quarter. Ramp-down events (20% of outages): 7 × 0.2 = 1.4 incidents per quarter
Cost for a conventional MRI system	Quarterly cost due to ramp-down (helium refilling + labor): **1.4 incidents × ($40,000 + $2,000) = $58,800 per quarter** **Annual cost: $58,800 × 4 = $235,200 per year**
Cost for a 0.55T MRI system with AutoResponse	No helium refilling or manual intervention required, so ramp-down recovery costs are **$0**.
Savings due to AutoResponse	For a remote MRI installation experiencing regular power outages: The AutoResponse feature eliminates the need for helium refilling and engineer intervention, saving **$58,800 quarterly** or **$235,200 annually.** It also reduces downtime, enabling continuous scanning and avoiding disruptions in patient care, which could otherwise result in lost revenue and cause delays in diagnosis.

Parameter	**Conventional MRI scanner**	**MRI scanner with DryCool technology and AutoResponse**
Power outages (per quarter)	7–8	7–8
Ramp-down events (per quarter)	1.4	1.4
Helium refill cost (quarterly)	$40,000	$0
Labor cost (quarterly)	$2,000	$0
Total quarterly cost	$58,800	$0

Disclaimer: The cost estimates provided above – including helium refilling, labor, and system downtime – are approximate values based on general market observations. Actual costs may vary significantly depending on geographic location, local helium supply chains, service provider fees, and regulatory considerations.

Abbreviations: $ = U.S. dollars (consider local currency exchanges for regional currency calculation)

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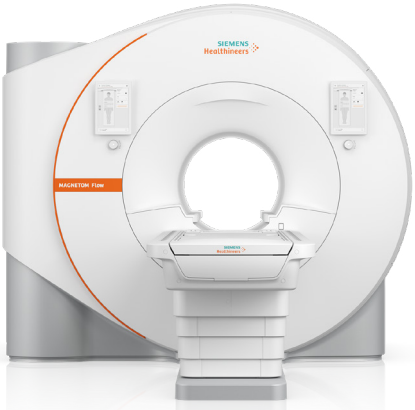
Empowering you

Learn more about the
1.5T MAGNETOM Flow. Platform



Breaking barriers

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