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Embedded Intelligent Sensor for Conveyer Belt-Fuzzy System Application

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Abstract:

A conveyor belt includes at least one rip detection sensor, one position detection sensor and a speed measurement sensor. In this paper a complete sensor solution for the industrial conveyer belt is given. in this the intelligent sensors are used having one master intelligent sensor and number of slave sensors depending upon the length of the belt .the intelligent sensor system not only increases the life of the conveyer belt but also increases overall efficiency of the system and it also reduces the processing overhead of the final unit since most of the processing is done in this sensor set by the intelligent master sensor herby increasing not only the belt life but as well as it extends the sensor life as the conveyor belt wears.

1. INTRODUCTION

In a multitude of commercial applications, it is common to employ a heavy duty conveyor belt for the purpose of transporting product and material. The belts so employed may be relatively long, on the order of miles, and represent a high cost component of an industrial material handling operation. In many applications, the belts are susceptible to damage from the material transported thereby and a rip (slit, cut or tear) may develop within the belt. A torn or ripped as shown in figure 1 belt can be repaired once detected. The cost of repairing a heavy duty conveyor belt and the cost of cleaning up material spilled from the damaged belt can be substantial. If, however, such a rip or tear commences and the belt is not immediately stopped, the rip can propagate for a substantial distance along the belt.

Figure 1 Typical torn or ripped conveyor belt system

It is, therefore, desirable to detect and locate a rip in the belt as quickly as possible after it commences and to immediately terminate belt operation, whereby minimizing the extent of the damage to the belt. It is well known to employ sensors within conveyor belts as part of a rip

 Vol. 1,Issue 1,pp. 1-6

detection system. In a typical system, sensors in the form of loops of conductive wire are affixed or embedded in the belt and provide a rip detection utility as part of an overall rip detection system. Rip detection is achieved through the inferential detection of an "open circuit" condition in one or more of the sensor loops in the belt. Typically, an electrical energy source external to the belt is inductively or capacitively coupled to a sensor loop in the belt. A break in the conductive loop of the sensor may be detected by a remote transmitter/receiver (exciter/detector). Disposition of a plurality of such sensors at intervals along the conveyor may be effected with each sensor passing within read range of one or more exciter/detectors at various locations [1]. A rip or tear will encounter and damage a proximal sensor loop and the existence of the tear will be detected when the proximal sensor loop damage is detected as an open circuit by the reader at its next pass. In this manner, the existence of a tear will be promptly detected and repaired and damage to the belt there from minimized.

2. INTELLIGENT SENSOR SYSTEM

A conveyor belt intelligent sensor system is shown in figure 2. The system includes a conveyor belt having three embedded slave sensors spaced along the belt and a master intelligent sensor .The master intelligent sensor functions detects and process namely a rip or tear in the belt ,speed of the belt and in the example considered will also help in position determination.. Three slave sensors are positioned to detect and convey the status of a conveyor belt to the master intelligent sensor for further processing and computations. as the slave sensors passes proximally to the master intelligent sensor ,the slave sensor then transmit information concerning the status of conveyor belt to master intelligent sensor. A master intelligent sensor detects and identifies slave sensors in the belt as the slave sensors passes proximally. The master intelligent sensor receives and processes the information concerning the detection and identity of the slave sensors.

