DESIGN OF POWER PROTECTION SYSTEM IN ANALOG INPUT AND OUTPUT FOR WIRELESS DATA LOGGER

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ABSTRACT

Electronics industries are extremely cautious for the safety, ground loop elimination and signal level shifting of the analog circuits. The technology promises to overcome the several challenges for a flexible and inexpensive linear isolation solution. This paper presents the design of a analog isolator at a very low cost by taking care of the other issues. This design can prolong the circuit lifetime by the use of self-oscillating circuit, digital isolator and Butterworth filter circuit.

Keywords*:* *Self – Oscillating Modulator (PWM) Circuit, Digital Isolator and Butterworth Filter (Demodulator) Circuit*

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1. INTRODUCTION

The analog isolation amplifier that contains linear input and output circuits separated by an internal isolation barrier catches the eye due to its flexible features. In comparison with the digital isolator, which is easily available in the market with a variety of ranges and with very low cost, the analog isolator, on the other hand, has limited ranges, high cost and is not easily available in the market.

The main purpose of the work is to fulfil the needs of the market and industry by designing an analog isolator at very low cost, more flexibility and convenient sizes. Use of self – Oscillating Modulator (PWM) Circuit in Digital Isolator and Butterworth Filter (Demodulator) Circuit to accomplish the Analog Isolator System. There is a wide scope for study of analog isolator due to its high demands in the industry and the market.

Since Analog Isolator is based on Digital Isolator, it has certain limitations. On the contrary, it provides large scope to deal with the associated analog isolator problems. There are three basic types of Analog isolation system present in market: Optical Isolation, Electromagnetic Isolation and Capacitive Isolation.

An ISO linear Analog Isolation system will be developed using Digital Isolator with the help of self-oscillating Modulator and Butterworth filter Demodulator circuit. A self-oscillating pulse width modulator (PWM) converts the linear analog input signal into a series of fixed-frequency, variable duty cycle pulses in which the width of each pulse is proportional to the sampled input signal amplitude. This modulated (digital) signal is passed through the CMOS digital isolator and then restored to analog signal format by a Butterworth analog filter. Which will provides safety, signal level shifting, ground loop elimination and channel to channel and channel to bus isolation with the added benefits of competitive performance and greater economy and user-flexibility and isolation ratings of up to 5 kVrms.

2. SYSTEM DESIGN

From the Table 1, noise density is related to PWM modulation frequency where increasing modulator frequency results in higher noise density. The noise sources for all three circuits are a combination of thermal noise from both active and passive components and phase noise generated by the digital isolator.

Table 1: Circuit Performance

Circuits	Resolution (Bits)	PWM Frequency (MHz)	Bandwidth (KHz)	Output Ripple (mV)	Noise Density μVrms/Hz
1	12	1.12	100	10 mV	0.58
2	10	2	500	40 mV	1.10
3	9	2.25	250	10 mV	1.43

