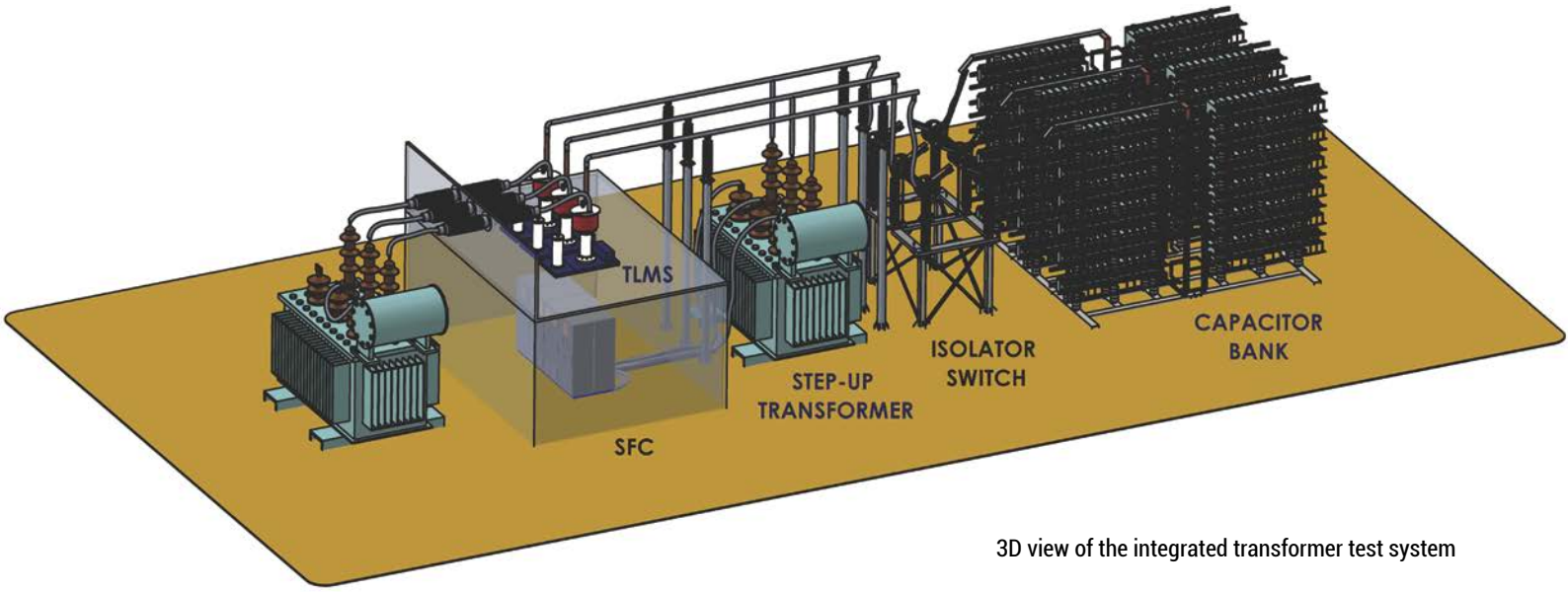
The use of Integrated Transformer Test Facilities is slowly and steadily gaining ground in power and distribution transformer industry for conducting routine, type and special tests as per IEC60076



3D view of the integrated transformer test system

Modern trends in transformer testing

The use of **Integrated Transformer Test Facilities** is slowly and steadily gaining ground in power and distribution transformer industry for conducting routine, type and special tests as per IEC60076.

The integrated transformer test facility (ITTS) is suitable for conducting the following tests:

- No-load loss, excitation current and harmonic current
- Load loss and short circuit impedance
- Temperature rise test
- Zero sequence impedance
- Induced overvoltage and partial discharge (PD) test
- No-load and on-load OLTC operation
- Long duration (LTAC) and short duration AC test (ACSD)

ITTS comprises the following major equipment:

1. **Static frequency converter (SFC)** duly fitted with sine filter, EMI filter and common mode noise rejection filter, is fully controlled from the PC with controlling and monitoring software instead of MG sets, voltage regulators and associated switchgear.

2. **Multi-tapped step-up intermediate transformer** with tap selection remotely controlled from the PC used for controlling SFC.

3. **Transformer loss measuring system** comprising of:
   - Single multi-tapped HV current comparator instead of multiple conventional CTs.
   - Single standard capacitor instead of multiple conventional PTs.
   - Signal processing electronics interface.
   - 3-phase power analyser specifically meant for low power factor measurements.
   - PC with controlling, monitoring, analysing & report generating software.

4. **Capacitor bank** meant for compensating inductive reactance at different voltage, and reactive power levels can be configured automatically or manually depending upon the customer's preference. Automation reduces the configuration time but is more expensive. The decision generally depends upon manpower cost / testing throughput required.

