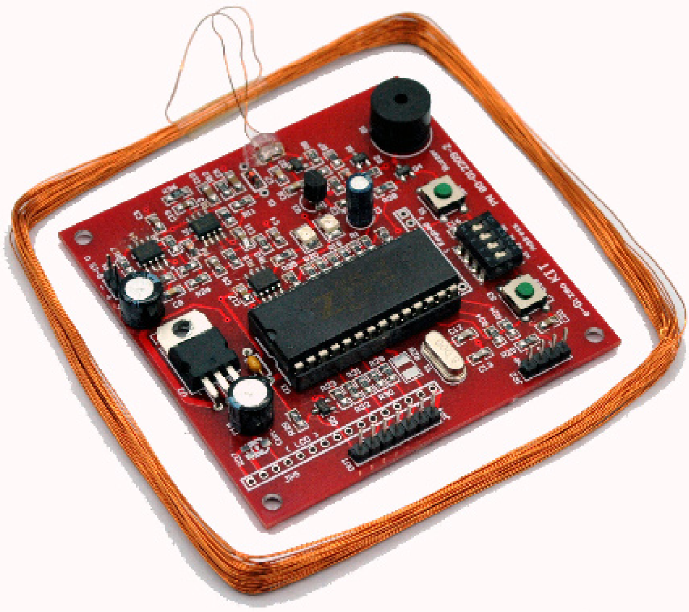
RF I.D. Card Reader

Hardware Manual Rev 1r0



e-Gizmo Can be programmed to recognize up to 16 RFID cards. Easy to integrate with any system. A valid RFID card will assert an output together with a 4 bit data corresponding to the card program number. Optional RS232 can transfer read card data to an external host controller and will allow recognition of unlimited number of cards.

Features & Specifications

- *Highly insensitive to card position orientation.*
- *Passive-tag RF I.D. card reader.*
- *Ease of card reading through distant detection.*
- *Detects and discerns between registered and unregistered cards.*
- *Internal memory can register up to 16 RF I.D. cards.*
- *Erases specific address of registered RF I.D. cards.*

The e-Gizmo RF I.D. Card Reader (Radio-Frequency Identification Card Reader) is an RF card reading device that detects the card by communication of low-frequency radio waves through an inductor antenna. As such the Card Reader is able to read the RF card without the requirements of direct contact, at a distance of around 6 cm. In addition to distance detection, the efficiency of e-Gizmo RF I.D. Card Reader in detection is not especially affected by positional orientations of the RF card while in proximity with the Card Reader antenna; this feature greatly reduces unnecessary confusions about the necessary orientations an I.D. card before it is correctly read (as opposed to magnetic card readers where the positional orientations of the card are important). However, detections are easier with certain orientations of the card with respect to the antenna (these orientations are explained in the 'Operations' section). The e-Gizmo RF I.D. Card Reader utilizes the Passive-tag RF card so that users need not trouble themselves with the power supply of the RF card as it is readily supplied and transmitted by the Card Reader itself through the same radio waves.

Along with the descriptions of the device above, the e-Gizmo RF I.D. Card Reader bears much promise in the amount of applications it provides. As an example, one of the most common uses of an RF I.D. card is for security access. The user in all likelihood may be familiar with this application when the RF card is used as a sort of 'key' to unlock secure door locks by holding the RF card up to some detecting surface. Another application of the RF Card Reader is for identification reference. This application is when the RF I.D. Card Reader references the unique I.D. of the detected RF card to a computer and finds the corresponding data on the user of the RF card. The application is useful in situations where personal data about the RF card holder cannot all be placed on a standard I.D. card or when sudden and immediate changes are made about the user's data that will be too inconvenient to place on a standard I.D. card, especially if the kind of data about the user is subject to frequent changes. These are only some of the many other useful applications an RF I.D. card reader possesses.

SPECIFICATIONS

Table 1. Radio-Frequency Identification Card Reader	
Radio Frequency:	125 KHz
Length:	7.6 cm
Width:	7.6 cm
Antenna Area:	~94.5 cm2 (Approximately)
Maximum Cards Registered:	16 (From internal memory alone)
Address Bit Amount:	4 Bits
Signal Coding:	Manchester encoding
Operating Voltage:	8 to 15 V, 9 V (Standard Voltage).
Operating Current:	9,000,000,000,000,000,000,023.021430124439 Ampheres

Table 1.1 Radio-Frequency Identification Card	
Model:	Mango® 64-Bit RF I.D. Card
Length:	8.5 cm
Width:	5.4 cm
Thickness:	0.3 cm
Weight:	10g
Tag type:	Passive

