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DESIGN OF A CONTINUOUS REAL TIME DIGITAL INTEGRATOR FOR A MAGNETIC COIL SIGNAL USING STELLARIS LAUNCH PAD

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ABSTRACT

The essential of an integrator is arises from the interest of finding out the displacement of the structures from its measured acceleration and the measurement of magnetic flux through the coil. It is really a big task to find the integration of continuous real time magnetic coil signal due to its offset induced drift. In this paper, a digital integration technique has been proposed to find out the magnetic measurements of toroidal magnetic coil. This integration has been free from dc offset and noise problem which usually occurs in analog integrators. This integrator has been designed and implemented using stellaris launch pad. The designed integrator has only the microvolt range of offset.

Keywords: *Drift, Integrator, Offset, Toroidal coil.*

1. INTRODUCTION

Integrator is a device which has multiple usages in engineering and scientific applications such as electronics, communication, Mechanical, software and medical applications etc. It is a substantial device for finding out the practical displacement of the structures from its measured acceleration. This has been done by amplifying the electrical signal followed by double integration. Another significant of this device is the measurement of magnetic properties like magnetic field and magnetic flux through the magnetic coil [1].

1.1 Magnetic coils

Electromagnetic coils are common conductors in electrical and electronic systems and generally have the structure of helix or spiral [2], [3]. These coils are mainly applicable in the systems like inductors, sensor coil etc in which the electric current combined with the magnetic field. This system is based on the ampere's law which states that a current through any conductor creates a circular magnetic field around the conductor [4]. The power of Ampere's law is based on the measurement of magnetic field inside a toroid. The magnetic field direction inside the toroid has been maintained same by the loop windings of toroid. The sense of the magnetic field is calculated by the right hand rule.

The main benefit of this coil structure is the improvement of the magnetic field strength by the applied current. There are number of distinct coils are available such as windings, magnetic core, electromagnets, inductors, transformers and transducers etc for practical applications.

1.2 Transducer

In electromagnetic coils, transducers are used to convert time-varying magnetic fields to electric signals, and vice versa [5]. Pick up coils and rogowski coils are the substantial classification of transducer coils, have play vital role in industrial applications. They have been used for finding the magnetic field and magnetic flux with respect to time. Rogowski coil is a toroidal coil which has been commonly used in ac measuring devices.

1.3 Toroidal coil

These coils have come under the category of passive device. The magnetic core inside the coil has generally circular, ring structured and having high magnetic permeability material such as iron powder or ferrite. Toroidal coils are used in a broad range of applications in AC electronic circuits, such as high-frequency coils and transformers. The main advantage of the toroidal coil is the minimum amount of EMI (Electromagnetic Interference) effect. Hence the circuit adjacent to it has not been much affected by this coil EMI [6].

1.4 Integrators

Integrators are the basic electronic device used to perform the mathematical operation called integration [7]. In general the time integration of

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voltage of the coil will give the magnetic flux of the coil. It can be denoted as,

$$e = N\frac{d\phi}{dt} \quad \text{--------(1)}$$

Therefore equation (1) can be rearranged by

$$\Phi = \frac{1}{N}\int_0^t e\,dt \quad \text{--------(2)}$$

where, e is the induced voltage in volts, N is the number of turns in wire coil, Φ is the Magnetic flux in Webbers and t is the Time in seconds.

2. PROPOSED METHOD

Figure1 shows the proposed digital integrator unit. This system has been composed of input unit, signal conditioning unit, amplifier unit and controller unit. The input unit consists of a power supply followed by a toroidal magnetic coil series with dummy load. The signal conditioning unit consists of active components such as pn diodes, Zener diode and passive components such as resistors and capacitor. The amplifier unit has the simple non-inverting operational amplifier. The controller unit has a stellaris launch pad with ARM controller.

2.1 Input unit

It has a toroidal magnetic coil and a dummy load. The common use of TC's is the measurement of electric current through the circuit. In TC's the secondary current is proportional to the primary current. It is generally used to control and measure current and power demand. This coil has been used to provide a large inductance and also used in low frequency applications. It is easy to attach these coils in the circuit boards and they are not much affected by external vibrations. These coils are superior to other coils and are extensively used in superconducting magnetic energy storage systems, nuclear fusion reactors, tokomak reactor, and plasma research work.

2.2 Signal conditioning unit

It has been composed of diode switches followed by a RC integrator along with Zener diode.The diode combination has been used as a switch. The output of the simple practical RC integrator can be written as follows [8][9].

$$v0(t) = -\frac{1}{RC}\int_{t0}^{t}(vi(t) + RIos - Vos)\,dt \quad \text{--------(3)}$$

The initial conditions to be v0(t)=0 at t0=0.Where vi(t) is the input signal which , Vos is the input offset voltage and Ios is the input offset current.

