

RFID DESIGN, SIMULATION, AND IMPLEMENTATION

Faculty Paper
Multidisciplinary Research

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Abstract

Manufacturers, retailers, and government agencies are tracking, securing and managing supplies from the time they are raw materials through the entire life of the product. They commonly use Radio-Frequency Identification (RFID) to identify pallets, containers, vehicles, tools and other assets, monitor inventory and route materials through production process. RFID technology can make internal process more efficient and improve supply chain responsiveness. Most companies that adopt RFID technology reduce supply chain costs and grew revenue because of the added visibility RFID provided.

RFID technology is not a new technology, but it is being used in new ways by different industries, driven by technological advances and decreased costs. Once used in World War II to identify friendly aircrafts, RFID is now used by both the public and private sectors, from hospitals to supermarkets and even car manufacturers. This paper presents RFID system design, simulation, and implementation.

Introduction

RFID systems include tags, readers, and software to process the data. There are many publications covering these topics including the famous RFID Journal [1]. Tags are usually applied to items to be scanned. Readers can be unattended standalone units for monitoring a dock door or conveyor line. These readers are integrated with a mobile computer. The reader sends out a radio signal that is received by all tags in the RF field tuned to that frequency.

Tags receive the signal via their antennas and respond by transmitting their stored data. Tags can hold serial numbers, activity history, or other data. The read/write device receives the tag signal via its antenna, decodes it and transfers the data to the computer system through a cable or wireless connection.

RFID Tags

RFID tags are small electronic devices that consist of a small chip and an antenna. The chip typically is capable of carrying some kind of information depending on applications. Tags are usually applied to items, often as part of an adhesive bar-code label. Tags receive the signal via their antennas and respond by transmitting their stored data. RFID tags can be as small as a grain of rice and as large as a brick, or thin and flexible enough to be embedded within a adhesive label. They can vary in performance depending on the application, including read/write ability, memory and power requirements. The paper presents RFID design and simulation and two different circuit implementation strategies.

RFID tags serve the same purpose as a bar code or a magnetic strip on the back of a credit card or ATM card; it provides a unique identifier for that object. RFID tags can hold multiple types of data including serial numbers, configuration instruction, activity history or even temperature and other data provided by sensors. The read/write device receives the tag signal via its antenna, decodes it and transfers the data to the computer system through a cable or wireless connection. Tags can be as small as a grain of rice and as large as a brick, or thin and flexible enough to be embedded within a adhesive label. They can vary in performance depending on the application, including read/write ability, memory and power requirements. There are three types of RFID tags. These types are differentiated by how they communicate and how that communication is initiated

- 1- Passive tags which have no onboard power and do not initiate communication. A reader is needed to send electromagnetic waves that couple with the antenna on the tag.
- 2- Semi-passive tags that do not initiate communication with readers but they DO have batteries. This onboard power is often used to drive circuitry on the chip which stores information such as ambient temperature.
- 3- Active tags that can initiate communication and have onboard power. These tags have the longest range of all three types of tags, able to communicate 100 or more feet.

RFID Tag Design

An RFID tag was designed, simulated and implemented for this study. The main blocks in the system designed and implemented here are an oscillator, a pulse source, and an analog switch.

1- Oscillator:

A Colpitts oscillator is an electronic oscillator which uses a combination of inductance with capacitance for frequency determination. Colpitts oscillators are LC oscillator that has an oscillation frequency given by:

$$f_0 = \frac{1}{2\pi\sqrt{L \cdot \left(\frac{C_1 \cdot C_2}{C_1 + C_2}\right)}}$$

A Colpitts oscillator was used in the design because it is fairly stable, easy to tune, and has wide range of Frequencies

2- Pulse Source:

A 555 timer is an electronic circuit that is available is a solid state chip. The duty cycle of the timer output can range from 55%-95%. The 555 timer oscillation frequency is given by:

$$f = 1.44 / ((R1+R2+R2) * C)$$

3- Analog Switch:

The analog switch used in the RFID tag consists of a P channel JFET, active LOW. The switch turns on when the timer output is LOW and passes the carrier signal to the ASK output.