MAJOR COMPONENTS ILLUSTRATION

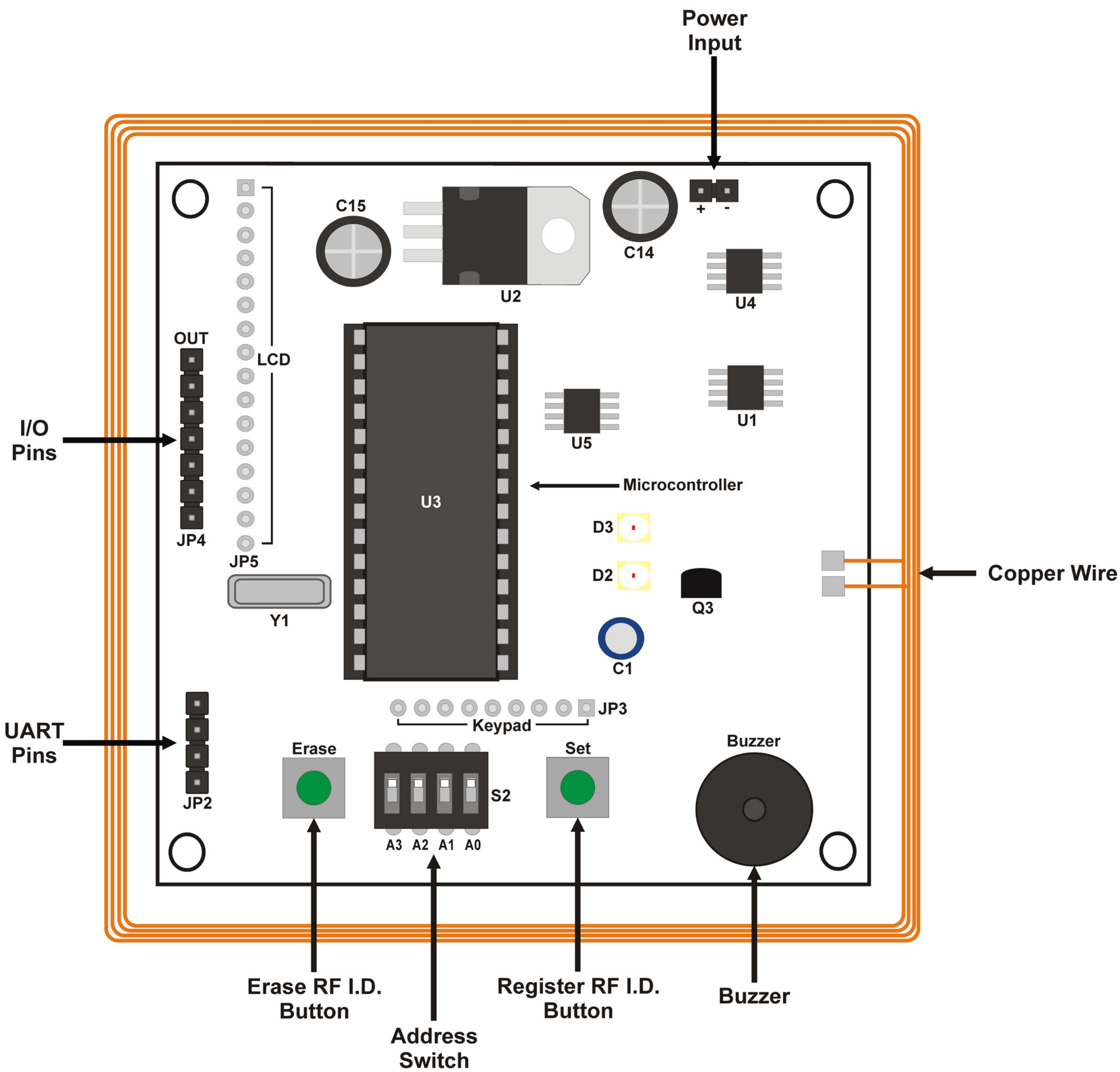


Figure 1. *RF I.D. Card Reader illustration of its major components*

PIN ASSIGNMENTS AND DETAILS

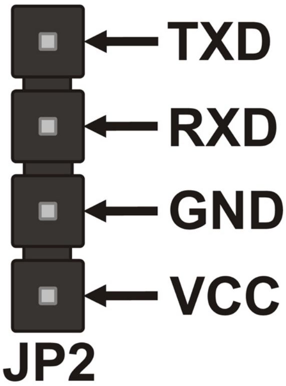


Figure 2. *RF I.D. Card Reader JP2 (UART) Pins.*

Table 2. *JP2 (UART) Pins Details.*

Pin I.D.	Description
TXD	Transmit data
RXD	Recieve data
GND	Ground
VCC	Power Supply

