TrueIsol Technology

TrueIsol is a technology developed by SAKER as a means to improve safety, system simplicity as well as other operative figures in Medium Voltage current or voltage measurements. This paper explains the different approaches to MV measurements in the market, describes how TrueIsol works and what are its main advantages over previous solutions offered by the industry.

Current approaches to HV measurements

The main issue in dealing with MV is electrical isolation, i.e. providing safety in the low voltage parts from the MV areas because the energy present in MV power lines can be destructive to equipment and threatening to human life. As such, manufacturers have come up with different approaches over time to deal with this issue. The most common ones follow.

Power Line Frequency Inductive Transformers

Inductive transformers are a well known solution to measuring AC current or voltage. Voltage transformers are found in the phase-to-phase or phase-to-neutral varieties. The first type is heavier and more expensive due to increased isolation requirements.

The main drawbacks of inductive transformers are weight, size, inability to measure DC, load dependent accuracy and resonant frequencies amongst others.

Resistive dividers

Sometimes a simple resistive divider with a few high voltage resistors on the high side is used to scale down the voltage. It is a simple solution that however requires additional electronics to amplify the output signal to useful levels where it can be fed for example to measuring electronics or to special protection relays that accept low power signals according to IEC 61869-6.

Usually a gas discharge tube is placed at the output of the divider to prevent over voltages at the output from damaging electronics. Although this solution is simple, and can be used to measure AC and DC, it is restricted to a number of applications and specific motor protection relays.

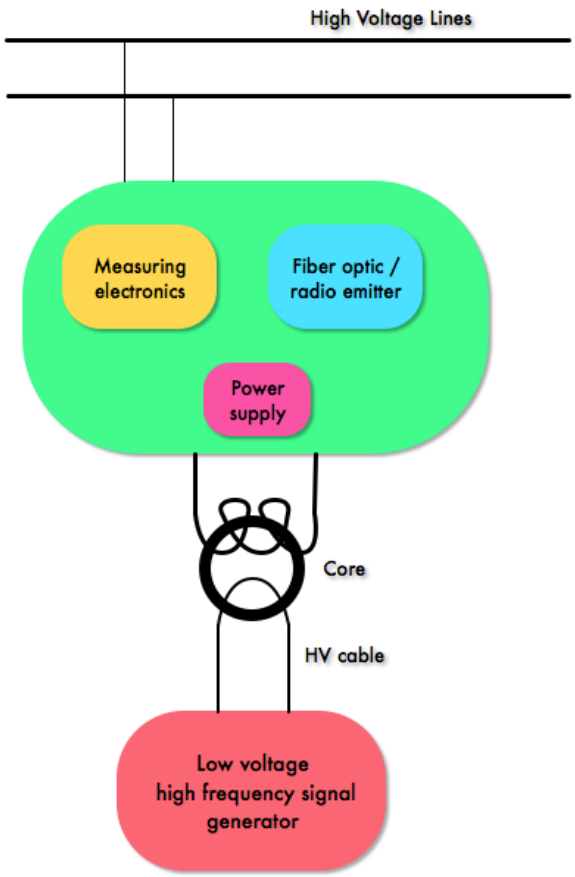
Capacitive dividers

The same concept used in resistive dividers can be used with capacitors. They won't measure DC but their response is good over high frequencies. An electronic amplifier is also needed to produce an usable signal for other electronic equipment. An advantage of this type of device is the low power dissipated in the capacitors compared to a resistive divider.

For high voltage however the low capacitance capacitor sitting at the top of the divider is critical and usually manufactured in a vacuum process which makes it expensive and available from only a few suppliers. Typical solid-filled capacitors are not recommended for use on power frequency lines since lightning impulse voltages can damage the insulation permanently.

