Digital optics fibre current transformer



SEMINAR REPORT ON DIGITAL OPTICS FIBRE CURRENT TRANSFORMER WITH C. T POWER SUPPLY DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING ABSTRACT A digital optics fiber current transformer (CT) based on Rogowski coils and fiber transmission with excellent insulation to Electromagnetic to replace a conventional open-terminal ferrous core one for use in high voltage systems is described in this paper. The Rogowski coil generates a low-level voltage signal in proportional to the differential of the primary current.

A passive integrator is constructed from precision components to get the corresponding voltage signal of bus current. The technology of signal sampling, processing and communication for the current transformer is introduced. The large panel LCD screen displays the waveform, RMS value, frequency, periods and so on. At the same time the present supply power techniques at high voltage side are analyzed, and puts forward to a new closed-loop regulating method through tailor-made small CT to obtain stable supply power.

The experiment results verified that the designed power supply can operate normally as the current of bus is above 8A. The accuracy of current measurement is 0. 2% and the whole system can satisfy the demand of current measurement in power system. CHAPTER 1 INTRODUCTION With the rapid development of power system and the increase of voltage level of transmission and distribution, the traditional electromagnetic current transformer exposed a series of faults, such as the complex insulating construction, high manufacturing cost, combustible and explosive character and so on.

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Furthermore, not only the ratio error and phase error caused by the windings, but also nonlinear factors of the ferrous core, such as eddy current and hysteresis loss, contributed big errors that is hard anticipated to the current measurement. So it is no fit to high precision measurement and informative need of high voltage grid again. New type optics fiber current transformer is characteristic of good capability of counteraction of electromagnetic interface (EMI), wideband range, small size, light weight, low production cost, convenient setups, transmit the digital signal, conformability the tendency of modern power system.

The paper proposes a novel optics fiber current transformer, which detected the current of grid bus by Rogowski coil, then integrated the output of Rogowski coil, fulfilled analog to digital conversion and followed electro-optic transformation of the detected current on high voltage side. Subsequently, the optical pulse signal is transmitted to the microprocessor on low high side through optical fiber cable. The corresponding digital signal of measured bus current is obtained by optic electric conversion under the DSP control.

The large screen LCD displays the waveform, RMS value, frequency, period of current. CHAPTER 2 CURRENT TRANSFORMER The line in Sub-Station operates at high voltage and carries current of thousands of amperes. The measuring instrument and protective devices are designed for low voltage (generally 110V) and current (about 5A). Therefore, they will not work satisfactory if mounted directly on the power lines. This difficulty is overcome by installing Instrument transformer, on the power lines. Instrument transformers are used for measuring voltage and current in electrical power systems, and for power system protection and control. Where a voltage or current is too large to be conveniently used by an instrument, it can be scaled down to a standardized, low value. Instrument transformers isolate measurement, protection and control circuitry from the high currents or voltages present on the circuits being measured or controlled. In electrical engineering, a current transformer (CT) is used for measurement of electric currents.

Current transformers, together with voltage transformers (VT) (potential transformers (PT)), are known as instrument transformers. When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer also isolates the measuring instruments from what may be very high voltage in the monitored circuit.

Current transformers are commonly used in metering and protective relays in the electrical power industry. [pic] Current transformers are commonly used in metering and protective relays in the electrical power industry. They are identified by series connection. Tapings are taken inorder to change the turns as per required. Current transformers transform amps (current) and usually have ratios of 100/1 or 2400/1. They come in different classes and accuracy factors depending on the application which can be for instrumentation or protection.

When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. When the current in the primary exceeds the rated current, the relay coil is energized and these trip the circuit breaker. The CT used in this substation is having 4 cores. One core for metering, two cores for protection and one for special protection. [pic] 2. 1 DESIGN

Like any other transformer, a current transformer has a primary winding, a magnetic core, and a secondary winding. The alternating current flowing in the primary produces a magnetic field in the core, which then induces a current in the secondary winding circuit. A primary objective of current transformer design is to ensure that the primary and secondary circuits are efficiently coupled, so that the secondary current bears an accurate relationship to the primary current.