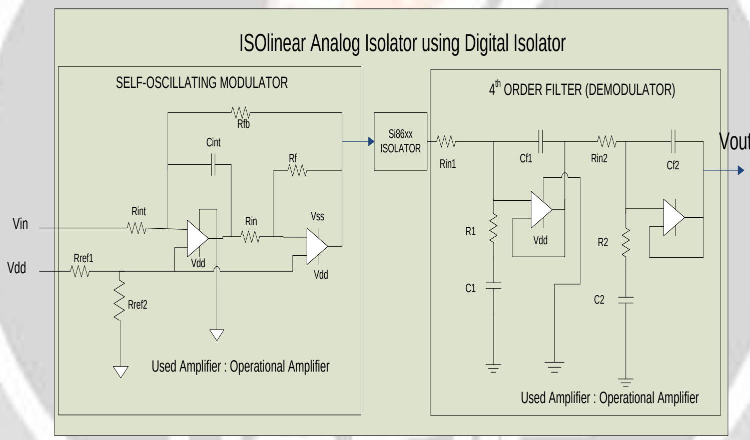

Fig.1. Operational Circuit diagram

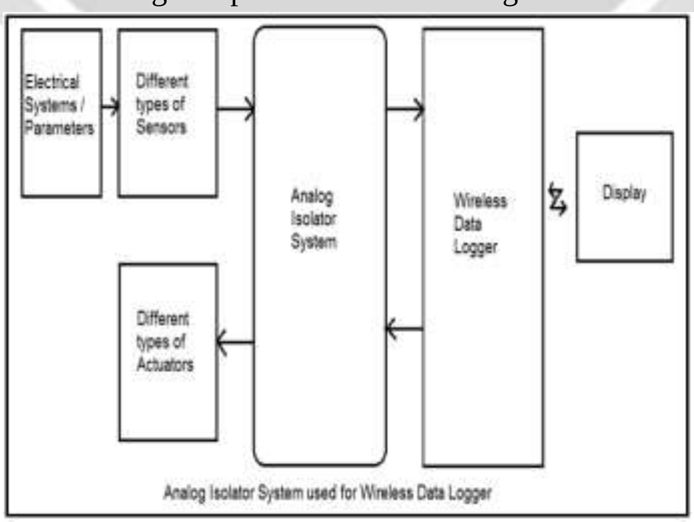

Fig. 2. Block diagram compromises all components

3.WORKING

3.1 Noise and Ripple vs. Modulation Frequency:

Noise density is related to PWM modulation frequency where increasing modulator frequency results in higher noise density. The noise sources for all three circuits are a combination of thermal noise from both active and passive components and phase noise generated by the digital isolator.

Therefore, it is important to optimize the PWM modulation frequency (Fmod) for the desired signal bandwidth. Too low an Fmod minimizes noise density but can increase output ripple (depending on the output filter design), and too high an Fmod reduces output ripple but increases noise density. Therefore, modulation frequency must be chosen for the compromise of noise density and output ripple.

3.2 PWM Operation :

The self-oscillating modulator consists of an op-amp integrator and comparator with hysteresis. The comparator has a hysteresis voltage range determined by the values of feedback resistor. For a given comparator output state, the integrator output voltage ramps until the comparator's threshold is reached, at which time the comparator output changes state and the cycle repeats. The op-amp used in this modulator design must have a slew rate >>2Fmod and rail-to-rail outputs. The comparator must have a response time <10 ns.

3.3 Butterworth Filter (Demodulator) Optimization:

Analog wave is get generated back from PWM signal. It is based on Sallen- Key topology with Butterworth response and unity pass-band gain. Note that a lower-order filter can be used if the ripple requirements are relaxed. A Butterworth filter is chosen for its maximally flat pass band response and moderately steep roll-off above the cut- off frequency and is more than adequate for most linear isolator applications. While active filter design theory is beyond the scope of this application note, filter design can be simplified with the help of well-established look-up tables and by using a generic transfer function

3.4 Si8642 CMOS Digital Isolator:

The operation of an Si8642 channel is analogous to that of an opto coupler, except an RF carrier is modulated instead of light. This simple architecture provide a robust isolated data path and requires no special considerations or initialization at star – up.

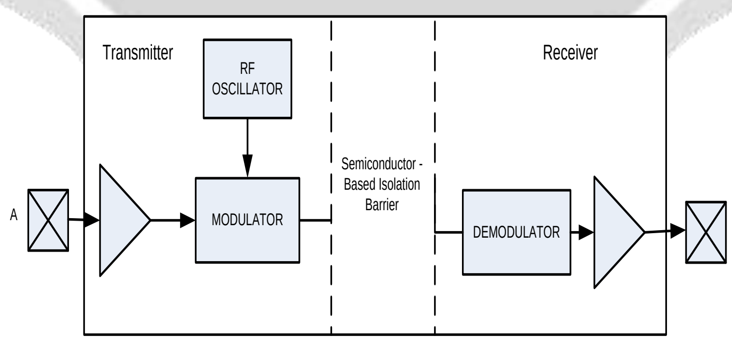

Fig.3. Simplified Channel Diagram

A channel consists of an RF Transmitter and RF Receiver separated by a semiconductor-based isolation barrier. Referring to the Transmitter input A modulates the carrier provided by an RF oscillator using on/off keying. The Receiver contains a demodulator that decodes the input state according to its RF energy content and applies the result to output B via the output driver. This

RF on/off keying scheme is superior to pulse code schemes as it provides best-in-class noise immunity, low power consumption, and better immunity to magnetic fields.