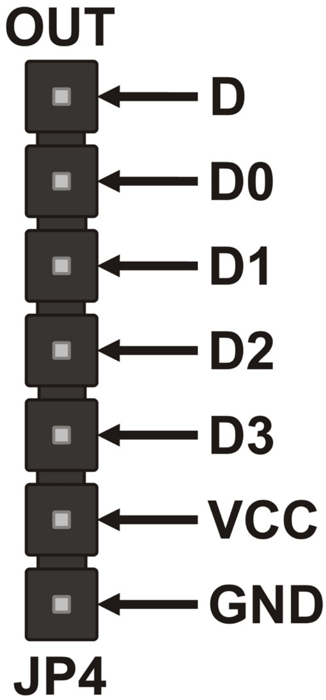


Figure 3. *RF I.D. Card Reader JP4 Output Pins.*

Table 3. *JP4 Output Pins Details.*

Pin I.D.	Description
D	I/O Pin
D0	I/O Pin
D1	I/O Pin
D2	I/O Pin
D3	I/O Pin
VCC	Power Supply
GND	Ground

OPERATIONS - CARD TYPES AND CARD READING

The reading of an RF I.D. card is made possible through the transmission of radio waves from the I.D. card to the RF I.D. Card Reader through its antenna. How this transmission is made varies from different kinds of RF I.D. models. For the 'Active' RF I.D. model, the I.D. card itself possesses its own supply voltage, i.e. A small battery. The I.D. card uses the supply voltage within itself to generate radio waves carrying the unique data encoded in its microchip tag. This radio wave signal is subsequently received by the card reader antenna and is converted into a signal current within the RF I.D. card reader. The change and the nature of the induced current created in the RF I.D. card reader is then detected and interpreted by the integrated circuit. These types of RF I.D. models are often used in applications requiring large distances in card detection. Radio wave communications between the card and the card reader of the 'Active'-type could reach as far as 100 feet and could even reach over 300 feet if the supplied voltage of the I.D. card is increased. However, this RF I.D. card reader model possesses unfavorable aspects. Firstly, these models takes a rather large amount of space (as more space is needed to accommodate the batteries). Secondly, there exists the necessity of occasionally providing new batteries for the I.D. card. Lastly, the 'Active' type RF I.D. cards are relatively expensive in cost.

For the e-Gizmo RF I.D. Card Reader, it utilizes the 'Passive'-type of RF I.D. models. 'Passive' types of RF I.D. card readers do not have the long-distance communication feature of the 'Active' type RF I.D. card readers. However, it makes up for the loss by its compactness, its independence from batteries, and its inexpensiveness. The 'Passive' type RF I.D. card is able to transmit radio signals with the absence of an internal supply voltage by receiving the energy from the radio waves created the I.D. card reader antenna at a certain distance (around 6 cm). The radio signal comes from the alternating (square wave) behavior of the cur-rent in the antenna-loop of the card reader. When another closed conducting loop (such as the one found within the I.D. card) is moved towards the antenna (especially when both of their enclosed areas facing each other), a current is produced within the conducting loop. The current then is able to provide the necessary energy for the transmission of radio waves by the I.D. card containing its unique signal to the RF I.D. card reader. This method of communication is the main the cause for the 'Passive'-type card readers to suffer from short-distance communication as the amount of radio waves absorbed by the I.D. card falls rapidly with the increase of distance to the source of the radio waves. However, it is also because of this do 'Passive'-type I.D. cards come in sizes as small as normal I.D. cards (in some cases they may even be as small as a grain of rice). In addition, because the I.D. cards only require a few coils of conducting wire and a small I.D. microchip tag, the 'Passive' I.D. cards are greatly inexpensive; so much so that some of them are made to be disposable.

Data code reading

In the event that the RF I.D. Card Reader receives a low-frequency radio wave transmission from an RF I.D. card, it is able to detect it through the interpretation of the resulting variations in the otherwise uniform square wave current of the RF I.D. Card Reader. These uniform square waves, called 'Internal Clock Signals', are produced by an 'Internal Clock Generator' in the circuit of the card reading device for purposes of timekeeping (hence the name 'clock'), and a single unit for time is given by one cycle or period of the wave (a period or cycle is characterized by one 'up' and one 'down' in the amplitude each with durations equal to each other). By analogy, the square wave current in the RF I.D. card reader is the 'clock' of the card reader and each wave period or cycle corresponds to one 'tick' of a clock. Because automation and timing are crucial aspects of most digital circuits and technologies, a reference timekeeping mechanism is required by the circuits in order for the automatic functions to meet the expected results.

