RHM International

HV DryShield® - RIF®

Digital Technology Solution: The BIIT™ Bushing

A Bushing with Integrated Low Power Voltage and Current Transformers

This article introduces the reader to the BIIT™ bushing technology; an intelligent HV bushing with integrated low power voltage and current transformers. The BIIT™ bushing with its safety and environmental benefits and its integrated current transformer and voltage transformer measuring and monitoring functions is no longer just an isolation component but an intelligent device that can have a big positive impact on the configuration of a substation.

BIIT™ Bushing

Background

The BIIT™ bushing was developed as a digital solution for bushing applications in T&D substations. The technologies used for the BIIT™ bushing come from products previously developed by RHM International. The condenser core insulation used is the resin impregnated fiberglass technology which was first introduced to the market in 2003 as a new transformer bushing type, the first totally dry-type paperless bushing in the industry. This bushing type utilizes a finely graded condenser design and a core insulation composed of fiberglass impregnated with epoxy resin wrapped between capacitive screens for a linear surface potential profile from the conductor to the grounded flange. The low-power measurement functions include an integrated Rogowski coil for measuring current and a capacitive voltage divider for measuring voltage. RHM International's low power system combined electronic voltage and current transformer (eVCT), which was developed for the IEC 61850 market, was the first device to use this combination of technologies.

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Some Applications for the BIIT™ Bushing: How this technology can open new and unique configurations to the systems on which it is installed

The BIIT™ bushing with its safety and environmental benefits and integrated monitoring functions is no longer just an isolation component, but an intelligent device. The BIIT™ bushing can replace traditional bushings on a transformer, providing digital transformation of the equipment.

Since no internal bushing CTs are required, there are no limiting dimensions for the bushing oil end to consider, and the size of the bushing turret can be reduced, allowing for better standardization.

Photo: RHM International, Shutterstock

GIS lineups can be simplified by using the BIIT™ bushing for its incoming connections as the current transformer and voltage transformer compartments in the GIS can be eliminated thereby reducing its overall footprint and SF6 gas volume. This type of miniaturization is particularly important for mobile substation applications, which have strict dimension and weight restrictions.

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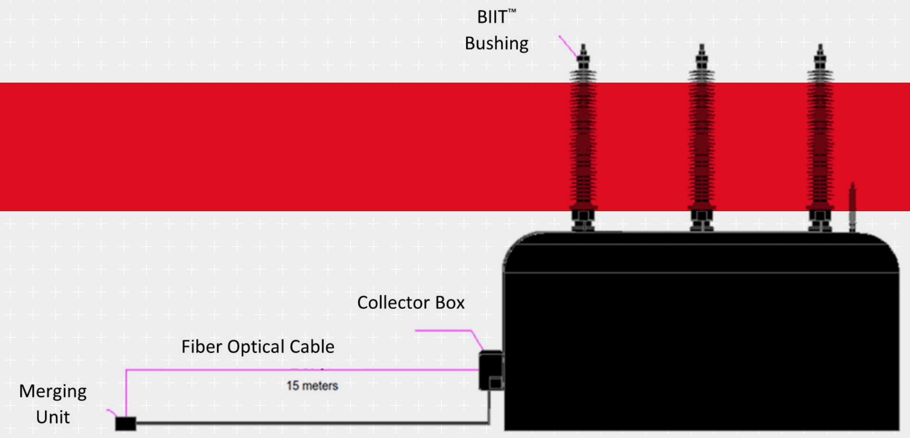

