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Research Article

A PRACTICAL BUFFER CIRCUIT IMPLEMENTATION IN A HIGH VOLTAGE AREA WITH MICROCONTROLLER APPLICATION

***G.Sujatha[1]and D.Murali[2]**
[1]Institute of Food and Dairy Technology, Alamathy (PO), Koduvalli, Chennai- 52.
[2]Department of Electrical & Electronics EngineeringGovernment College of Engineering. Salem -11
**Author for Correspondence*

ABSTRACT
This paper investigates a practical buffer circuit to connect a high voltage side with the low voltage side. This application is widely used in industries where the speed and direction of rotation of the industrial motor is monitored by a shaft encoder (analog or digital). This paper deals with the implementation of buffer circuit whose input is from an industrial motor in which an analog encoder is fixed to monitor its speed and direction. The output of the encoder is sine wave and is converted to a square wave using comparator circuit. Additional optocoupler circuits are included to avoid transients reaching the microcontroller section since the circuit is connected is connected to high voltage area.

Key Words: *Industrial Drive, Comparator, Hcpl6730 Optocoupler, Microcontroller, Buffer Circuit*

INTRODUCTION
Electric drives have inherent advantages over other prime movers. Special motors and control gears have been developed to suit every application. Over the years induction motor (IM) has been utilized as workhorse in the industry due to its easy build, high robustness, and generally satisfactory efficiency. Squirrel cage induction motor is used for all constant speed applications because of its low cost, rugged design and simple control gear. Wound rotor induction motor is used where one or more of the following consideration is involved: (i) High starting torque,(ii) Low starting current,(iii) Speed control over a limited range. Synchronous motor is suitable for all constant speed application (Jul-Ki Seok*et al*., 2001). It is generally more economical in rating above 100 kW particularly for slow speed drives because of high power factor, better efficiency and lower cost. DC motors are invariably used where smooth and precise control over a wide range with or without quick speed reversals is needed. The type of electric drive and control gear for a particular application are determined by the following consideration:

- ✓ Duty; whether heavy, medium light,
- ✓ Starting torque,
- ✓ Limitations on starting current,
- ✓ Speed control range and its nature,
- ✓ Need for automatic control,
- ✓ Environmental conditions.

The speed and position of the industrial drives is monitored by a shaft encoder (analog or digital) and the output is given to the comparator (Szabat, 2009). The encoder used in this paper is analog and hence an analog signal from the encoder is given to the comparator which converts it in to a square wave form. The Comparator circuit acts as a buffer circuit between the heavy machinery and the microcontroller circuit. Also HCPL6730 optocoupler is used to isolate one section of a circuit from another, each section having different signal voltage levels to ensure compatibility between them.

MATERIALS AND METHODS
Buffer circuit
Some circuits have output impedance very high. If these circuits are coupled with another circuit of low input impedance, the desired functionality of the latter circuit will be drastically affected. Because the first circuit tries to deliver large voltage to the second and the second invariably requires small input

voltage. To avoid the circuit disfunctionality, a buffer circuit (a circuit with high input impedance and low output impedance) is used. Another application is in the delay matching. In delay matching, the latter circuit requires a delay of say "n" seconds after the first circuit's output. A buffer circuit is used in such cases also. The circuit design is totally different than the impedance matching case (Ujiie *et al.*, 1988). An opamp buffer circuit is one where the input signal is connected to the plus input, and the output is connected to the minus input. Within the performance limitations of the opamp, the output will track the input. The advantage of the buffer circuit is that it presents very little load impedance to the input signal, while providing low impedance from the output to drive whatever circuitry is connected there. Since the operational amplifier IC 741 has high input impedance and low output impedance, it is used in this project as a comparator whose input is derived from the output of an industrial drive. Since an analogue encoder is used, an analog signal is obtained which in turn is given to the input of the comparator. The output of the comparator is a square wave and is fed to the optocoupler.