Electronic measurement device powered by high frequency transformer

A common approach used in the industry is to use some form of measuring electronics (ie. resistive divider, amplifier, Analog to digital converter) to measure the HV voltage or current in the line. The current needed to supply the electronics comes from the secondary of a high frequency transformer. The primary consist of a high voltage cable that carries a low voltage



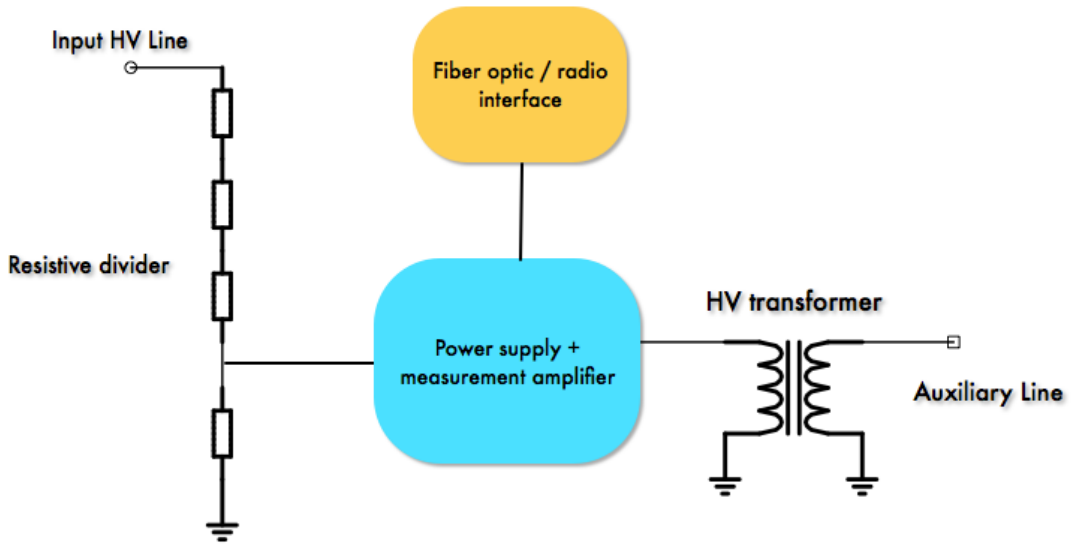
high frequency signal and its wound around a magnetic core. A voltage is induced in the secondary that once rectified and filtered can be used to supply other devices.

In this particular case the insulation between HV and LV parts is provided by the cable carrying the primary high frequency component. The drawbacks of this arrangement are increased complexity and radiated EMI from the HV cable loop in the primary that acts as an antenna.

Electronic measurement device powered by power line frequency transformer

It is also possible and sometimes seen in the industry to power the measurement electronics with an auxiliary HV inductive transformer that provides both the necessary energy and the isolation required by the system. Although this is a technically simple and viable solution it greatly increases the cost and size. Also the total system isolation is limited by the transformer, as in the previous case, not by the fiber optic or radio interface used to transmit the measured voltage or current samples.

A typical example is depicted where the HV line is sensed with a resistive divider and the measurement electronics is powered by the secondary of an inductive transformer. The resistors provide insulation and the transformer provides isolation, same as the fiber optic link. However the system isolation is limited by that of the transformer and the higher the HV present in the line, the bigger and more costly the inductive transformer has to be.