Transformer Application

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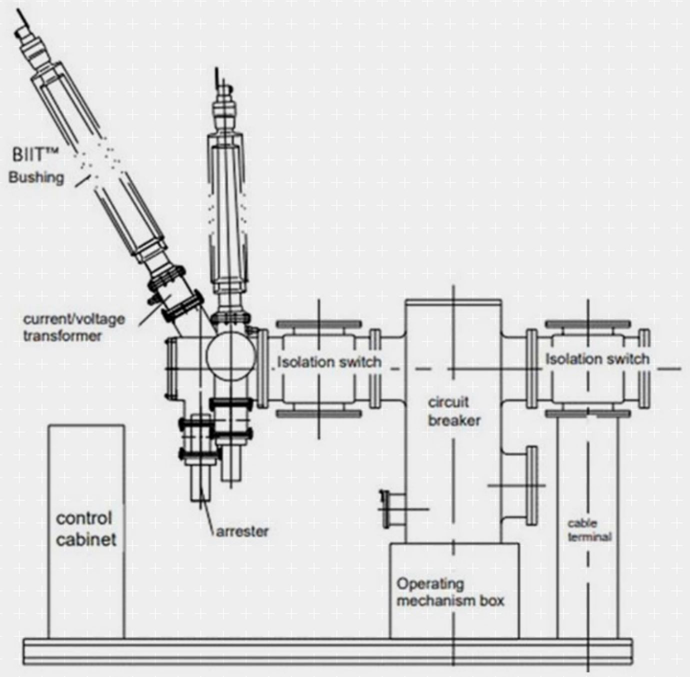
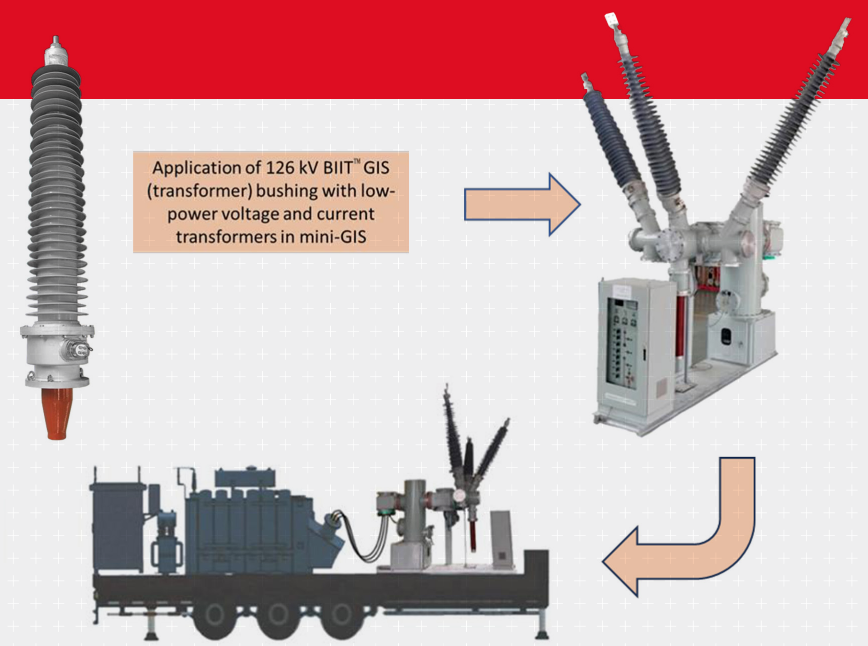


Mini-GIS Component Layout

By integrating voltage and current transformer functions with a bushing design that is explosion-proof, seismic-resistant and free of oil and gas environmental impacts, utilities can now take a forward-looking approach to replacing high failure rate, large power consumption traditional equipment.



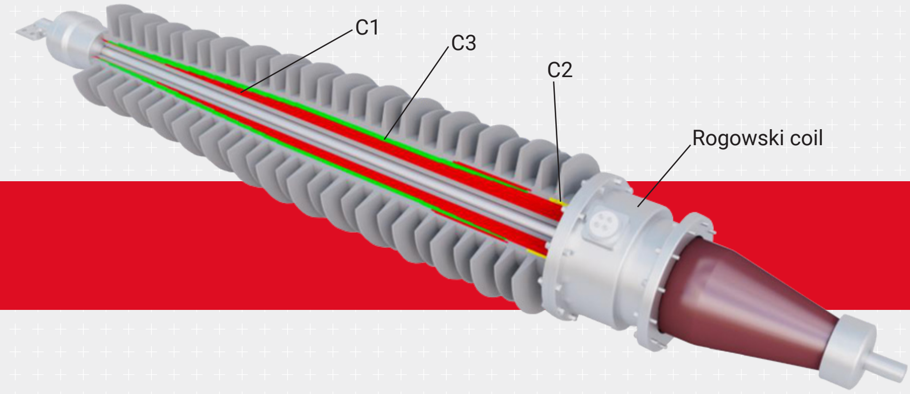
Mini-GIS Application for Mobile Substation