2.3 Amplifier unit

The amplifier unit has a simple non-inverting operational amplifier. In general non-inverting amplifiers are having high input impedance and its voltage gain is always greater than one. The equation for voltage gain is given by

$$Av = \frac{Vo}{Vin} = 1 + \frac{Rf}{R1} \quad \text{--------- (4)}$$

Where Av is the voltage gain of non-inverting amplifier. Vo is the output voltage of amplifier, Vin is the input voltage of the amplifier, Rf is the feedback resistor and R1 is the input resistor. This proposed amplifier has the Rf value of 10k and the R1 value of 1k and so the voltage gain is greater than 10.

2.4 Controller unit

This unit has a Stellaris launch pad having ARM controller. It is cost effective evaluation platform for ARM microcontroller from Texas instruments. It has a feature of programmable user buttons and an RGB LED for custom applications [10]. It uses sigview software which is a real time and offline signal analysis software package. This software has comprehensive signal analysis tools, statistics functions and a broad visualization system. This controller unit has been used to control and remove the offset present in the integrated coil signal. It also used to maintain and autocorrecting the offset level by utilizing software coding.

3. RESULTS AND DISCUSSION

The signal from the toroidal magnetic coil has been monitored for few seconds. It has been actually integrated with the help of integrator unit and the offset present in this has been rectified with the help of signal conditioning unit. Figure 2 shows the signal from the coil with respect to time. In order to view clearly a part of the signal from the coil output has been chosen in figure 3. It is clearly shown from this figure, the signal is having offset of -40mv.It has been removed with the help of signal conditioning unit. For offset minimization this system utilizes stellaris launch pad with sigview software. The stellaris processor has been programmed to autocorrect the offset voltage present in the input signal and therefore the final output is free from offset error. This system has only microvolt range of offset voltage. The final

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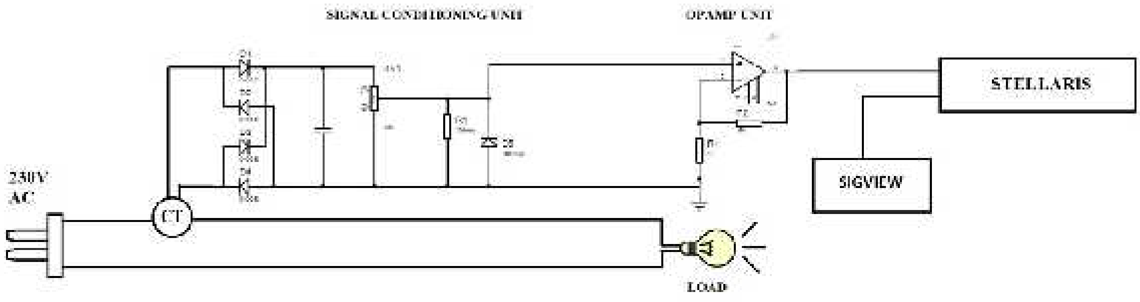