5. **Remote-controlled isolator switches:**
   - For connecting and disconnecting the capacitor bank.
   - For disconnecting the transformer under test immediately after the heat run test to perform winding resistance measurements.

6. **HV filter for PD applications** to attenuate high-frequency background noise in the power line.

7. **Multi-channel PD detector** for testing 3 or 6 phases simultaneously.

Static frequency converter (SFC):

SFC enables single or three-phase testing without changing its connections and allows independent setting of voltage and frequency in both single and three-phase modes

SFC is a state-of-the-art three-phase frequency converter which is built around an intelligent microprocessor control along with IGBT based converter system which uses sine wave pulse-width modulation (SPWM) for system management. SFC is available for a wide range of power handling capacities starting from 50 kVA to 500 kVA with air-cooled heat dissipation and from 500 kVA to 10,000 kVA with water-cooled heat dissipation. The input power supply to SFC is 3-phase, 3-wire, 50 / 60 Hz, which is first converted into the DC power supply, and then the AC output power supply is regenerated from this DC power supply, which allows us to control the output voltage and frequency of this regenerated AC power supply.

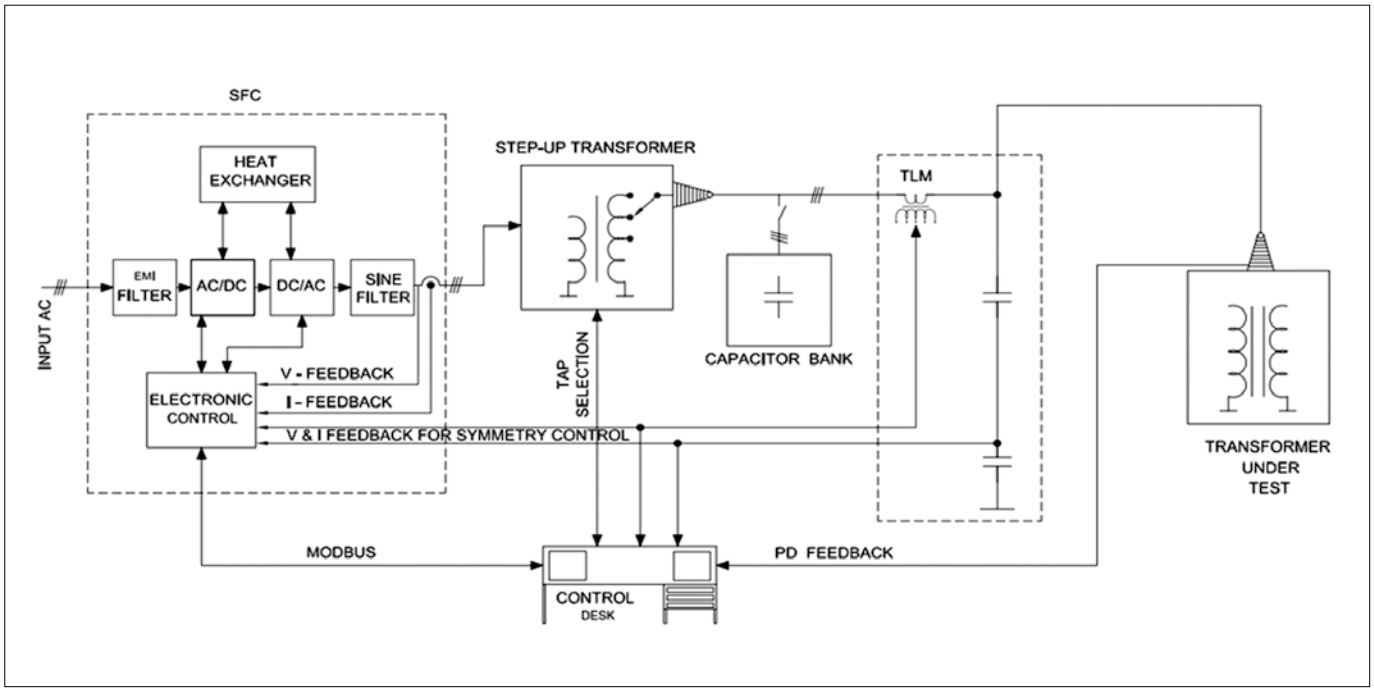
SFC is specially designed for testing all types of power and distribution transformers as it provides variable output voltage and variable output frequency. SFC equipped with customised and highly efficient electronic control and software along with filtration circuitry provides high power quality output by eliminating high-frequency distortions produced by fast-switching semiconductors (IGBTs).

Single SFC replaces 50 / 60 Hz motor-generator set, high-frequency motor-generator set, and their respective voltage regulators and switchgear conventionally used for testing transformers. The compactness of SFC makes it suitable for use in mobile test facilities as well, which was practically not possible with MG sets. Additionally, it saves significant testing time as changing connections from one MG set to another gets eliminated and also saves significant maintenance time required for regular maintenance of MG sets.