RFID Tag Circuit Simulation

The RFID tag consisting of the oscillator, pulse source and analog switch was simulated using Multisim software. The complete Multisim circuit of the RFID tag is given in Figure 1 while the output signal of the simulated circuit is given in Figure 2.

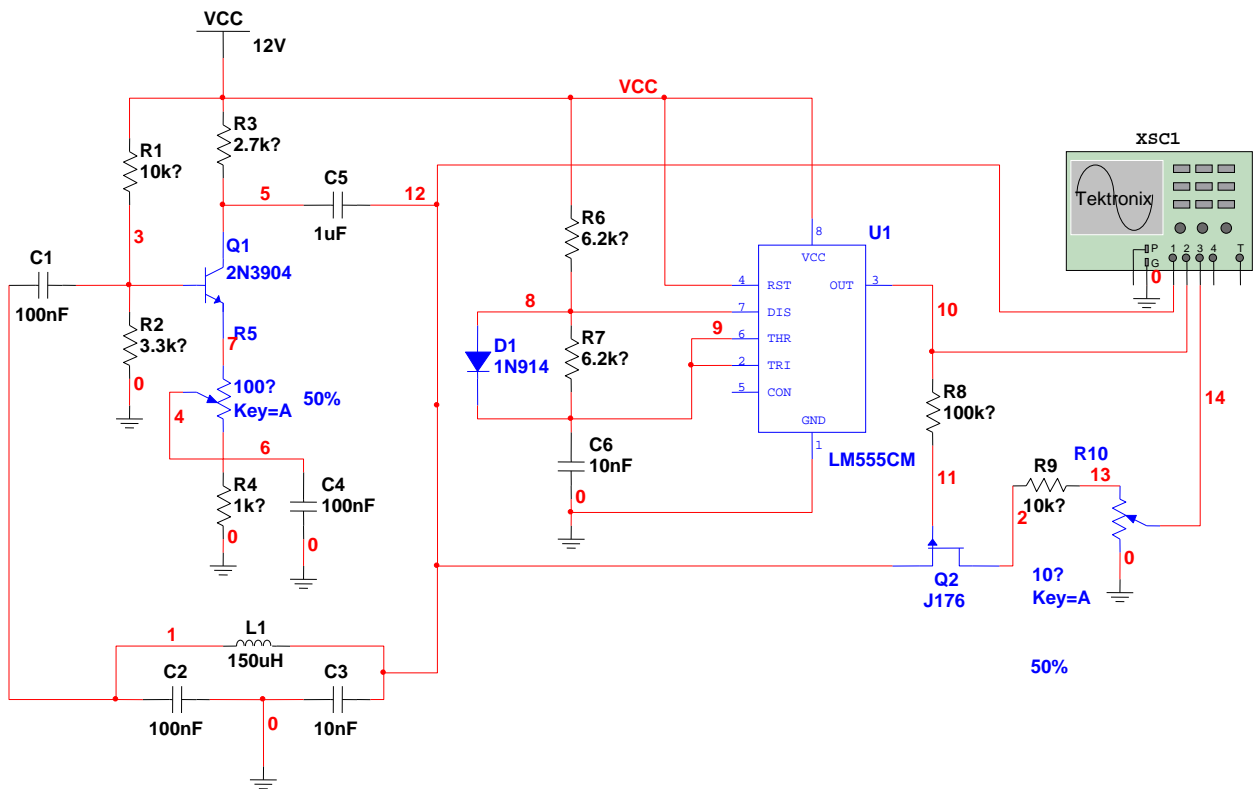


Figure1: The complete Multisim circuit of the RFID tag

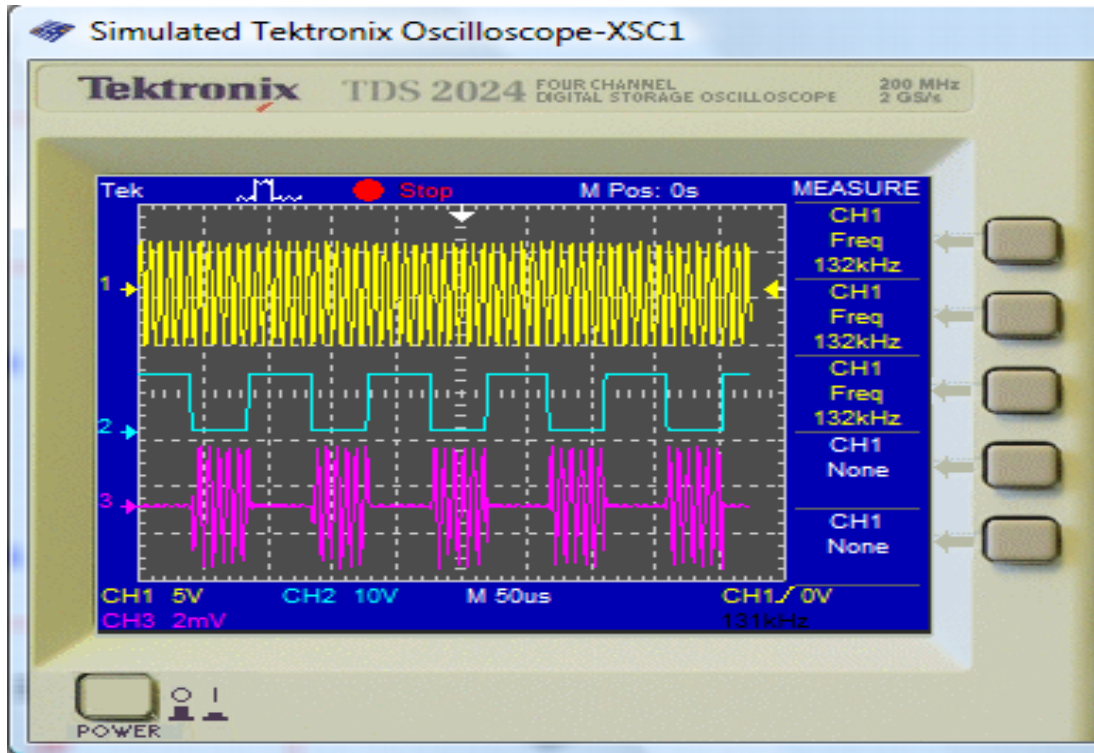


Figure 2: RFID tag simulated circuit output signal.

RFID Readers

Readers can be unattended standalone units for monitoring a dock door or conveyor line. These readers are integrated with a mobile computer handheld or forklift use or incorporated into bar-code printers. The reader sends out a radio signal that is received by all tags in the RF field tuned to that frequency.