The most common design of CT consists of a length of wire wrapped many times around a silicon steel ring passed over the circuit being measured. The CT's primary circuit therefore consists of a single ' turn' of conductor, with a secondary of many hundreds of turns. The primary winding may be a permanent part of the current transformer, with a heavy copper bar to carry current through the magnetic core. Window-type current transformers are also common, which can have circuit cables run through the middle of an opening in the core to provide a single-turn primary winding. When conductors passing through a CT are not centered in the circular (or oval) opening, slight inaccuracies may occur. Shapes and sizes can vary depending on the end user or switchgear manufacturer. Typical examples of low voltage single ratio metering current transformers are either ring type or plastic moulded case. High-voltage current transformers are mounted on porcelain bushings to insulate them from ground. Some CT configurations slip around the bushing of a high-voltage transformer or circuit breaker, which automatically centers the conductor inside the CT window.

The primary circuit is largely unaffected by the insertion of the CT. The rated secondary current is commonly standardized at 1 or 5 amperes. For example, a 4000: 5 CT would provide an output current of 5 amperes when the primary was passing 4000 amperes. The secondary winding can be single ratio or multi ratio, with five taps being common for multi ratio CTs. The load, or burden, of the CT should be of low resistance. If the voltage time integral area is higher than the core's design rating, the core goes into saturation towards the end of each cycle, distorting the waveform and affecting accuracy. . 2 BASIC FUNCTIONS OF CURRENT TRANSFORMERS ARE: [pic] 1. To reduce the line current to a value which is suitable for standard measuring instruments relays etc 2. 2. To isolate the measuring instruments, meters, relays etc. from high voltage side an installation. 3. To protect measuring instruments against short circuit currents. 4. To sense abnormalities in current and give current signals to protective relays to isolate the defective system. There are four main factors determine the capability of current transformer ie 1. Insulation level (Service voltage) 2. Rated primary current . Short time withstand current 4. Burden and Accuracy THE CURRENT TRANSFORMERS MUST: [pic] 1. Withstand operational voltage and over voltage in the network 2. Withstand rated primary current in continuous operation without exceeding maximum allowed temperature rise. 3. Be capable o sustain thermal and mechanical stresses developed due to system fault current 4. Feed current to external circuit with specified accuracy at specified primary currents 2. 3 USAGE Current transformers are used extensively for measuring current and monitoring the operation of the power grid.

Along with voltage leads, revenue-grade CTs drive the electrical utility's watt-hour meter on virtually every building with three-phase service and single-phase services greater than 200 amp. The CT is typically described by its current ratio from primary to secondary. Often, multiple CTs are installed as a " stack" for various uses. For example, protection devices and revenue metering may use separate CTs to provide isolation between metering and protection circuits, and allows current transformers with different characteristics (accuracy, overload performance) to be used for the devices pic] FIG: Current transformers used in metering equipment for three-phase 400 ampere electric supply. 2. 4 SAFETY PRECAUTIONS Care must be taken that the secondary of a current transformer is not disconnected from its load while current is flowing in the primary, as the transformer secondary will attempt to continue driving current across the effectively infinite impedance. This will produce a high voltage across the open secondary (into the range of several kilovolts in some cases), which may cause arcing.

The high voltage produced will compromise operator and equipment safety and permanently affect the accuracy of the transformer. 2. 6 ACCURACY The https://assignbuster.com/digital-optics-fibre-current-transformer/ accuracy of a CT is directly related to a number of factors including: • Burden • Burden class/saturation class • Rating factor • Load • External electromagnetic fields • Temperature and • Physical configuration. • The selected tap, for multi-ratio CTs For the IEC standard, accuracy classes for various types of measurement are set out in IEC 60044-1, Classes 0. 1, 0. 2s, 0. 2, 0. 5, 0. 5s, 1, and 3.

The class designation is an approximate measure of the CT's accuracy. The ratio (primary to secondary current) error of a Class 1 CT is 1% at rated current; the ratio error of a Class 0. 5 CT is 0. 5% or less. Errors in phase are also important especially in power measuring circuits, and each class has an allowable maximum phase error for a specified load impedance. Current transformers used for protective relaying also have accuracy requirements at overload currents in excess of the normal rating to ensure accurate performance of relays during system faults. . 7 BURDEN The load, or burden, in a CT metering circuit is the (largely resistive) impedance presented to its secondary winding. Typical burden ratings for IEC CTs are 1. 5 VA, 3 VA, 5 VA, 10 VA, 15 VA, 20 VA, 30 VA, 45 VA & 60 VA. As for ANSI/IEEE burden ratings are B-0. 1, B-0. 2, B-0. 5, B-1. 0, B-2. 0 and B-4. 0. This means a CT with a burden rating of B-0. 2 can tolerate up to 0. 2 ? of impedance in the metering circuit before its output current is no longer a fixed ratio to the primary current.