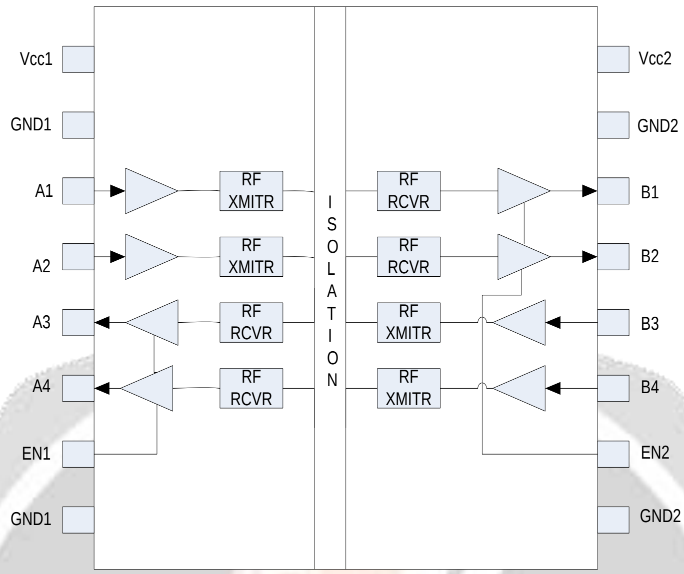

Fig 4. Pin diagram of RF Transceiver

3.5 Step – up and Step – Down Circuit:

Step – up circuit is used at the output sides of Analog Isolator to step – up voltage from 5v to 10v as per their requirement. When the outputs coming from the Demodulator circuit as 5v but any Actuator needs to run on 10v then we have to provide the output as 10v. At that time we can step – up the output voltage to 10v by just activating the step – up circuit.

While Step – down circuit is used to step down the voltage from 10v to 5v at the input sides of Analog Isolator so that digital isolator always works on 5 v input range.

Digital Isolator used in the Analog Isolator system works on 5 v input range and Provide Isolation up to 5 kv rms. So there is always need to give only 5v to Analog Isolator. But, there are chances that outputs coming from different sensor can be even 10 volt. So we need to reduce that voltage to 5v. Therefore, step – down circuit is included.

Self – Oscillating PWM Generation:

Below diagram is used for the generation of pulse width varied PWM signal with the help of Analog input signal and reference triangular wave.

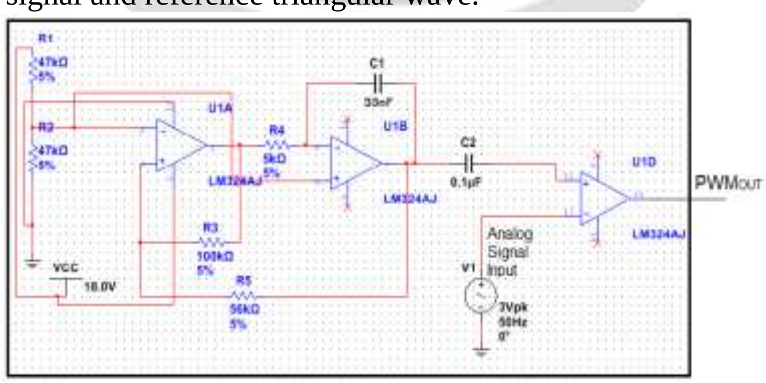

Fig. 4: Hardware Analog to PWM generation circuit design

4. RESULTS

Self – Oscillating PWM Generation:

Below diagram is used for the generation of pulse width varied PWM signal with the help of Analog input signal and reference triangular wave.