RFID Reader Design and Simulation

An RFID Reader was designed, simulated and implemented for this study. The main blocks in the reader designed and implemented here are a band pass filter, 2 stage amplifier, a half-wave rectifier, a low pass filter, and a comparator.

1- 125KHz Band-Pass Filter:

A 2-pole band pass filter was designed to assess the 125 kHz signal coming from the RFID tag and reject signals or noises coming from other sources that fall outside the pass band. The filter was designed to have high Q filter with narrow bandwidth

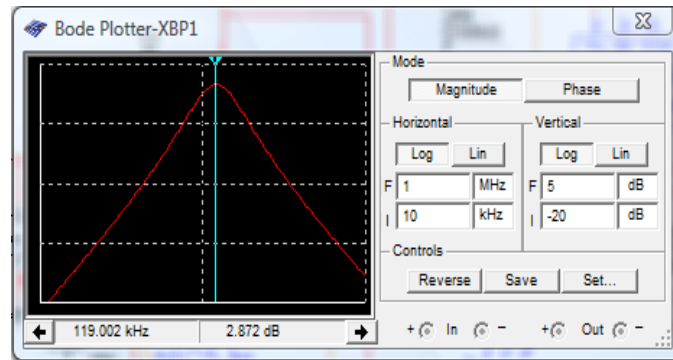


Figure 3: 125 KHz Active Band Pass Filter simulated circuit output signal.