Items that contribute to the burden of a current measurement circuit are switch-blocks, meters and intermediate conductors. The most common source of excess burden in a current measurement circuit is the conductor between the meter and the CT. Often, substation meters are located https://assignbuster.com/digital-optics-fibre-current-transformer/

significant distances from the meter cabinets and the excessive length of small gauge conductor creates a large resistance. This problem can be solved by using CT with 1 ampere secondaries which will produce less voltage drop between a CT and its metering devices. CHAPTER 3 OPTICAL CURRENT TRANSFORMER . 1 Introduction A logical step to overcome the problems caused by electromagnetic interference on the sensor signal is to use a signal transmission that is immune to electromagnetic fields. Optical signal transmission using optical fibres are the best solution for that purpose. Normally, the optical signal is not influenced by electromagnetic fields. In a suitable designed sensor however, several properties of the light that is used as the signal carrier can be influenced, e. g. intensity, state of polarization, spectral properties and phase delay.

Ideally, the sensor signal is directly generated by the interaction of the magnetic field with the sensor medium. Several such magneto optical effects are known to occur in magneto-optic active materials. The most interesting magneto-optic effect in transmission for magnetic field sensing is the Faraday effect. It causes the polarization of linearly polarized light to rotate at the presence of a magnetic field when propagating in a material exhibiting the Faraday effect. Another effect in transmission is the Zeeman effect, which causes the split of a spectral line into several components at the presence of a magnetic field.

The most important effect in reflection is the MOKE (Magneto-Optic Kerr Effect). It occurs for example in thin magnetized metal films and exists in three different geometries: The PMOKE (Polar Magneto-Optic Kerr Effect) occurs with the magnetization direction perpendicular to the surface of the https://assignbuster.com/digital-optics-fibre-current-transformer/

film, the LMOKE (Longitudinal Magneto-Optic Kerr Effect) with the magnetization in the film plane and also in the plane of incidence. In TMOKE (Transverse Magneto-Optic Kerr Effect) geometry, the magnetization direction is in the film plane but perpendicular to the plane of incidence.

These effects are for example used in magneto-optic disks for reading the data with help of the Kerr effect but are not suitable for magnetic field measurements because of their non-linearity. Other magneto-optic effects are the Voigt effect, the Cotton-Mouton effect and the Majorana effect. But not only direct magneto-optic conversion is used as a sensor principle, also different magneto-mechanic-optical or magneto-electric-mechanic-optical transducers have been presented for magnetic field sensing purposes.

Therefore, OCTs (Optical Current Transducers) are here defined as sensors that directly or indirectly use optical sensing methods to measure electrical currents. The advantage of direct magneto-optic transducers using optomagnetic active materials is the absence of additional disturbance variables caused by mechanical or electrical sensor parts such as hysteresis, saturation, induction, temperature influence and damping. Over the last 30 years, numerous current measurement systems based on optical devices have been developed.

OCTs have numerous potential advantages over conventional current transformers (CTs), depending on their sensor principle. Potential advantages are: – Immunity to electromagnetic interference (EMI) – High electrical insulation – Large bandwidth – Potentially high sensitivity – ease in signal light transmission – being compact and lightweight – potentially lowcost – no danger of explosion – ease of integration into digital control systems – No saturation – Hysteresis-free (dependent on the principle) – Passive measurement However, in most fields of application, OCTs have to compete with mature technologies.

Consequently, many customers simply desire sensor systems having good performance with reasonable price (except for special uses) and choose conventional technologies. Therefore, only few optical devices, mainly developed by the customer itself, i. e. electric power companies and electric power distributors, or major industrial companies, are field-tested and used. Optical fibre sensors have been studied extensively over the last years. Fig. 9 and Fig. 10 show the distribution of measurands and measurement technologies in optical fibre technology based on the 15th Optical Fiber Sensors Conference 2002 [Lee03].

Fig: Distribution according of papers according to measurands [pic]Fig: Distribution of papers according to used technologies The diagrams shown above illustrate that there is a big interest in optical current/voltage sensors. Fibre grating technologies have a great share of the publications (Fig. 10) partly because this technology was at an intense research phase at that time. However, OCTs not only utilize fibre sensing elements. Also other geometries and principles or hybrid devices have been proposed.