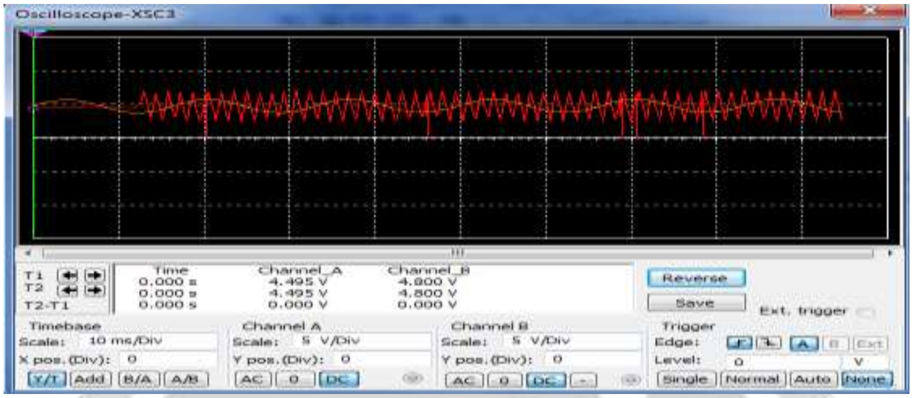

Fig. 5: PWM Inputs

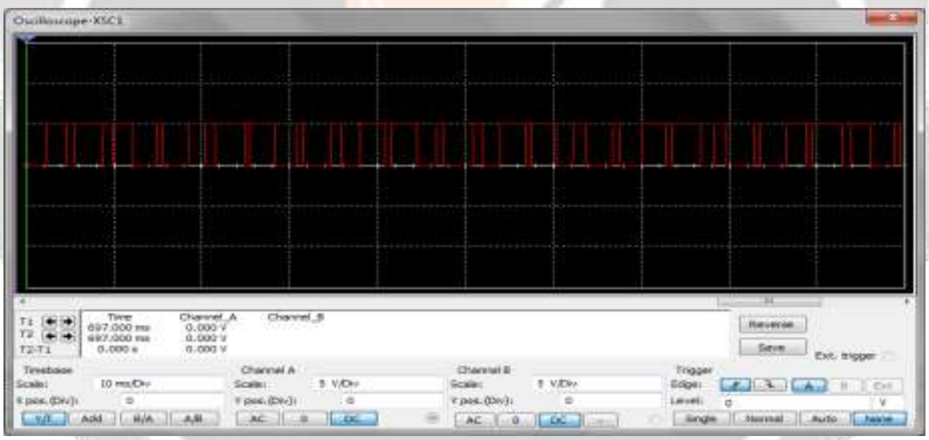

Fig. 6: Waveform of Analog to PWM generation.

Butterworth Filter (4th Order Demodulator) Optimization:Below waveform represents the Output coming from the 4th Order Butterworth (Demodulator) Filter.