2- 2-Stage Amplifier:

A 2-stage amplifier, figure4, was designed to increase the very small signal from the RFID tag to a usable level. This amplifier takes the output of the BPF and amplifies it to 8.82Vp-p.

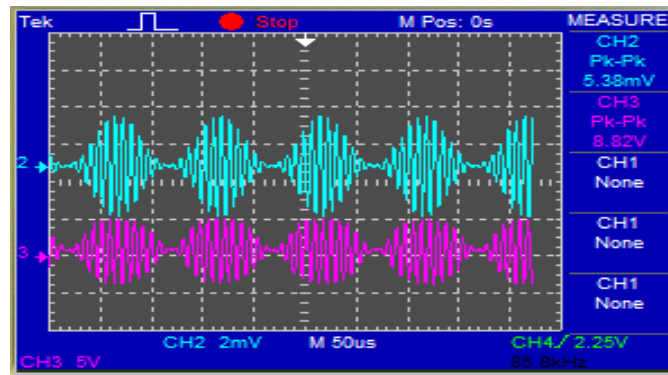


Figure 4: 2 stage amplifier simulated circuit output signal.

3- Half-wave rectifier

A half-wave rectifier was used to allow only the positive portion of the AC signal to go through the circuit. The input and output of the rectifier are given in figure 5.

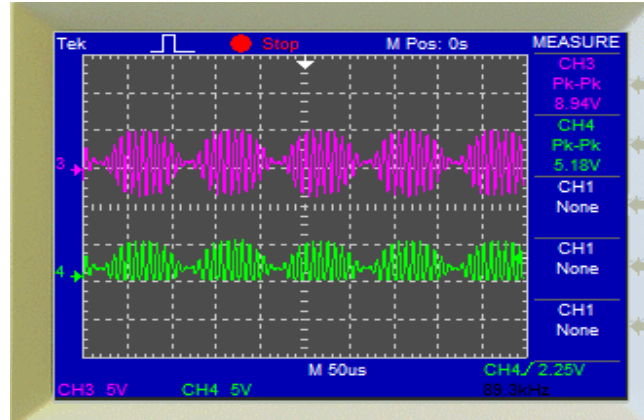


Figure 5: half-wave Rectifier simulated circuit input and output signals.

4- Low Pass Filter (22kHz)

A two pole Low pass filter was designed with a Butterworth response. The filter output is given in Figure 6.

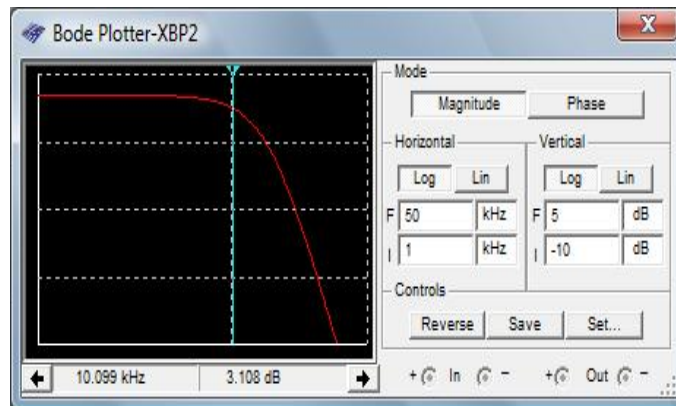


Figure 6: Low Pass Filter simulated circuit output signal.

5- Comparator

The comparator circuit compares the input level coming from the LPF to a reference voltage. Then, If input $< V_{ref}$ output 0, and if input $> V_{ref}$ output 1. So, the comparator circuit restores the digital signal to a usable stream of digital data, 0's and 1's

RFID Implementation and Testing Using a Programmable Analog Module (PAM)

The RFID circuit was implemented on a bread. The complete RFID circuit is given in figure 7. Then, the RFID circuit was tested and the test results are given in figure 8.