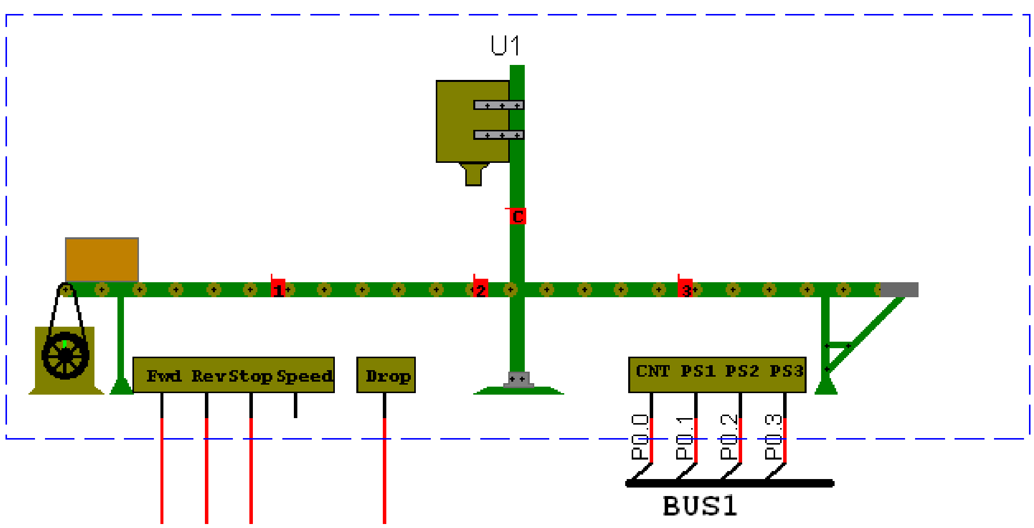

Figure 2 Intelligent Conveyor belt system

Three slave sensors are spaced along the belt at locations maintained in a master intelligent sensor memory map. A calibration table is stored within master intelligent sensor system memory whereby the distances between an identified slave sensors in the belt may be ascertained. Each slave sensors is thus a synchronizing reference point along the belt. Upon detection and identification of a slave sensors by the master intelligent sensor, at a given speed of belt movement in direction (forward or reverse), associated time and distance target values may be acquired by reference to the memory map (calibration table) for slave sensor in the belt. That is, the master intelligent sensor uses the slave sensors as reference addresses in the belt. Locating a slave sensor allows the system to synchronize the belt with the master intelligent sensor memory. The master intelligent sensor detects and identifies slave sensors for the sole purpose of generating time and distance target values conveyer belt in relationship to the detected and slave sensors.

Since the spatial relationship of each slave sensor in the belt is stored in the calibration table, time and distance target values may be acquired from the calibration table using any of the slave sensors as a reference point. A malfunction of one or slave sensor over time will not affect the capability of the system to physically correlate exact belt position to the stored data within the master intelligent sensor system memory. Any of the remaining slave sensors may be used to correlate the master intelligent sensor system memory with the physical belt.

The system as described in figure 3 uses the slave sensors to synchronize the position of the belt with the memory map of the belt in the sensor system [2]. The system is self-calibrating. The slave sensors, as described below, are spaced along the belt and pass master intelligent sensor which detects and identifies each slave sensor as it passes. The master intelligent sensor detects and identifies the presence of each slave sensor as it passes the master intelligent sensor and their separations in time and distance computations are made. The time and distance counters for individual slave sensor separation is recorded. This calibration process continues until a repeating pattern of slave sensors is detected and identified. The pattern of slave sensors within the belt is thus updated and stored in memory each time a self-calibration is made. The time delay between the slave sensors is computed to detect the rip in the conveyer belt, if the target values are exceeded a command to stop the conveyor belt is given. This slave sensor position also helps in determining the position and speed of the belt.

