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Exploring multifunctional in the realm of transformer diagnostics

Acquiring diagnostic insight into the condition of an asset through testing has several dimensions. Foremost, testing must be safe. Having diagnostic information should deliver positive net value when weighed against the cost of its acquisition. A test instrument must effectively overcome measuring complexities that are inherent byproducts of a live power system test environment and must consistently deliver representative results.

Central to strengthening a test(s)’s value proposition is to reduce its costs and maximize its value. The savings supplied by multifunctional instruments have spurred their popularity and are considered in this article. Megger’s TRAX multifunctional instrument, specifically, not only delivers on cost reduction but delivers big on maximizing value too. True to the saying “the devil is in the details,” technically differentiating features of the TRAX strengthen its value proposition, particularly with regard to transformer diagnostics. These technical nuances and their importance will be summarized.

Savings in multifunctional

The resultant cost savings is a compelling reason to move away from separate instruments in favour of a multifunctional test set. These include:

1. Easier usability. Less operator training is required; users of separate instruments need to familiarise themselves with the quirks of each, whereas users of well-designed multifunction test sets enjoy a consistent user interface across all functions, which means that the learning process is simplified.

2. Easier manageability and transportability. Users of multifunction instruments always have all of the test facilities they need readily at hand; there is never a need to go back to the van or, worse, back to base to fetch another instrument for the next test. Plus, a single multifunction tester is much easier to transport than several individual instruments.

3. Lower upfront “side-by-side, test for test capability” costs. Multi-functional test sets cost less than the individual instruments that would be needed to cover the same range of testing requirements. Four single-function test instruments = four displays, four user interface systems, four enclosures, etc. = higher total cost than one multifunction instrument with one display, one UI system, one enclosure, etc.

4. Time savings. Multifunction test sets provide on-going savings by reducing testing time. There is only one instrument to unpack, power up and configure; the same cable set is used for a whole range of measurements, so the connections only need to be made once; and, when carrying out a range of tests, users of multifunction instruments move quickly and easily from app to app, rather than having to go from instrument to instrument.

Transformer diagnostics with Megger’s TRAX multifunctional test set

An extensive number of electrical field tests may be performed on a transformer with the Megger TRAX multifunctional test instrument, including:

- Single or three-phase (fully automated 3ф with TSX300) measurements of:
  - Turn ratio
  - Winding resistance
  - Dynamic resistance measurements on on-load tap changers (OLTC)
  - Adaptive demagnetization
  - Exciting current
  - Leakage reactance/short-circuit impedance
  - Frequency response of stray losses
  - Zero-sequence impedance

- HV tan delta/power factor (with the TDX) measurements:
  - Dielectric frequency response (1 – 500 Hz)
  - Individual temperature correction (ITC) of tan delta/power factor
  - Automatic voltage dependence de-
Together these testing capabilities allow for the assessment of the transformer windings and winding leads, the insulation, the core, and accessories (tap changers, bushings, bushing CTs and surge arresters) – the testing of all of which ultimately will verify the transformer’s whole condition. One might imagine that combining this much functionality into one instrument risks an oversized instrument with unwelcome complexity.

Navigating around potential multifunction pitfalls

Attention to “balance”, in particular, is paramount when combining multiple tests into one instrument. Desirable outputs/sources must be provided while avoiding excessive weight. Easy usability must be preserved while providing ample versatility. More specifically, a multifunctional test instrument design must:

- be capable of generating high currents and voltages yet remain easy to transport. For users with interests that cover a wide geographical area, it is highly desirable for the instrument to weigh less than the international maximum shipping weight of 32 kg for check-in luggage on passenger flights.
- alleviate the potential conflict between versatility and ease of use. There’s little point in producing a multifunction instrument that can perform a wide range of tests if many of the tests are difficult to access and set up. This only leads to user frustration and ultimately dissatisfaction with the product, however impressive its claimed abilities may be.

Megger’s TRAX, the main section of which weighs just 26 kg, excels in attaining this balance. The outputs, discussed in part below, are pragmatic. The user interface of the TRAX, which utilizes the latest colour touch-screen technology, presents functions in the form of apps (“virtual instruments”). When the user has decided what to measure and has selected the app/instrument to work with from the start screen, the display shows only those elements that are appropriate to that function. Provision is also made for full manual testing with a generic instrument app that allows the user to freely select outputs, measurement inputs and the way in which the measured data should be processed.