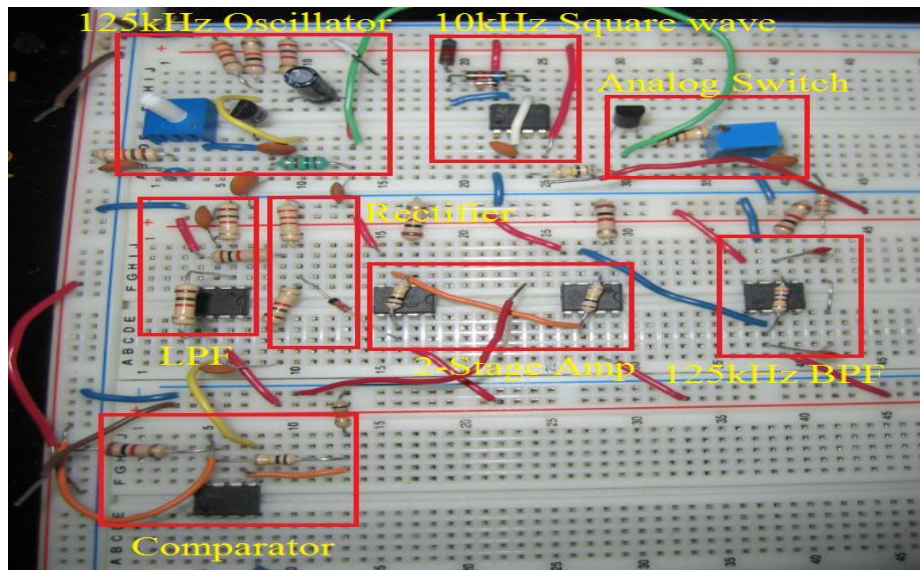


Figure 7: RFID Physical Board Layout.