The BIIT™ Bushing

The BIIT™ bushing utilizes a capacitance-voltage equalizing insulation core wrapped using a trademarked composite insulating material system. The finely graded capacitor design is composed of a main capacitance C1, which withstands the voltage, a low-voltage capacitance C2, which extracts the voltage signal and an anti-interference capacitance C3. The outer insulation are silicone rubber sheds directly set on the core body. Based on the principle of capacitor voltage division, the measurement of the terminal voltage on C2 provides the signal source for the low-power voltage transformer. An anti-interference capacitance C3 effectively improves the precision of terminal voltage signal.

Photo: RHM International

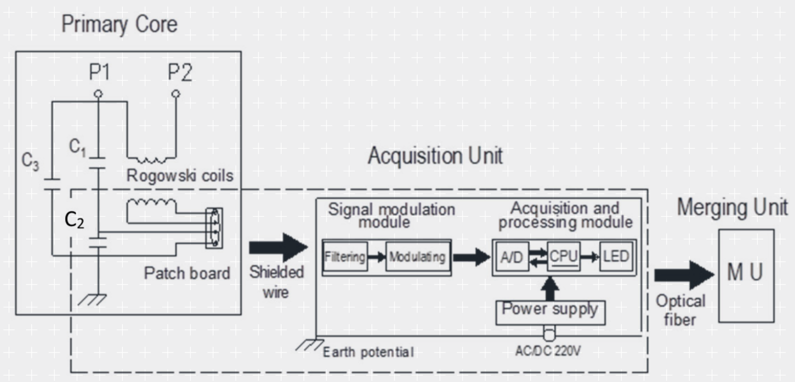
Using Faraday's electromagnetic induction principle, several large inductance hollow coils are set at ground potential inside the ground flange and outside the grounding screen to provide the signal source for the low power current transformer. An acquisition unit composed of a signal modulation module, an acquisition processing module, and a power supply module converts the analogue signals into a digital optical signal, which is sent to the merging unit via optical fiber. The merging unit combines and synchronizes the data from the acquisition unit and transmits the measured current and voltage data in the form of Sampled Values to the digital substation process bus.



Physical Structure of the BIIT™ Bushing

As the power industry prepares for a future digital grid the BIIT™ bushing offers a first step into the implementation of digital sensors in older and new substations. By integrating voltage and current transformer functions with a bushing design that is explosion-proof, seismic-resistant and free of oil and gas environmental impacts, utilities can now take a forward-looking approach to replacing high failure rate, large power consumption traditional equipment. Some application examples for the BIIT™ bushing are discussed further below.

An excellent example of the cost benefits that can be achieved with the integrated instrument transformer technology is the development of combined equipment designs for conventional AIS substation HV feeder bays.



BIIT™ Bushing Schematic

Type Testing the BIIT™ Bushing Design Criteria

In 2021 a full series of type tests in accordance with the IEC 60044-7/8 and IEC 60137 standards was successfully completed on a BIIT™ bushing prototype. The following is a brief summary of the type tests performed.