Optical Current Transducers will in the following be divided into five main groups: – OCTs based on the Faraday effect – Interferometric principles – OCTs based on Bragg gratings – Micromechanical sensors with optical readout – Other optical current sensing principles These main groups will be

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presented in the following chapters. This classification is however, not accurately defined but rather used to give an overview over the existing principles. 3. 2 OCT BASED ON FARADAYS EFFECT EXPLANATION OF FARADAYS EFFECT The Faraday effect is a magneto-optical effect that causes a change of the state of polarization of light.

Thus, the concepts of polarization and birefringence are briefly explained to give a better understanding of the Faraday Effect and the problems arising in sensor applications. Polarization Light can be regarded as a plane wave and, like all electromagnetic waves, has the electric and magnetic fields perpendicular to the direction of propagation. Conventionally, only the electric field vector E is described when speaking about polarization, since the magnetic field vector is always perpendicular and proportional to it. The two components of the electric field vector are defined as x and y components.

For a simple harmonic wave, these components vary sinusoidally with the same frequency. However, their amplitude and phase might differ, compare Fig. 11. [pic] Fig: 11 Linear, circular, elliptic, polarization Special cases of polarization are linear polarization, which only occurs when both components have the same phase (Fig. 11 a)) and circular polarization which supposes that the two components are exactly 90° out of phase and have exactly the same amplitude, Fig. 11 b). The direction of rotation of the vector depends on which of the two components is 90° ahead of the other one.

These cases are called right-hand circular polarization and left-hand circular polarization. All the other cases, where the two components differ in

amplitude or phase are called elliptical polarization, Fig. 11 c). Birefringence Birefringence, or double refraction, is the decomposition of a ray of light into an ordinary ray and an extraordinary ray when it passes through an optically anisotropic material, depending on the state of polarization of the light. One can distinguish between two different kinds of birefringence: linear birefringence and circular birefringence.

Linear birefringence occurs in an optically anisotropic material with different speeds of light propagation for different geometrical axes due to material anisotropy or geometrical constraints in an optical waveguide. The difference of the corresponding indexes of refraction [pic] is the linear birefringence. Linear polarized light passing through a linear birefringence medium experiences a phase difference in ° of [pic] where I is the length of the light path and ? 0 is the wavelength of the light. This phase difference causes a change of the polarization state and is for example used to change the state of polarization (? 4-plate). This effect may also occur in optically isotropic materials due to mechanical stress and electric and magnetic fields. Circular birefringence occurs in a material where the speed of propagation of the light is different for left-hand polarized and right-hand polarized light. The material is then called an optically active material. The difference of the two different indices of refraction, ? nc, is the circular birefringence [pic] Circular birefringence rotates the polarization of linearly polarized light by the angle [pic]

In addition to the magnetic circular birefringence, a linear birefringence can be induced by a magnetization perpendicular to the light propagation direction. This effect is called Voigt or Cotton-Mouton effect, whereas the https://assignbuster.com/digital-optics-fibre-current-transformer/

latter is often denoted to a molecule orientation effects to a magnetic field in fluids. There may also be a magnetic field dependent difference in optical absorption between the linear or the circular polarization states: MLD (Magnetic Linear Dichroism) and MCD (Magnetic Circular Dichroism). The Faraday effect The Faraday effect is named after Michael Faraday who discovered this phenomenon in 1845.

It describes the rotation of polarisation of light propagating in the direction of a magnetic field. When a beam of light is sent through a material exhibiting the Faraday effect, the polarisation of the light will be rotated by the angle ? in dependency of the magnetic field strength parallel to the light. [pic] The Faraday effect is proportional to the magnetisation of the material, [pic] where ? is the polarisation rotation, M is the magnetisation, I is the length of the light path and k a constant dependent on the propagating material, the wavelength and the temperature.

In paramagnetic and diamagnetic materials, the magnetisation and thus, also the polarisation rotation is practically proportional to the magnetic field strength . The rotation can then be described in terms of the magnetic field strength H and the Verdet constant V, [pic] The Verdet constant V is the specific rotation of a material and is defined as the angle over the magnetic Field times the length (°/T·m). [pic] V is determined by the magnetic properties of the material. B is the component of the magnetic flux density parallel to the light propagation direction.

The Faraday effect arises from the interaction of the electron orbit and the electron spin with the magnetic field. The general principle can be

understood as right-handed and left-handed circularly polarized light causing charges in a material to rotate in opposite senses. Each polarization therefore produces a contribution to the orbital angular momentum with opposite sign. A magnetic field gives rise to a spin polarization along the magnetic field direction and the spin-orbit interaction then leads to an energy contribution for the two circular polarizations having the same magnitude but with opposite sign [Blun01].