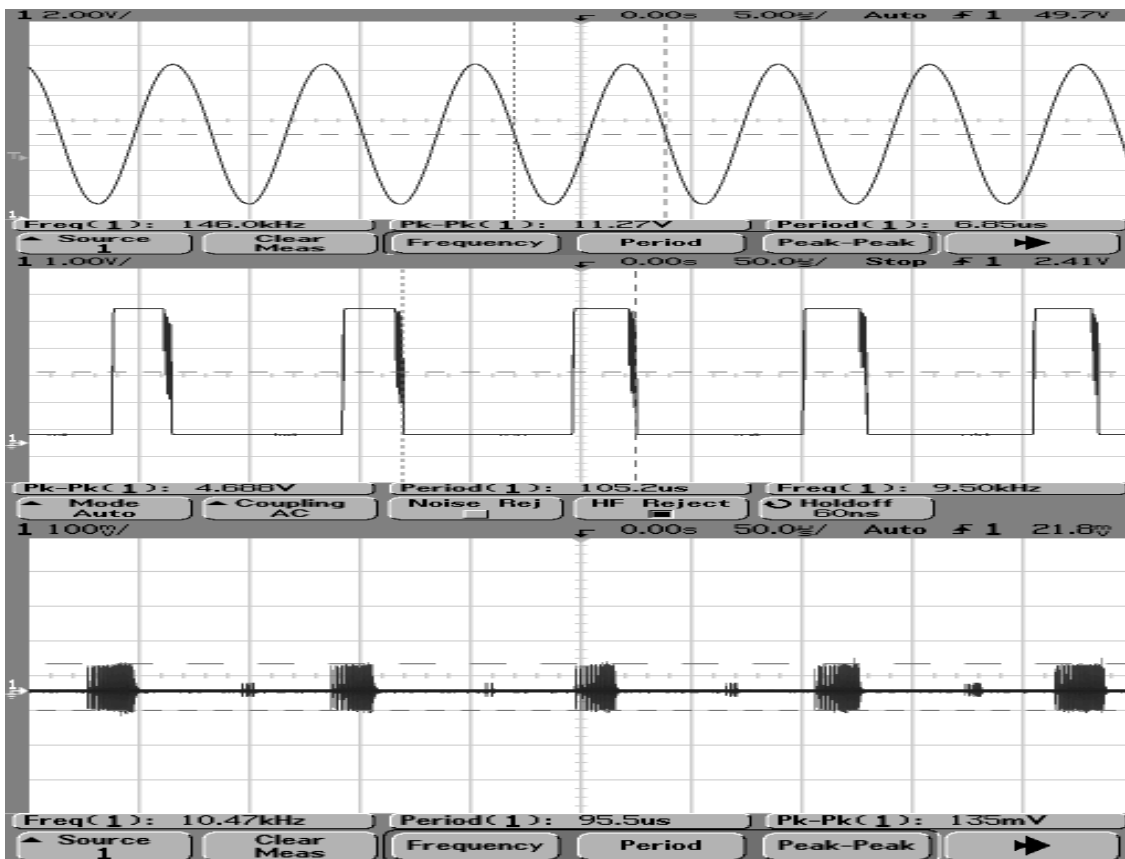


Figure 8: RFID Physical Board Testing Results.

RFID Implementation and Testing Using a Programmable Analog Module (PAM)

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The complete RFID circuit, given in figure 7, was implemented using a programmable analog module (PAM) [2] using the AnadigmDesigner2 software [3].

A PAM, given in figure 9, is an integrated device that is configurable analog blocks (CAB) that can be connected by interconnects between blocks. PAMs can operate in two modes:

- 1- Discrete –time devices possess a system sample clock (sample input through sample and hold circuit composed by semiconductor switch and capacitor)
- 2- Continuous-time devices arrays of transistor and op-amps connected through configurable switches

The uses of PAMs can simplify analog design and provide design adaptation using software. It also adds new feature and capabilities such as consolidation of components and reduction of board space and it provides designers with dynamic design optimization capabilities. A PAM circuit board is given in figure8. It includes a clock, power supplies, connectors and input & output buffers, EEPROM, and Serial Port

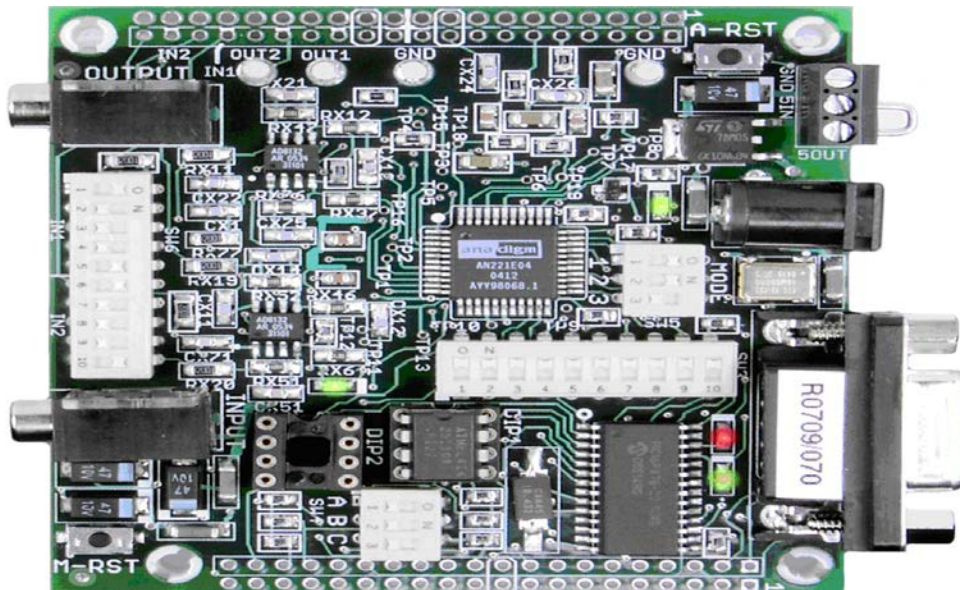


Figure 9: PAM Physical Board Layout.