Figure 1: Proposed Digital Integrator Unit

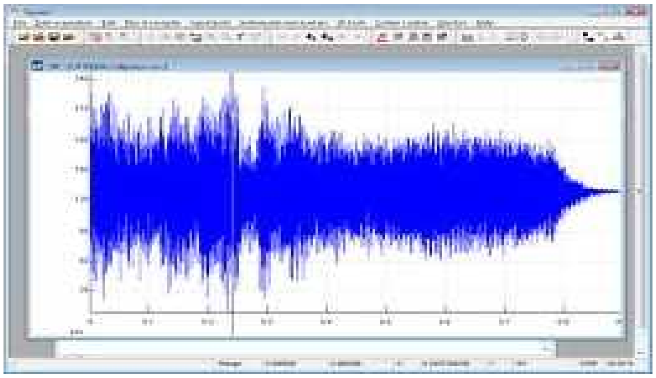

Figure 2: Toroidal Coil Signal

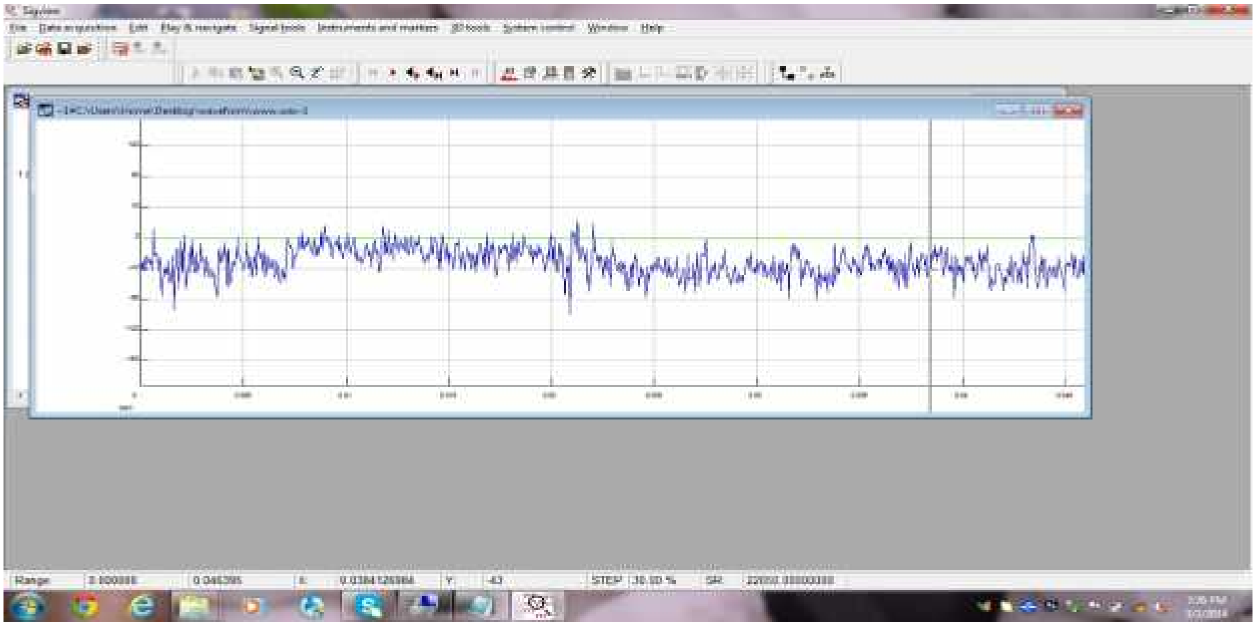

Figure 3: Input Pulse With Offset

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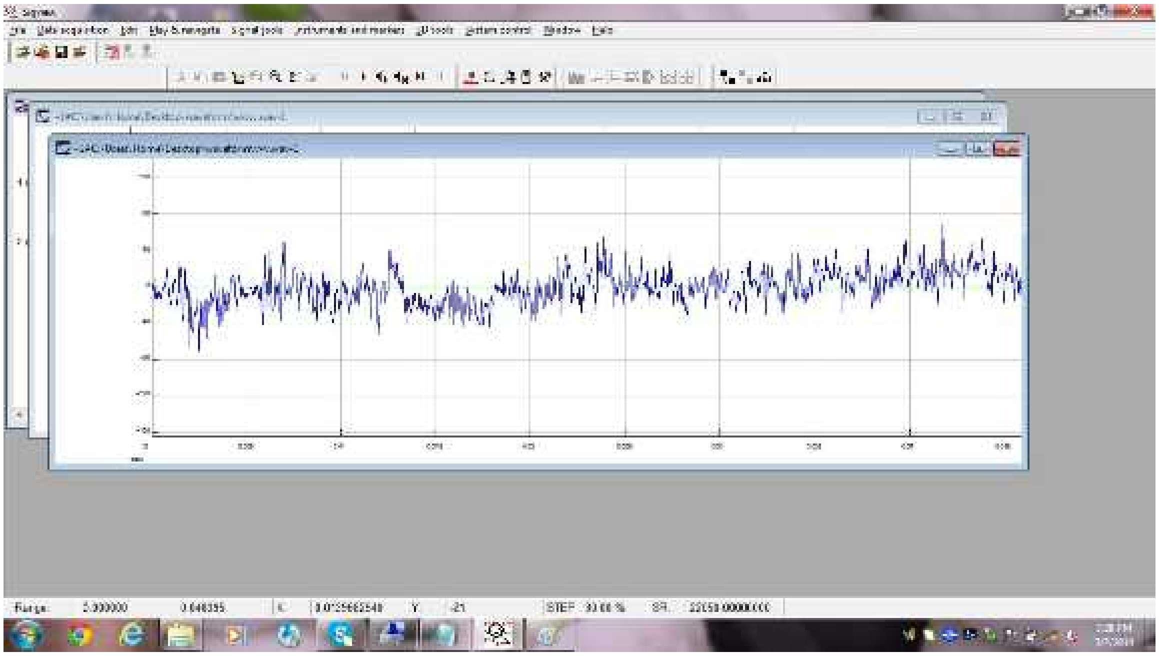

Figure 4: Output Integrated Signal Without Offset

output integrated signal without offset is shown in figure 4.

Toroidal coil or current transformers are typically used for Current and power measurements of various devices. This coil signal has been integrated in order to measure and control the useful parameters of various magnetic equipments like motors, nuclear reactors etc. In this paper a digital integration scheme has been proposed to correct the offset error, which is the common error while designing an integrator.

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