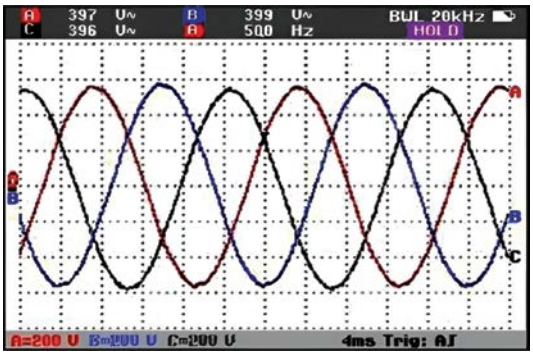
The static frequency converter maintains efficient AC power generation with typical efficiency in the range of 95–97 % to operate all types of output loads: resistive, inductive or capacitive. SFC provides overload, surge, short circuit, over-voltage and over-temperature protection to ensure the best performance and enhanced reliability. All electronic parts are cooled by forced air, and power devices are cooled by forced air or water circulation through heat sinks depending on the power rating.

SFC enables single / three-phase testing without changing its connections and allows independent setting of voltage and frequency in both single and three-phase modes. EMI filtering at the input ensures that high-frequency noise is not transferred back to the grid. Special high-frequency filtering coupled with common mode noise rejection filters allows the partial discharge measurement in a controlled shielded environment with specially designed isolated earthing. Additional low-voltage and high-voltage filters are provided for PD testing.

SFC allows the injection of harmonics in a controlled manner to test the harmonic behaviour of power/converter duty transformers under test, which is not possible with any conventional setup. High efficiency at nominal power with a controlled voltage resolution of 0.1 V and frequency resolution of 0.1 Hz is available at the output of SFC. Besides, the SFC is modular in construction, and its ratings can be enhanced at a later date if desired, and this, too, will not be possible with any conventional device.



Schematic of an integrated transformer test system



TLM uses standard current comparators instead of conventional CTs and standard capacitors instead of conventional PTs, which offers numerous advantages

Transformer loss measuring system (TLM):

TLM uses standard current comparators instead of conventional CTs and standard capacitors instead of conventional PTs. The main **advantage** of the same is:

- Current measurement for the complete range of transformers to be tested can be done using a single current comparator by remotely selecting different taps of the current comparator, thus eliminating the need of changing CTs with the change in the current requirement of the transformer under test, while still maintaining the measurement accuracy over the entire range. Typically, the current range is ranging from 50 mA to 4000 A using several taps.
- Voltage measurement for the complete range of transformers to be tested can be done using a single standard capacitor by remotely selecting the different measurement ranges, thus eliminating the need of changing PTs with the change in voltage requirement of the transformer under test while still maintaining the measurement accuracy over the entire range. Typically, the voltage range is ranging from 100 V to 200 kV using multiple divider ratios.
- Much better measurement accuracy as standard current comparators and standard capacitors have an accuracy of 0.01 % (100 ppm) as compared to 0.1 % or 0.2 % typically available with conventional CTs and PTs.

The output of standard current comparators and standard capacitors is then routed through signal processing electronics employing amplifiers to provide a wide dynamic range while still maintaining the measurement accuracy before feeding the signal to the power analyser. The signals measured by the power analyser are then transferred to the monitoring and analysing software, where all computations as per IEC requirements are done and displayed.

The signals measured by the power analyser can be transferred to the monitoring and analysing software, where all computations as per IEC requirements can be done and displayed

This software also allows the generation of the complete test report of the transformer under test.

To summarise, the main advantages of a modern integrated transformer test facility are the following:

- Reduces testing time by eliminating the need to change connections from one MG set to another, or a voltage regulator such as SFC provides variable voltage and variable frequency output.
- Reduces testing time by eliminating the need to change between different CTs/PTs for different voltage and different current requirements as ITTS covers a wide range with a single setup, thus increasing testing throughput.
- Increases measurement accuracy since the standard current comparator and the standard capacitor are 0.01 % accurate.
- Enhanced presentation capabilities due to customised report generation features.
- Reduces infrastructure costs as SFC is much more compact as compared to MG set, voltage regulator and all the associated switchgear and elimination of multiple CTs and PTs from the system also saves precious space in the test lab.
- Reduces acoustic noise pollution due to the lack of any moving parts in SFC.
- Reduced turn-on time / warm-up time from minutes to seconds.
- Compact control system with better aesthetics requires less space in the control room.
- Allows remote diagnostics, thus reducing downtime significantly.

Author

Anil Uppal – Managing Director of **KVTEK Power Systems** (www.kvtek.in) – the leading high voltage test and measuring equipment manufacturer with over 15 years of experience in this field and a customer base in more than 20 countries.