AnadigmDesigner2 Software

The AnadigmDesigner2 (AD2) Software is used to control the PAM module. This software is available for free and it is easy to use using drag and drop GUI. AnadigmDesigner2 software is built-in SPICE simulator, and it has built-in SG and oscilloscope. The blocks of any design using Designer2 are called CAMs which are software functions accessed by icons. The AD2 software includes a large library of standard functions. Figure 10 shows the RFID circuit in implemented using the AD2 software, and figure 11 gives the oscilloscope output for the test points in figure 10.

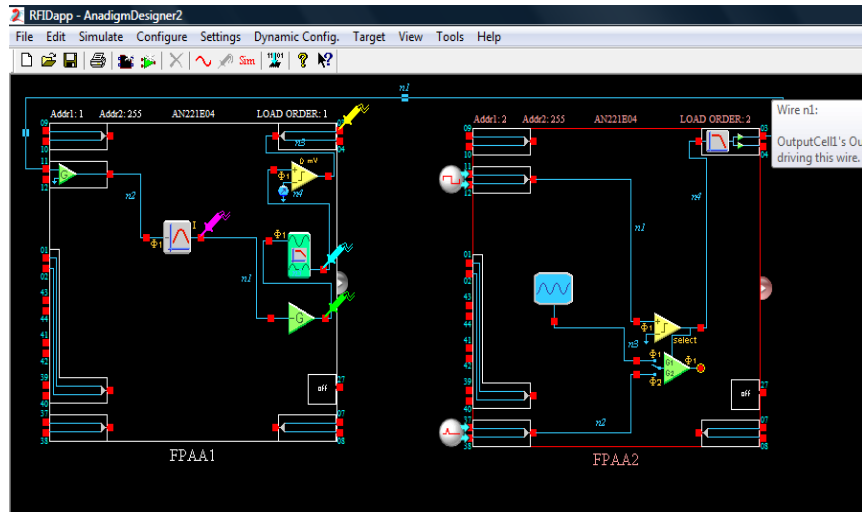


Figure 10: RFID Circuit in AnadigmDesigner2 Software

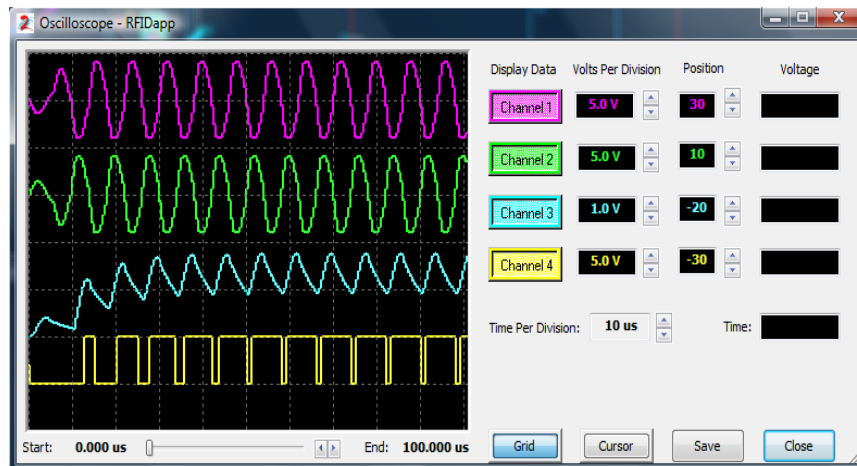


Figure 11: RFID Circuit in AnadigmDesigner2 Oscilloscope Output

Conclusion:

Programmable Analog Module can be used to Simplify Analog Design and Reduce Design time. PAM also Save Engineering costs and can be easily used to address design issues. By using PAM, designers quickly modify circuits. Board revisions are replaced with software changes, and capability can extend to customer.

References:

- [1] <http://www.rfidjournal.com/>
- [2] <http://servenger.com/products/index.htm>

[3] http://anadigm.com/sup_downloadcenter.asp?tab=ad2