This leads to right-handed and left handed polarizations having different refractive indices in the material. A linearly polarized wave can be seen as the sum of two circularly polarized waves with equal amplitude but opposite direction of rotation. As these two waves propagate with different speeds through the material, they will acquire a phase difference proportional to the travelled distance. In terms of their sum, these two beams, when they emerge, have a phase lag between them implying that the emerging beam has a rotated plane of polarization by an angle which is equal to half the phase change.

The superposition of the left- and right-hand polarized components can be seen in Fig. 13. [pic] Fig: Polarization before and after polarization rotation This effect is non-reciprocal, meaning a light beam passing a medium twice in opposite direction acquires a net rotation twice that of a single pass. It should be noticed that according to the material, the Verdet constant is temperature- and wavelength-dependent. BLOCK DIAGRAM FOR DIGITALOPTICS FIBRE CURRENT TRANSFORMER [pic] CHAPTER 5 ROGOWSKI COIL Rogowski coils have been used for the detection and measurement of electric currents for decades.

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They operate on a simple principle. An 'air-cored' coil is placed around the conductor in a toroidal fashion and the magnetic field produced by the current induces a voltage in the coil. The voltage output is proportional to the rate of change of current This voltage is integrated, thus producing an output proportional to the current. In most cases Rogowski coils have been made by placing the winding on a long, flexible former and then bending it round the conductor, but coils wound on rigid toroidal formers have also been used. In 18871 Professor Chattock of

Bristol University used a long, flexible coil of wire as a magnetic potentiometer and made magnetic reluctance measurements in iron circuits to investigate ' the more satisfactory designing of dynamos'. [[pic] | The coils were calibrated by bringing their ends together around an electric current. A recent use of the Chattock potentiometer is in the ' El Cid' technique which was developed by the CEGB (Central Electricity Generating Board) for testing the stator cores of generators and motors2.

Rogowski and Steinhaus also described the technique in 19123. They too were interested in measuring magnetic potentials. They describe a large number of ingenious experiments to test that their coil was providing reliable measurements. Chattock and Rogowski used ballistic galvanometers for integration. The fields and currents they used were DC and measurements were made either by switching the current off and on or by quickly moving the coil-a transient measurement! With alternating currents and modern electronic integrators it is now possible to produce a far more convenient measuring system. Many other authors have subsequently described applications of Rogowski coils for current measurement In 1975 the CEGB in Harrogate investigated Rogowski coils to deal with measurement problems in the power industry where conventional methods were unsuitable. The technology was developed for producing high-accuracy, reliable and robust measuring systems. Rogowski coils soon became the preferred method of current measurement for a whole range of special measurements and investigations, both within and outside the power industry. 5. 1 Coils and Integrators Practical considerations with coil manufacture

Achieving ideal properties in a practical coil demands considerable care in its design and construction. For the coil to follow Ampere's Law well it is essential that the cross-sectional area and the turns density remain constant along the length even when the coil is bent, if it is a flexible one. Both Chattock and Rogowski were well aware of the importance of good coil geometry and both remarked that their coils left room for improvement! The more accurately the coil is made, the better it will perform. The basic requirements for a good coil give scope for a wide range of designs and sizes.

Fig. 1 shows a selection of modern coils. The flexible coil design developed and patented by the CEGB/National Power uses modern materials and is very flexible. For example, a coil with a crosssectional diameter of about 7 mm can be wrapped round a conductor less than 10 mm diameter with only a small change in sensitivity A good-quality solid coil requires a former with a very uniform cross-section and a highly uniform winding. A special toroidal

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coil winder was built by the CEGB with a control system designed specifically to provide uniform windings.

These coils are used to build high-precision measuring systems which are accurate and stable to an uncertainty of less than 0. 1%. An alternative and easier method of making a solid coil is to wind it as a set of short, straight coils and arrange these in a regular polygon. This gives a good number of sides in the polygon the better the approximation. 5. 2 MEASURING SYSTEM The addition of an integrator to the coil completes the transducer to provide a voltage which reproduces the current waveform. Fig. 2 shows a typical active system using an inverting integrator.