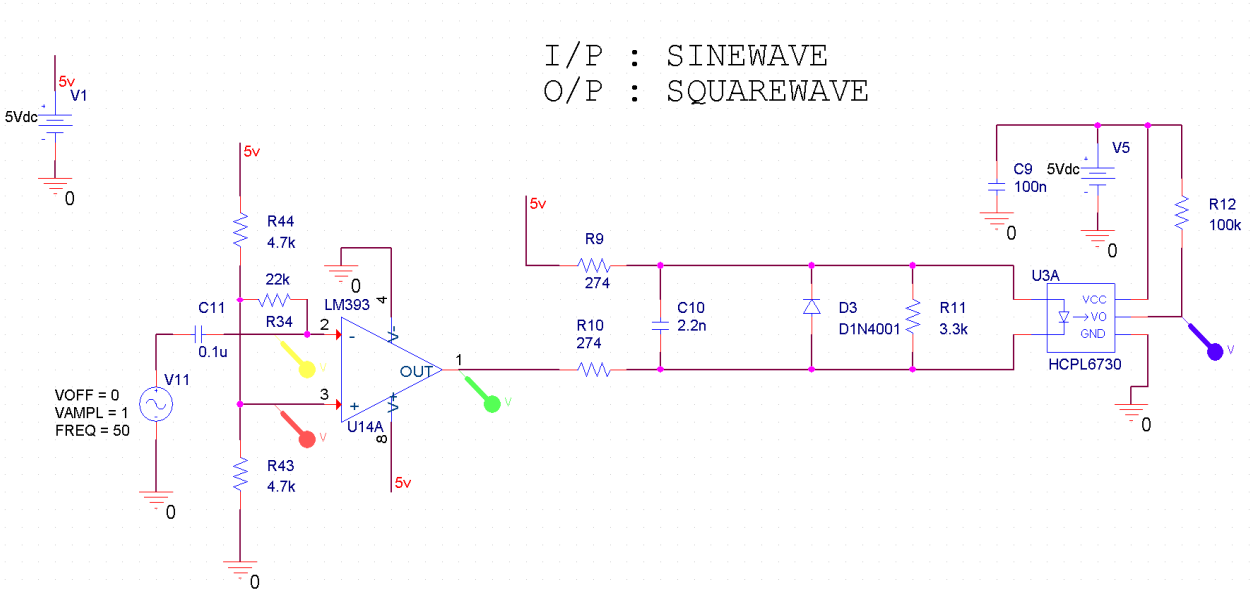

Figure 1: The output of the comparator circuit is obtained as show in the figure (2).The sine wave is converted in to square wave.

Encoder

An encoder is a device, that converts information from one format or code to another, for the purposes of standardization. AMCI DC25 Absolute Analog Single – turn Rotary Shaft Encoder is used in this project which has the following electrical specification.

Output precision : 12 bit analog voltage or current
Voltage configuration : 0 to 5Vdc, 0 to $10V_{dc}$, ± $10V_{dc}$
Current configuration : 4-20 mA, 0-20 mA
Power up setting time : 20 msec max
Voltage load capacity : 2K ohm min.
Current load capacity : V_{in}< 15Vdc: 420 ohm maxV_{in} =24Vdc: 800 ohm max
Power requirements : 4.75 to 26.4 V_{dc}, 1.5W max.