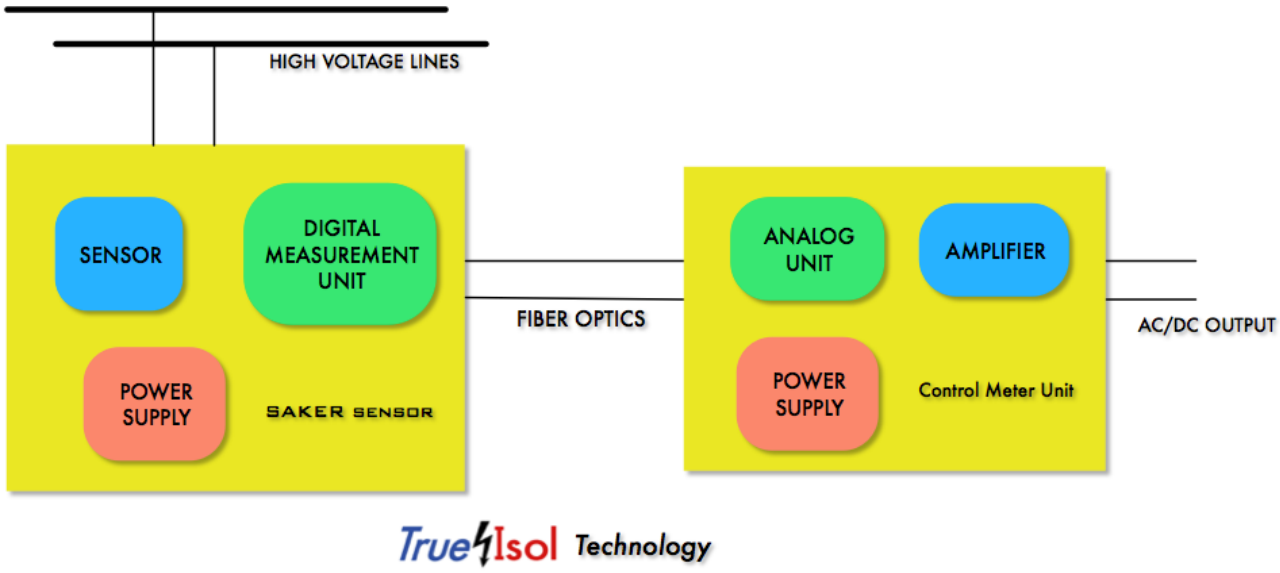


Power over fiber optic

Power-over-fiber, or PoF, is a technology in which a fiber optic cable carries optical power which is used as an energy source rather than carrying data. Usually more than one multimode fiber are used for this purpose. The receiver side is fitted with a photocell that will generate electrical current to power up the necessary circuits. This system is however expensive, specially the power laser, and the output power of the transmitting device degrades over time.

The SAKER approach

Long time ago we thought it would make sense to use the energy present in the voltage line to be measured as a way to power the necessary electronics that would measure the voltage digitally and send the information via fiber optic, i.e. create a medium or high voltage self-powered and fiber optic isolated sensor. And we did it, whether the line carries 1kV DC or 20kV AC. We call this technology TrueIsol or True Isolation, a patented technology from SAKER, since they only connection between the LV side and the HV side is made with fiber optics.



Our sensors with TrueIsol technology thus provide the following characteristics:

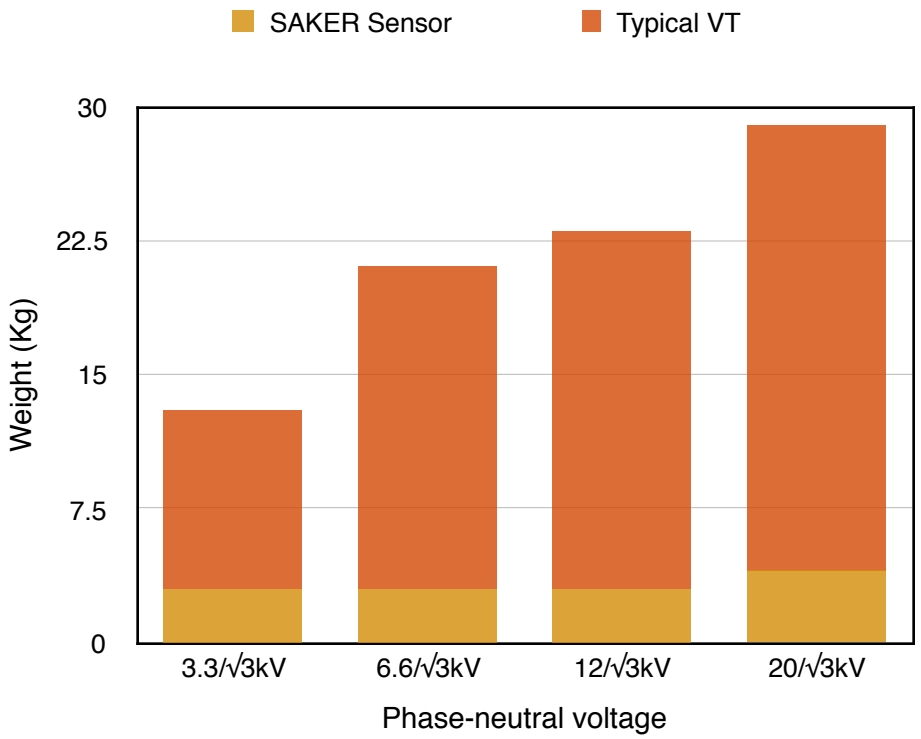
- Self-powered
- Fiber optic isolation
- Digitally modulated outputs
- AC or DC measurements