Other integrator designs, including passive integrators, can be used depending on the circumstances. The characteristics of an integrator are described by an integration time constant, t = CRc and a ' degeneration' time constant, T = CRf. Some form of low frequency degeneration is essential or the integrator output will drift because of thermal EMFs and offsets in the operational amplifier. In designing complete systems other factors, particularly the limitations of the operational amplifiers used, must also be taken into account.

The sensitivity of a complete system is the ratio between the current being measured and the voltage output. If M is the mutual inductance between the Rogowski coil and the conductor, the output liom the coil is given by [pic] The output of the integrator, within the designed working bandwidth, is [pic] and the sensitivity in volts per ampere is: [pic] [pic] For a given coil the sensitivity can be adjusted over an enormous range by adjusting 7. For

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example, the same flexible coil can be used to measure currents ranging from a few milliamperes to several megamperes.

With the coils themselves there is also plenty of scope for modifying their characteristics by altering the turns density and cross-sectional area. The full range of permutations of coils and integrators provides an exceptionally versatile current-measuring system. The sensitivity in volts per ampere is equivalent to a resistance and can be thought of as an ' equivalent shunt resistance'. Unlike a resistor, however, a Rogowski coil provides galvanic isolation and produces no heating. 5. 3 LINEARITY Unlike current transformers, and other ferromagnetic- cored devices, Rogowski coils are linear.

There are no effects from saturation and the mutual inductance is independent of the current being measured. The only factor limiting linearity would be an electrical breakdown in the winding caused by too high a voltage being developed across the ends of the coil. Many of the features of Rogowski coil systems that make them suitable for transient current measurements stem from this inherent linearity. The integrator is also linear within certain predictable limitations. For reliable operation the designer must be aware of the limitations and design within them.

Selection of components and circuit layout are also important in achieving high-integrity measurements. The main limitations with integrators are saturation, when the output voltage becomes too large, and a slew-rate (rate of change of output for a step input) limit, which occurs when fast current edges are being measured. By examining the output waveform it is usually obvious when saturation has occurred and it is normally a simple matter to design the integrator to ensure that the output remains in the linear range. Fig. 3 shows an example of a waveform where the slew-rate limit has been exceeded.

The effect shows up as a shift in the DC level between the start and finish of the transient. The problem is rectified by correct integrator design. 5. 4 HIGH FREQUENCIES High-frequency behaviour is obviously very important with some transient measurements. High frequencies-coils At frequencies up to a few tens of kilohertz the coil behaves as a simple mutual inductor and measurement is straightforward. At higher frequencies the self inductance and self-capacitance of the coil become significant. A simple equivalent circuit for studying high-frequency effects is shown in Fig. . If the inductive impedance of the coil is comparable with the input resistance of the integrator there can be amplitude and phase errors which depend on the coil design. For most cases the effect is small at frequencies below a few tens of KHz. For critical applications compensation circuitry can be included in the integrator. The self-capacitance & self-inductance of the coil cause a resonance. The resonant frequency is an important parameter of a Rogowski coil and is crucial to an understanding of its high-frequency behaviour. Using the equivalent circuit of Fig. the transfer function of the coil/integrator combination can be calculated (Fig. 5). The integrator input resistor, & has a damping effect and the resonance can be under damped, over-damped or critically-damped depending [[pic] | on the value of &. If a coil is to be operated close to its resonant frequency the damping conditions must be carefully considered in the design. The self-resonant frequency of a coil

depends on its size, on the winding details and, in the case of flexible coils, on the length.

Typical values are given in Table 1. The resonant frequency is also affected by whether or not the coil is fitted with an electrostatic screen, and by the length of the output cable between the coil and the integrator, since both of these introduce additional capacitance. At very high frequencies the coil behaves as a transmission line and correct termination of both ends of the coil is important. The induced voltage distribution along the length of the coil also becomes significant because of propagation time delays and this makes the output of the coil dependent on conductor position.

Integration at high — frequencies The effect of slew-rate limitations on fast current edges has already been discussed. At frequencies approaching a few hundred kilohertz, bandwidth limitations of the operational amplifier used for integration become significant and active integration using a circuit such as the one shown in Fig. 2 can be difficult. An alternative at higher frequencies is passive integration using a circuit as shown in Fig. 6. This is characterized by a time constant, T= CR and the output from the coil/integrator combination is given by eqn. . Using passive integration in conjunction with a ' low-output' coil it has been possible to measure current edges with a rise time of 0. 5 μ s. Passive integrators should be used at frequencies much greater than 1/T. If lower frequency components are present the waveform will be distorted, although a distorted waveform can sometimes be ' recovered' by operating on it mathematically Passive integrators are useful in applications where very large currents flowing for a few microseconds are measured. [pic]

Another approach to high-frequency integration is by operating the coil into a low impedance and using the inductance of the coil to perform a' self integration'. The output signal is then a current rather than a voltage and the low-frequency limit is determined by the inductance and resistance of the coil, including any termination and sensing impedances. Coils operating on this principle have been used by the CEGB/National Power for monitoring discharge pulses in high-voltage insulation. They are capable o f measuring currents in the frequency range 10 kHz-100 MHz.