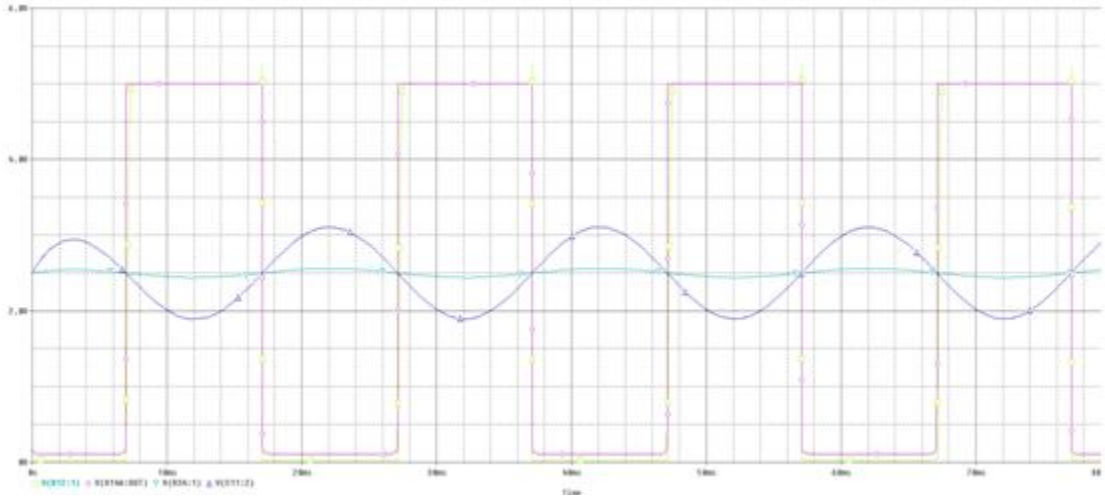

Figure 2

Comparator

A voltage buffer amplifier is used to transfer a voltage from a first circuit, having a high output impedance level, to a second circuit with a low input impedance level. The interposed buffer amplifier prevents the second circuit from loading the first circuit unacceptably and interfering with its desired operation. In the ideal voltage buffer in the diagram, the input resistance is infinite, the output resistance zero (impedance of an ideal voltage source is zero). Other properties of the ideal buffer are: perfect linearity, regardless of signal amplitudes; and instant output response, regardless of the speed of the input signal. If the voltage is transferred unchanged (the voltage gainA_v is 1), the amplifier is a unity gainbuffer; also known as a voltage follower because the output voltage follows or tracks the input voltage. Although the voltage gain of a voltage buffer amplifier may be (approximately) unity, it usually provides considerable current gain and thus power gain (Wonseok 2007). However, it is commonplace to say that it has a gain of 1 (or the equivalent 0 dB), referring to the voltage gain.

Optocoupler

The function of opto coupler is to isolate one section of a circuit from another, It is used to prevent electrical noise or other voltage transients that may exist in a section of a circuit from interfering with another section (ie., from high voltage to low voltage) when both sections have a common circuit reference. Noise or voltage transients can be caused by a poor printed circuit board layout. HCPL6730 optocoupler is used which is a photo darlington output. The figure (i) shows the optocoupler with photo Darlington output. It has a high current transfer ratio when compared to photo diode and photo transistor output.

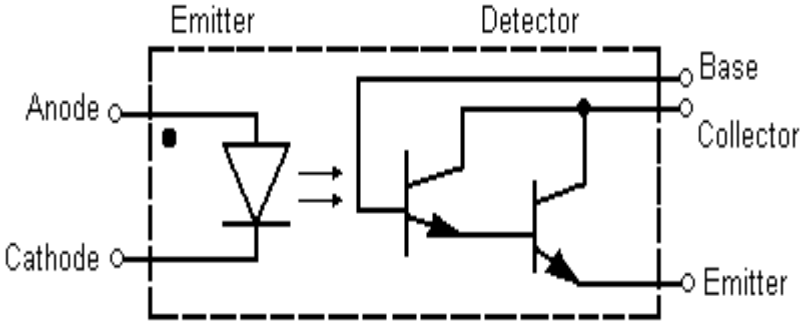

Figure 3: Optocoupler with Photo Darlington Output

Current transfer ratio (CTR) is defined as the ratio of output current by input current.At a minimum, optocouplers require current to bias the LED and some form of bias on the output side. The total input plus output current varies widely, depending on the type of optocoupler. When forward biased, the

optocoupler LED is low-impedance, and device power consumption increases with LED forward current, which can range from 1 mA to over 15 mA. In some cases, the LED may require an external driver, further decreasing system efficiency while increasing BOM complexity and cost. The optocoupler output impedance can be low or high depending on its architecture. Most low-cost optocouplers have a simple transistor output that is high-impedance when LED forward current is at zero and relatively lower impedance when LED forward current is in its specified operating range. Other (usually higher speed) optocouplers have an active photo coupler and output driver that requires an external bias voltage. Such devices have low output impedance but at the expense of increased total operating current, which can range from 15 mA to over 40 mA.

RESULTS AND DISCUSSION

An electrical transient is a temporary excess of voltage and/or current in an electrical circuit which has been disturbed. Transients are short duration events, typically lasting from a few thousandths of a second (milliseconds) to billionths of a second (nanoseconds), and they are found on all types of electrical, data, and communications circuits (Johnston 1996). Hence to avoid the transients and protect the microcontroller suitable optocoupler and buffer circuits are introduced in between the industrial motor drive and to the microcontroller section. It is found that the buffer circuit acted as impedance matching circuit and as a current booster. The input and output voltages were equal without affecting the overall gain of the circuit. However the amplification of current was noted. Also the buffer circuit was able to couple two circuits having different input and output impedances. That input of the microcontroller which is generally used for control application and the output of the electrical drive whose speed and direction were controlled by an analog encoder. The output waveform of the comparator was noted using cathode ray oscilloscope as shown in fig 2. The sine wave was converted to square wave using the circuit shown in fig. 1 which uses IC 741 which has very high input impedance and very low output impedance. Thus a low costpractical buffer circuit with isolation circuit using optocoupler was constructed and implemented in a High Voltage Area with Microcontroller Application.

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