Main benefits

Less weight, smaller: transport cost savings & handling safety

Typical insulated voltage and current transformers are very heavy due to the solid casting necessary to provide electrical insulation and mechanical strength. The copper windings and the iron core adds to the final weight. This fact makes international shipping costly and slow as sometimes only road transport is economically viable. The materials supply chain is thus negatively impacted.

The next table shows weight data (in kg) of single pole inductive voltage transformers and predicted equivalent products from Saker vs line voltage. In the case of double pole insulated voltage transformers the difference is even greater because the extra insulation needed in this type of transformer clearly adds to the final weight.



Weight does not only affect costs but also creates handling safety issues when installing the transformers. Usually special cranes or the manual intervention or multiple workers are needed to move around the transformers which can create personal safety issues.

Characterized frequency response

Most high voltage sensors are not specified in their frequency response. This is true especially for inductive voltage transformers where the stated accuracy is only valid for the line frequency (50 or 60Hz). Moreover inductive VT can present multiple resonant frequencies as can be expected from any system involving inductances. These resonances can create hazardous situations when impulse lighting type voltages appear at the primary as in this cases the constant division ratio of the transformer does not hold and becomes smaller, creating larger voltage spikes at the output.

Commonly available HV resistive dividers also fail to provide spectral characteristics. In this particular case, resistive dividers act as a high-pass filter not a low-pass one contrary to popular belief. This means that over the corner frequency the resistive divider ratio will decrease not increase, outputting a signal larger than expected. As such at least the +3dB corner frequency should be stated, but it is not.

TrueIsol sensors are accurately characterized and their bandwidth is controlled depending on the application with electronic filters.

DC voltage measurement

TrueIsol devices will measure both AC and DC voltages and currents, contrary to inductive transformers that will only measure AC. This is useful for example in railway applications where some catenary lines share both a DC (3kV for example) and AC (25kVrms) voltage.