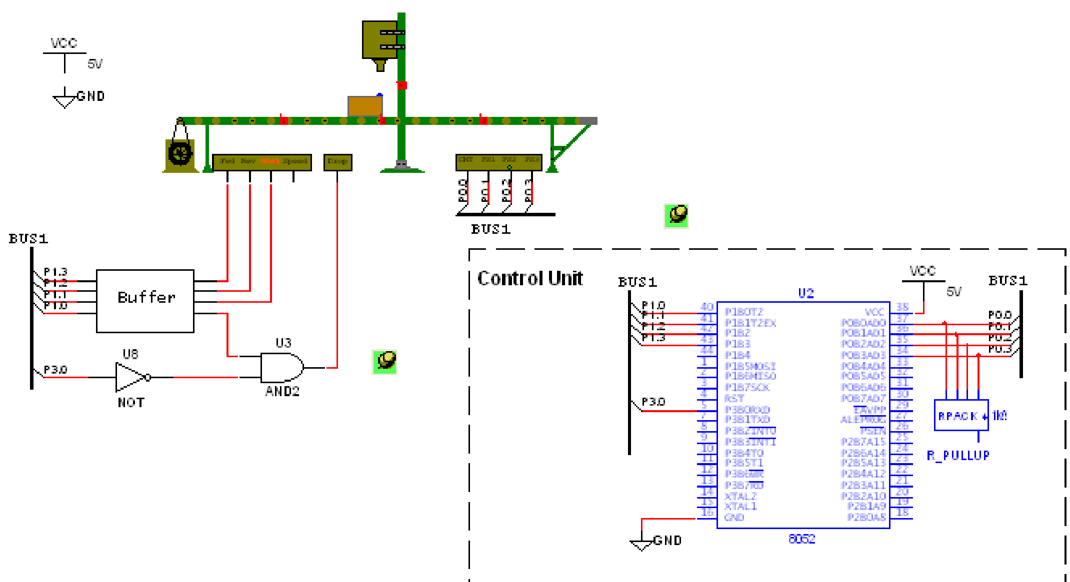

Figure 3 Master intelligent sensor system

3. CONSTRUCTION

Slave sensors consist of an RFID tag circuit shown in figure 4, it provides magnetic decoupling and amplitude modulation. The circuit is made up of a first inductor and a second inductor connected in series, a first capacitor, a second capacitor, and a switch. The circuit includes a first resonant circuit formed from a parallel connection of the series connected first and second inductors, and the first capacitor. The first resonant circuit has a primary resonant frequency. The circuit also includes a second circuit formed from a series connection of the second capacitor and the switch. The series connection of the second capacitor and the switch are connected in parallel to the second inductor.

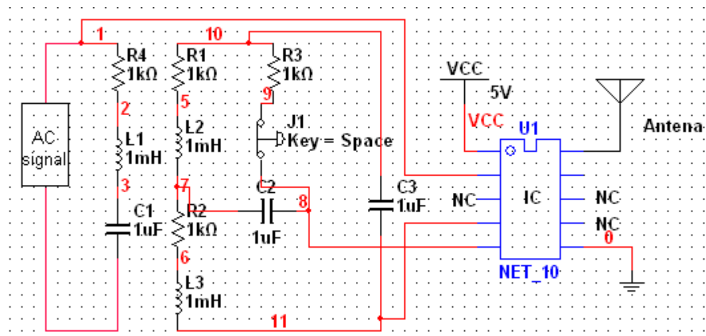

Figure 4 Typical RFID tag Circuit

One end of the series connected second capacitor and switch is connected to the common connection between the series connected first and second inductors [3,4]. Master intelligent sensor consists of:

1. A sensing element that receives data from slave sensors
2. A computational element (microcontroller) that analyzes the measurements made by the sensing element, and
3. A communication interface to the outside world that allows the device to exchange information with other components in a larger system.

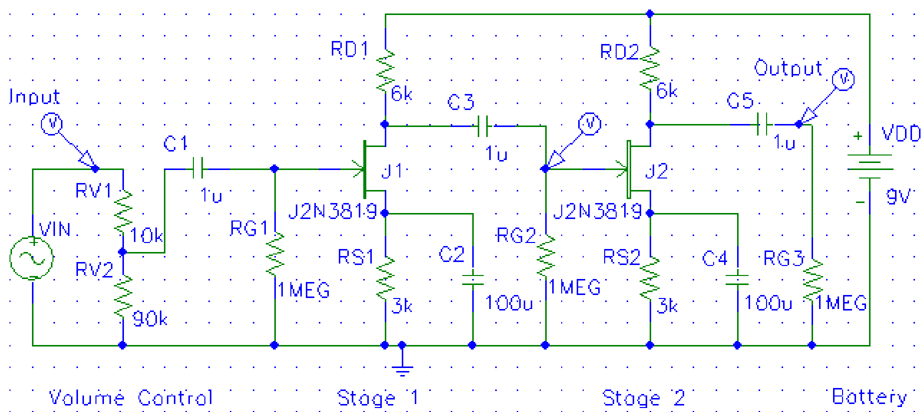

Figure 5 Typical slave circuit for intelligent conveyor belt sensor system

The belt is stopped whenever there is a failure or malfunction of the slave sensor (shown in figure 5). Slave sensor failure, not a break or failure of the conveyor belt may cause the master intelligent sensor to stop the belt. Such action is not desirable in case of slave sensor failure [5,6]. In addition, identification of slave sensor in the belt using a memory map of the belt sensor locations may not be accurate if certain slave sensor malfunction or operate intermittently. As a conveyor belt ages, it is not uncommon for slave sensor to fail or operate intermittently.

4. SIMULATION AND RESULTS:

The intelligent sensor proposed in this paper was simulated using national instruments Multisim, the complete arrangement for the simulation setup of the intelligent sensor is shown in figure 6. For making the sensor intelligent 8052 microcontroller was used and the programming of the microcontroller was done using c language [7, 8]. The intelligent sensor simulation results showed that these sensors can easily be deployed and used for the rip detection, position determination and speed measurement [9, 10].