Test Object Parameters

Rated Primary Voltage: 110/√3 kV
Rated Primary Current: 2000 A
Highest Rated Voltage for Equipment: 126 kV
Power-Frequency Withstand Voltage: 255 kV
Lightning Impulse Withstand Voltage: 550 kV
Rated Short-Time Thermal Current: 40 kA, 3 s
Rated Dynamic Current: 100 kA
Rated Voltage Factor: 1.5, 30 s
Current Metering: Rogowski Coil, Accuracy Class 0.2
Current Protection: Rogowski Coil, Accuracy Class 5P
Voltage Metering: Capacitance Voltage Division, Accuracy Class 0.2
Voltage Protection: Capacitance Voltage Division, Accuracy Class 3P
Output: Digital

Type Tests Performed

Test	Requirements
Measurement of dielectric dissipation factor (tan δ) and capacitance at start and end of tests.	tan δ at 10 kV, 1.05/√3 and U_m shall not exceed 0.4% The maximum permissible increase of tan δ between 1.05/√3 and U_m shall not exceed 0.1%
Dry lightning impulse withstand	15 FW positive impulses/550 kV; 15 FW negative impulses/605 kV; 5 CW negative impulses/666 kV
Wet power-frequency withstand	230 kV, 1 min
Electromagnetic compatibility	RIV shall not exceed 500 μV at $1.1U_m/\sqrt{3}$ kV
Temperature rise	Tested at 1.2 x I_{rated} Metal parts in contact with insulation 100K/130°C Terminals 75K/105°C
Cantilever load withstand	4000 N, 1 min perpendicular to terminals
Dry lightning withstand	5 FW negative impulses/578 kV
Dry power-frequency withstand	255 kV, 1 min
Partial discharge	$<$ 10 pC at U_m, $1.5U_m/\sqrt{3}$, $1.2U_m/\sqrt{3}$ & $1.05U_m/\sqrt{3}$
Tap insulation withstand	2 kV, 1 min
Flange tightness	0.15 MPa, 15 min
Accuracy	Electronic voltage transformer: accuracy classes 0.2/3P Electronic current transformer: accuracy classes 0.2/5P
Short-time current	I_{dyn} = 100 kA; I_{th} = 40 kA, 3 s
Composite error electronic current transformer	5P20
Temperature cycle accuracy	Electronic voltage transformer errors shall meet the requirements of accuracy classes 0.2/3P under rated frequency, rated voltage and between -40°C and +40°C Electronic current transformer errors shall meet the requirements of accuracy classes 0.2/5P under rated frequency, rated voltage and between -40°C and +40°C
Visual inspection and dimensional checks	Surface of the bushing is clean and smooth.

Eric Euvrard has an extensive international engineering background having held different technical and managerial functions in Europe, USA and China in Commodities, Automotive, Aerospace, Advanced Nanomaterials and Fiber Optics Networks industries, before creating RHM International in 2005 where he presently serves as President. Eric received education in France, in the USA, and in Switzerland.

Summary

The BIIT™ bushing offers a first step into the implementation of digital sensors in older and new substations. By integrating voltage and current transformer functions with a proven bushing design that is explosion-proof, seismic-resistant and free of oil and gas environmental impacts, utilities can now take a forward-looking approach to replacing its traditional aging equipment, while improving the configuration of stations' environment.

Looking ahead, the BIIT™ bushing's integrated low power instrument transformer technology can reduce the size of equipment for future digital substations. An excellent example of the cost benefits that can be achieved with the integrated instrument transformer technology is the development of combined equipment designs for conventional AIS substation HV feeder bays. Traditional, free-standing equipment like circuit breakers, disconnectors, current and voltage transformers that make up a conventional AIS substation HV feeder bay can be combined into a single piece of equipment, making HV feeder bays more compact and economical.

Robert L. Middleton was born in 1948 in Winnipeg, Canada. He received his degree in Electrical Engineering from the University of Manitoba in 1971. He is a registered professional engineer in the Province of British Columbia. He has an extensive background in generation and transmission engineering including quality assurance. He has served on several CSA, CIGRE and IEC working groups and co-authored numerous technical papers. He is presently the Chief of Technology and Engineering for RHM International, a manufacturer of high voltage dry type current transformers, bushings and cable terminations. Prior to joining RHM International he worked over 40 years at two western Canadian provincial electrical utilities.

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