When it comes to transformer testing, as one example, the specific technical features of a multifunctional instrument also determine the magnitude of savings provided as well as the degree to which the value of the results are enhanced. Several technically differentiating features of the Megger TRAX are instrumental in strengthening its value proposition.
Further increasing the value proposition with Megger’s TRAX multifunction unit

Technical features that augment savings:
To increase test efficiency, Megger’s TRAX switchbox maximizes the number of transformer diagnostic tests that can be performed with one time lead connection to each bushing terminal. Rather than multiple ladder climbs to rotate lead connections after each single-phase measurement, the switching of connections between the TRAX and each successive phase is automated within the switchbox. After each of the three phases has been tested, it’s onward to the next test with no lead changes required. Not only does minimizing ladder climbs reduce overall testing time, it also reduces exposure to fall hazards. Turns ratio, winding resistance, dynamic winding resistance, exciting current, leakage reactance, frequency response of stray losses and zero sequence impedance measurements can all be performed through the use of Megger’s TRAX switchbox.

The efficiencies of a switchbox are verifiable but here, too, balance is important. Switchbox cables to each bushing terminal must be manageable, safe and affordable while the ratings of these leads remain practical for the intended tasks at hand. This is particularly important for winding resistance measurements.

Winding resistance tests are used to assess the integrity of the current carrying path between bushing terminals, detecting problems such as loose or defective connections, broken strands or high contact resistance(s) in tap changers. While simple in theory, the true resistance of the energized winding path is not immediately attainable. It is necessary to first saturate the transformer core in order to reach stability and obtain the actual winding resistance. The speed at which core saturation is reached is the cumulative effect of both applied current and voltage. There is no universal magic current threshold with which to perform a winding resistance measurement. A particular source will be sufficient to saturate the core quickly for one transformer while, for another, the same source may not be adequate. In addition, the magnitude of test current should not exceed 15% of the current rating of the winding so that heating of the winding is avoided.

When choosing a current source, the compliance voltage is also important. The compliance voltage is the maximum voltage a current source will go in its attempt to source the programmed current. A high compliance voltage is desirable. The Megger TRAX provides up to 100 A true DC at up to 50 V compliance voltage, thus

Megger’s TRAX switchbox maximizes the number of transformer diagnostic tests that can be performed with one time lead connection to each bushing terminal
After completing DC winding resistance testing, it is recommended to perform demagnetization before the transformer is put back into service, thus avoiding unnecessary high in-rush currents. Often, when a transformer trips off-line, or after applying DC test signals in, for example, a winding resistance test, the transformer core remains magnetized. All open-circuit AC tests on transformers (e.g. exciting current, SFRA, and to some extent even turns ratio), wherein a transformer is being excited and "transformer action" occurs, may be influenced by a saturated transformer. Demagnetization of the transformer is necessary to get representative results but not all demagnetization methods are created the same. The Megger TRAX method, which adapts a demagnetization cycle unique for the specific transformer design and size, is effective and fast, minimizing the time needed for a successful demagnetization.

Finally, from an insulation diagnostic perspective, the TRAX elevates power factor/\tan \delta\) measurements to a far more insightful platform, with the same differentiating features employed by the Megger's Delta 4000 series dedicated insulation power factor/dissipation factor test set. It does
Not only is Megger’s TRAX an extraordinarily balanced multifunctional instrument, it is packed with technically differentiating features that boost asset condition awareness

The value proposition of off-line electrical testing, such as for transformer diagnostics, is strengthened as the costs associated with testing are reduced and the diagnostic reach of the information grows. Multifunctional instruments, whereby the testing capability of multiple instruments is included in one, are increasing in popularity because of costs savings, including those delivered by easier usability, manageability and transportability, lower equivalent upfront costs, and reduction in test time. Balance is important with these instruments. The drive to include more testing capability (i.e. multiple power sources et al.) should not come at the expense of instrument weight and size, and its ease of use. While the power sources should not be overbuilt, they must be adequate for the test at hand.

A switchbox associated with a multifunctional instrument provides time savings in testing by minimizing the overall number of ladder climbs to complete testing. A switchbox is a junction point between the test instrument and the test specimen that “determines which track the train is routed” so that connections to bushing terminals do not have to be moved after completion of each single phase test. Balance is important here too. Switchbox cables to each bushing terminal must be manageable, safe and affordable, while the ratings of these leads remain practical for the intended tasks at hand. This is particularly important for winding resistance measurements. It is desirable, from a time perspective, to have a switchbox facilitate as many tests as possible.

Not only is Megger’s TRAX an extraordinarily balanced multifunctional instrument, it is packed with technically differentiating features that boost asset condition awareness. True dynamic (winding) resistance measurements, TRAX’s adaptive demagnetization procedure, and elevated insulation diagnostic capabilities through DFR, ITC and VDD are some examples.

For more information, visit megger.com/trax-tm

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