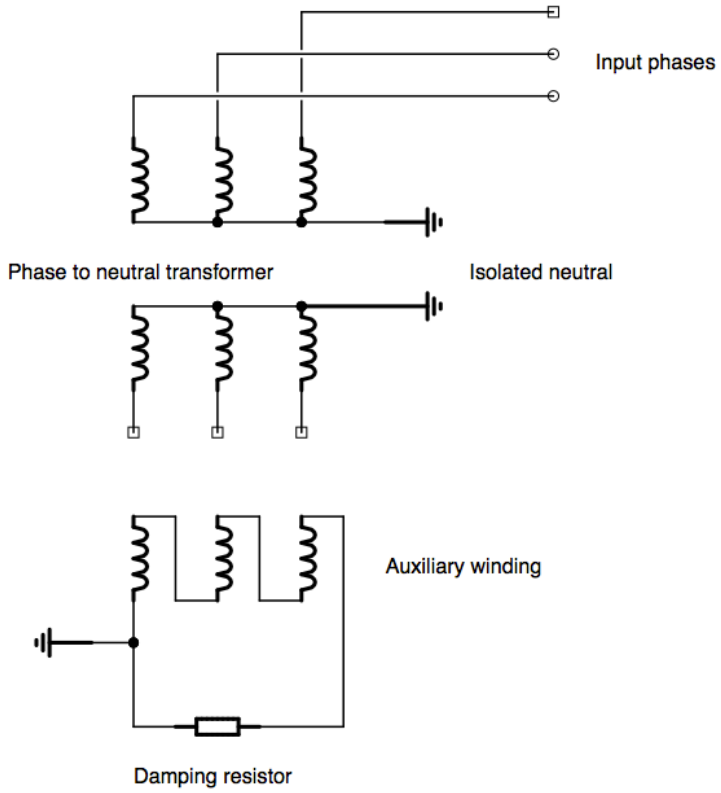
No need for fuses

The internal energy stored in TrueIsol devices at any point of operation is extremely low and that coupled with the high input impedance makes them intrinsically safe. A typical 6.6kV inductive voltage transformer has a DC input impedance in the range of some kOhms, whereas TrueIsol devices have MOhms, a 1000-fold increase. No need for fuses and fuse holders means less cost, less space and increased system simplicity.

Inductive voltage transformers, or any equipment with low input impedance needs to have its inputs protected by fuses in order to limit the inrush of currents in the event of internal failures or secondary short-circuits.

No ferroresonance

Phase to neutral inductive voltage transformers can show ferroresonance effect in systems with isolated neutrals. It is a well known and undesirable effect that can be destructive. Ferro resonance is a phenomenon characterized by over-voltages and irregular wave shapes and happens when saturable inductors (another instrument transformers...) resonate with capacitances in parallel with another inductor. Manufacturers suggest that a low value damping resistor be placed in an auxiliary secondary winding to reduce the risk of ferroresonance. Values consuming from 200W to 450W are recommended.
TrueIsol electronic sensors do not contain inductive elements and thus are resonant free.



Accuracy does not depend on load

TrueIsol sensors create an electronically controlled output that is feedback regulated. As such it will maintain its accuracy over a wide ranger of loads, frequencies and temperatures.

Resistive dividers for example need an amplifier for its output to be useful and even with such a device, most Protection Relays can not be fed with such low voltage signal as its input.

Inductive voltage and current transformers have their ratio and phase angle accuracy specified by international standards. Accuracy below a certain load (usually 5%) is not specified. It reaches minimum for the stated transformer burden and then increases again. This creates a problem with modern Protection Relays that use electronic means to measure the secondary voltage because the burden presented to the inductive transformer is usually very low. For example Siemems 7SK80 states a burden of 0.005VA at 100V which will create measurement precision problems if the protection relay is the only load present.

Reconfigurability

We can take advantage of electronics present at the Control Meter Unit and provide customer customization. For example if the sensor was ordered to provide a $110/\sqrt{3}$ output it could be later reconfigured in the field to output $100/\sqrt{3}$ with the same accuracy specifications.

Measure phase-to-neutral and phase-to-phase

Traditional sensors are ground-referenced and this applies to all resistive and capacitive dividers, limiting the scope of measurements they can make. Only the traditional and bulky inductive voltage transformer can make phase-to-phase measurements with its inherent electrical isolation.
Medium voltage SAKER sensors are self-powered and fiber-optic isolated and thus it makes no difference whether the measurement is made referenced to the neutral or to another phase.

Optical isolation advantages

Since the measurement information is transmitted over fiber optic the typical measurement improvements are obtained by using TrueIsol: increased attenuation against common mode interference, improved signal integrity in high EMI environments, remote measurements or protection against over voltage impulses.

No need for earthing shield

Typically earthing shields are included in between primary and secondary in casted inductive transformers or in any type of high frequency transformer were additional protection is needed. This creates a safety shield when dangerous voltages try to reach the secondary but usually comes at the cost of increased unit weight and cost.

With TrueIsol the isolation is provided via fiber optics and no inductive transformers, low or high frequency, are needed.

Avoids copper price volatility

Inductive transformers are made up mostly of insulating material, copper and iron. Copper shows price volatility in the metal markets and that fact will reflect in the final price of voltage transformers. This could negatively impact the forecasted cost of finished goods.
Saker sensors based on TrueIsol technology use electronic components whose price is expected to be stable over time.