Pettinga and Siersema' have described integrator circuitry that combines all three methods described above to give a very wide bandwidth system. [[pic] | 5. 5 TRANSIENT MEASUREMENTS Rogowski coil transducers have several features that make them suitable for transient measurements. Calibration Most current transducers should be calibrated using a current level similar to the one being measured to avoid any problems with nonlinearities. With large transients calibration is difficult because the current levels may be much larger than any steady current that can be generated for calibration purposes.

Rogowski coils don't suffer from this problem. Because they are linear they may be calibrated at any convenient current level and the calibration will be good for all currents including very large ones. In some transient measurements the magnitude of the current is not known in advance. A Rogowski coil may be fitted with the confidence that it will be usable at any current level. Physical characteristics [[pic]]

Rogowski coils are light-weight and compact compared with most other devices, particularly where high currents are involved. This has obvious advantages with transport and ease of installation but there are other, less obvious advantages. Thin, flexible coils can be installed in awkward places and are far less likely than any other transducers to need any modifications to be made to the plant. They can usually be fitted at any convenient time prior to testing and left until required without affecting subsequent operation or maintenance.

This contributes to increased flexibility in determining test schedules. Another advantage was discovered during overload tests on the main output connections of a generator. The application of a sudden transient of 760 kA caused the test piece to leap into the air. The Rogowski coils jumped with it and were unharmed! A heavy Passive integrator current transformer or shunt would have caused considerable damage. CHAPTER 6 HARDWARE CONSTRUCTION OF OPTICS FIBER CURRENT TRANSFORMER [pic] The Rogowski coil is widely used to detect the strong current or transient current.

The measuring principle is introduced in last section. The current i that output by Rogowski is a differential signal, then the output of integrator is input into the emitter follower, phase inverter and low-pass filter, at last realize the analog to digital conversion. IC AD7895 is used to realize analog to digital converter that is a fast 12-bit ADC with 3. 8us conversion time, high speed serial interface, 20mW low power component, the outer clock that provided by controller's SPI on the low voltage side through fiber is used to control the high speed transmit of series port. The digital electric signal is converted to optical signal by electro-optical conversion; at last the optical signal is transmitted to micro-processor on lower voltage side. The corresponding digital signal of measured current is obtained by optic-electric conversion under the DSP control. The measuring result is displayed by liquid crystal displayer (LCD). The whole system block is shown in Figure 2. CHAPTER 7 ENERGY SUPPLY ON HIGH VOLTAGE SIDE The general ways used to supply energy to high voltage side are: 1) a second toroidal TA fitted round the line provided an alternative power source.) The capacitive divider supply power. 3) Light from a laser located ground potential was transmitted by a second optics fiber to the high voltage side where the optical energy was converted into electrical energy. 4) Solar power and storage battery provided energy and so on. There is two drawbacks by small TA to supply power to high voltage side: on one hand the TA has no way to supply power normally under the condition of bus current is small enough or no-load; and on the other hand the TA protection is difficult to implement while the bus transmission current exceeds the peak values.

The supply power way by high voltage capacitive divider has these defects of stability, reliability, lower power rate that obtained from bus, bulked volume and high cost. Laser supply energy is concerned with the laser capacity, the conversion efficiency of photoelectric cell, so the laser supply power way can only provide limited power energy and the circuit design that has to meet lower power consumption requirement on high voltage side is difficult and increasing cost .

The application of solar power method is restricted due to the following fault: its output voltage fluctuated with the light intensity, surrounding and season https://assignbuster.com/digital-optics-fibre-current-transformer/

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variation, the energy conversion efficiency of photoelectric cell is lower so its supply power energy is small. Storage battery supply energy way is a simple and applicable method that the specific transformer provided the AC supply, power electronics circuit is used to charge the storage unit. But this way also has the faults of loss life of storage battery and difficulty of replacement on high voltage side.