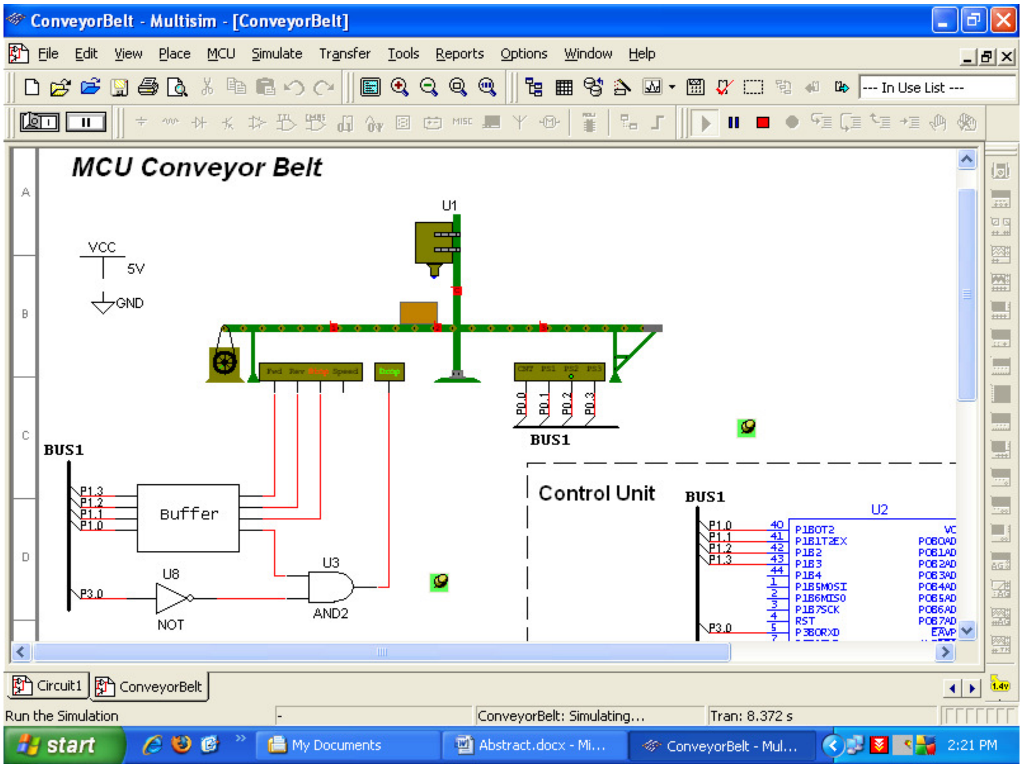

Figure 6 Simulation setup of the intelligent sensor

5. CONCLUSION:

The use of smart sensor for the complete sensor solution for conveyer belt will result in better detection of rip in the belt, thereby decreasing the chances of mis-happenings in the plants due to rips or damage in the belts. It is also capable of exact positioning of the objects over the conveyer belt therefore reducing the spillage or drop age of the material, at the last but not least it can also be used for speed detection of the conveyer belt which is very important factor. The use of intelligent sensor will grow with rapid pace and in future the sensors and actuators used in every industrial application will be intelligent sensors.

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Appendix: (C program for microcontroller based control unit)

```
/*******************************************************************
 *          C Program to control conveyor belt
 *******************************************************************/

#include "htc.h"        // htc.h points to the appropriate technology header file
                        // (in this case 8052.h) which assigns labels to commonly used
                        // registers such as P1, P2, P3 and specific bits such as P02, P03

int halt(void)  {
        while(1);
}

void main()
{

        P1 = 0x00;          // Clear control out for conveyor
        P2 = 0x00;          // Clear control in for conveyor
        P3 = 0x0FF;                 // Default for ext ports is already high
                                    // Need to ensure that ~Enable remains high

        P1 = 0x08;          // Start box moving forward

        // Poll until the box hits sensor 2
        while (!P02)        {
        }

        P1 = 0x03;          // Stop the box
        P3 = 0x00;          // Enable dropping mechanism
        P3 = 0x01;          // Disable dropping mechanism
        P1 = 0x08;          // Start the box moving forward

        // Poll until the box hits sensor 3
        while (!P03)        {
        }

        P1 = 0x02;          // Stop the box

        halt();

        return;
}
```