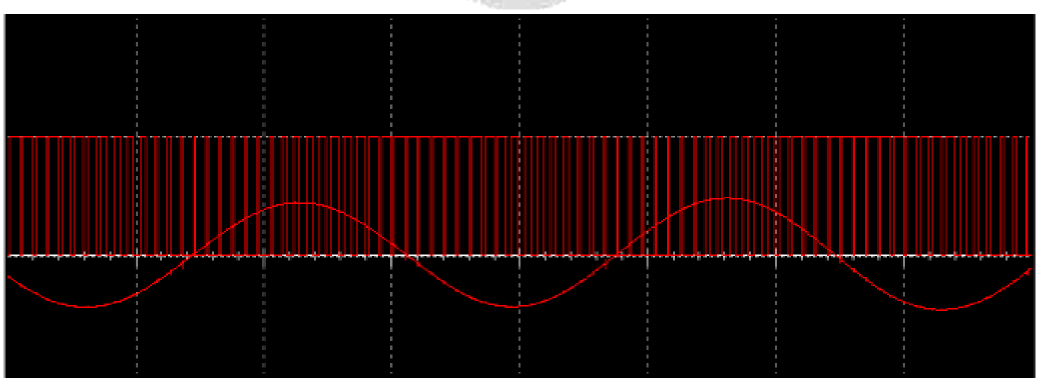

Fig 6 Waveform of PWM to Analog generation

5.CONCLUSION

In this paper the design of an Isolation system for Analog Inputs and Outputs for Wireless data logger by using the Digital Isolator, self-oscillating Modulator and Butterworth filter Demodulator. Paper depicts how we can implement the Scaling factor to scale voltage at different levels using op–amps with feedback circuit, How to Design an Analog Isolation system having 4-Channels isolation which provide proper Isolation to other Devices, How it provides safety to the Humans, Provides Ground loop isolation, Provides Channel to Channel isolation, Provides Channel to Bus isolation and Provides Signal level shifting also with help of Sensors, Actuators, Arduino UNO (Wireless Data Logger) working of Isolation system has been also tested. Future works for this Project can be down on various aspects. Such work like Noise immunity improvement, Device lower Cost reduction, Device size can be reduce further using better technology and Isolation ratings improvement and many more.

6.REFERENCES

[1]. Hank Zumbahlen, Basic Linear Design, Analog Devices, 2006, ISBN: 0-915550-28-1. Also available as Linear Circuit Design Handbook, Elsevier-Newnes, 2008, ISBN-10: 0750687037, ISBN-13: 978- 0750687034.

[2]. Walter G. Jung, Op Amp Applications, Analog Devices, 2002, ISBN 0-916550-26-5, Also available as Op Amp Applications Handbook, Elsevier/Newnes, 2005, ISBN 0-7506-7844-5.

[3]. S. Kaeriyama , S. Uchida , M. Furumiya , M. Okada and M. Mizuno "A 2.5 kV isolation 35 kV/us CMR 250 Mbps 0.13 mA/Mbps digital isolator in standard CMOS with an on-chip small transformer", *IEEE Symp. VLSI Circuits Dig.*, pp.197 -198 2010

[4]. F. Rothan , H. Lhermet , B. Zongo , C. Condemine , H. Sibuet , P. Mas and M. Debarnot "A ${\pm }$1.5% nonlinearity 0.1-to-100 A shunt current sensor based on a 6 kV isolated micro-transformer for electrical vehicles and home automation", *IEEE Int. Solid-State Circuit Conf. Dig. Tech. Papers*, pp.112 -113 2011

[5]. B. Chen "Fully integrated isolated DC-DC converter using micro-transformers", *Proc. 23rd Annual IEEE Applied Power Electronics Conf.*, pp.335 -338 2008

[6]. R. Kliger "Integrated transformer-coupled isolation", *IEEE Instrum. Measur. Mag.*, vol. 6, no. 1, pp.16 -19 2003

[7]. H. Taniguchi , Y. Ogino and H. Irie "PWM technique for power MOSFET inverter", *IEEE Trans. Power Electron.*, vol. PE-3, no. 3, pp.328 -334 1988

[8]. D. A. Grant , J. A. Houldsworth and K. N. Lower "A new high-quality PWM AC drive", *IEEE Trans. Ind. Applicat.*, vol. IA-19, no. 2, pp.211 -216 1983

[9]. Silicon Labs papers on “A Simple alternative to Analog Isolation Amplifiers”, Copyright 2013

[10]. Si86xx ISOlinear Users Guide by Silicon Labs, Copyright 2010

[11]. AN598: “High-Speed Level Shifting Using Si8xxx Isolators”.

[12]. Akiyama, N. Res. Lab., Hitachi Ltd., Ibaraki, Japan, “A high-voltage monolithic isolator for a communication network interface”.

[13]. Noise Reduction Techniques in Electronic Systems, Ott, 1988

[14]. Isolation Types and Considerations when Taking a Measurement Published on NI website Date: May 04, 2015
[15]. Ivan Selesnick and Charles Sidney Burrus, "Generalized Digital Butterworth Filter Design" Article in IEEE Transactions on Signal Processing , MAY 1998.
[16]. Kaszynski R. and Piskorowski J.; Inst. of Control Eng., Szczecin Univ. of Technol. "New Concept of Delay Equalized Low-Pass Butterworth Filters", Industrial Electronics, 2006 IEEE International Symposium.
[17]. C Bond , Butterworth Filters ,Polynomials, Poles and Circuit Elements @ 2003.