All kinds of supply power ways have the each advantages and disadvantages, so the combination of multiform supply power ways becomes the heating topics of research, but the complex construction maybe lower down the system reliability . Based on the situation, a tailor-made transformer is used to obtain energy from the bus. In order to satisfy the need of large fluctuation of bus current, we employ the following steps to enhance the performance of system. First the core of transformer is made with a high magnetic permeability alloy materials; secondly, the control unit is used to compensate the output voltage under the small bus current.

Permeability alloy is characteristic of lower saturation flux density, small excited current, high magnetic inductive capacity. So the transformer made with permeability alloy produce adequate high voltage under the surrounding of lower bus current. Although the primary side of transformer enters the saturation state, but the core of transformer lies in unsaturated region, even if the fluctuation range of bus current is large, the secondary side output voltage will fluctuate slightly so as to provide adequate energy for high voltage side. Inductive potential on transformer secondary side E is assumed to 7V, magnetic flux density B equals to 0. 8T, the voltage power frequency f is equal to 50Hz, sectional area of magnetic core re S sets 7. 5cm2 . The potential formula is: E= 4. 44fNBS Calculates the turns number of secondary side winding N 2 as 53. In the process of fabrication the double magnetic cores and windings parallels is used to supply AC power, then AC is rectified to DC, at last the positive 5V output voltage is obtained by integral stabilized voltage module.

Amplifier should be provided the bipolarized supply power, so DC/DC converter is used to convert to+5V ±5V. CHAPTER 8 SOFTWARE The Modular programming method is adopted in software design. The several modular programs include: system initialization, interrupt process, data acquisition and disposal, date receive and transmit and so on. The flow chart of whole system is shown in Figure 3. At the beginning of program, the processor counter is initialized with the total sampling points. After finishing the remaining operations, such as writing the system outputs, the processor enters an idle state, waits the timer interrupt.

When the content of the timing counter is equal to the content of the period register, it means that the current fast sampling period has elapsed. The timer produces interruption and microprocessor executes the inner loop. The flow chart of interrupt program shows in Figure 4. When all operations in the inner loop are done, the processor again enters an idle state, till the arrival of next timer interrupt, the inner loop is repeated. After that, the program execution is repeated from the beginning of the outer loop. [[pic] |[pic] | || CHAPTER 9 EXPERIMENT RESULT AND ANALYSIS The output voltage curve of

small transformer power with the tested bus current fluctuation is shown in Figure. 5. It is shown that the output voltage of supply power on high voltage area is stable when the bus current exceeds 12A . In order to test the performance of whole optical fiber system, the power frequency voltage signal produced by [pic] table adjustable power supply as the simulation of output voltage detected by Rogowski coil; the output differential signal by Rogowski coil is integrated, then follows analog-to-digital conversion, digital signal is converted into optical pulse signal in the high voltage side. Furthermore, optical pulse signal is transmitted to the ground potential side through an optical fiber cable. At last optical signal is transformed into electrical signal, the corresponding waveform of detected bus current is display by LCD under the DSP control in Figure 6.

To inspect the precision of optical fiber current transformer, a series AC current values produced by stably adjustable power supply keeps well linear relation to measuring value by DSP in Figure 6. Experiment results also show that electronics circuit on the high voltage side can operate normally while the measured bus current exceeds 8A. [pic] Phase error is also test by a 0. 1 ? , 0. 01 level high precision resistance to sample the detected bus current, the measuring results is same as the constructed prototype, the phase error is very lower, it is shown that the phase angle difference is small adequate.

CHAPTER 10 CONCLUSION The optics fiber current transformer is characteristic of good capability of counteraction of electromagnetic interface (EMI), wideband range, small size, light weight, low production cost, convenient setups, transmit the digital signal, conformability the tendency of modern power system. The paper proposes a novel optics fiber current https://assignbuster.com/digital-optics-fibre-current-transformer/

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transformer, which detected the current of grid bus by Rogowski coil, then integrated the output of Rogowski coil, fulfilled analog to digital conversion and followed electro-optic transformation of the detected current on high voltage side

The proposed optics fiber current transformer system is feasible to use for power system with correct theory, viable scheme. Its accuracy is more than an order of magnitude better than that of class 0. 2 conventional current transformers. The design supply power on high voltage side can operate reliably while the bus current exceeds the 8A and the phase delay of whole system is so small that the measuring output value can be used to system protection. . BIBLIOGRAPHY 1. W. F. Ray, C. R.

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