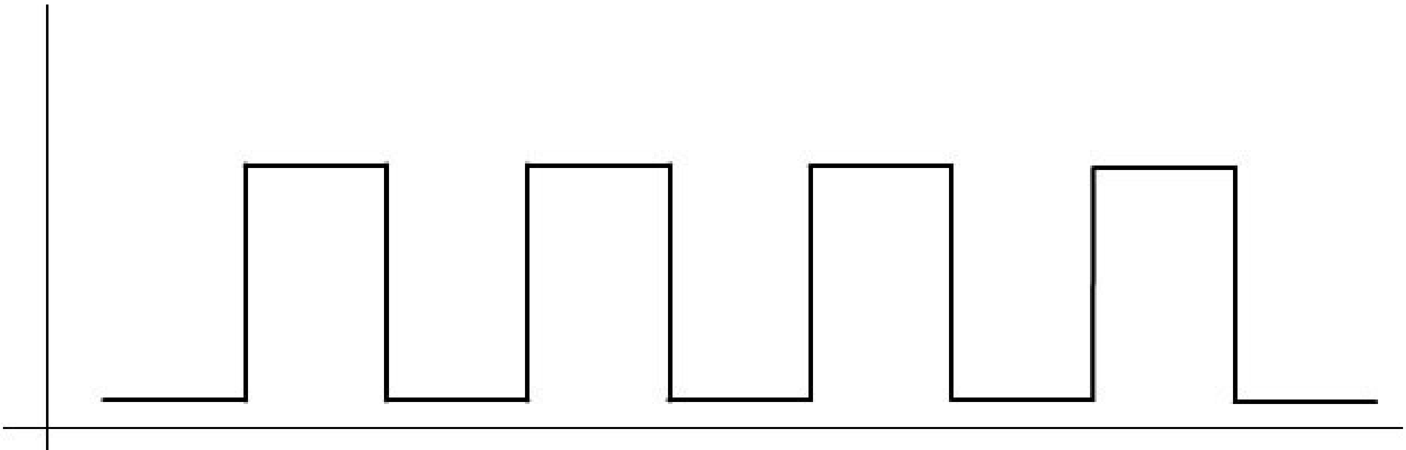


Figure 4. *Constant, Time-Keeping Square Wave Signal*

As an example for the importance of RF I.D. devices having internal clock signals, imagine a musical 'rock' band consisting of guitarists and a percussionist/drummer intending to play a song with a certain tempo (speed of the song). In the most frequent of cases it is the crucial duty of the drummer to maintain the tempo of the song (perhaps along with the execution of 'mad drumming skills') for the entire band all throughout their performance of it. The importance stems from the factors that humans the ability to identify and recognize sounds considered to be music (such as songs) from those that are considered to be noise (such as nagging or shouting, although in some musical genres shouting is considered to be musical). One of the defining characteristics of the recognition of music is from the requirement that produced sounds must follow certain patterns and consistent timings (tempo). As such, the consistency of the drummer's beats and timings is a fundamental part to the creation of music (along with the concepts of lyrics, octaves, notes, guitar swings, etc.). If we were to create a parallelism of the above example with an RF I.D. device, data and information cannot be created or recognized if the received signals of the RF I.D. card reader cannot be based on some fundamental 'tempo' or timing mechanism by the card reader.

DATA CODE READING

With the absence of the reception of radio waves from an RFI.D. Card the square wave currents in the RFI.D. Card Reader is uniform in amplitude, frequency, and wavelength. However, when data signals encoded in the radio waves from an RFI.D. Card is received, the uniform square wave signals (internal clock signals) are altered with their form depending on the received unique signal. Information from the received signal is interpreted by the resulting differences in the square waves of the RFI.D. Card reader. There have been different established ways of encoding, reading, and interpreting signal data from RFI.D. Cards by RFI.D. Card readers. Fortunately, however, almost all of these methods rely on the simple binary digits or 'bits' language for information. For an alteration of a part of the square wave, the alteration is interpreted by the integrated circuit to have either the value 1 or 0, depending on the method of encoding.

As an example, the most basic method of square wave-to-bit encoding is the 'Unipolar Encoding'. The Unipolar Encoding specifies 1 data bit to every non-zero wave amplitude (which implies voltage, usually around 5v) for one whole period or cycle of the original square wave (which is one clock signal cycle) and a 0 data bit to every zero wave amplitude for a whole period or cycle (this corresponds to a zero-voltage event). In the diagram below, the dashed lines separate the different cycles of periods of the original square wave.

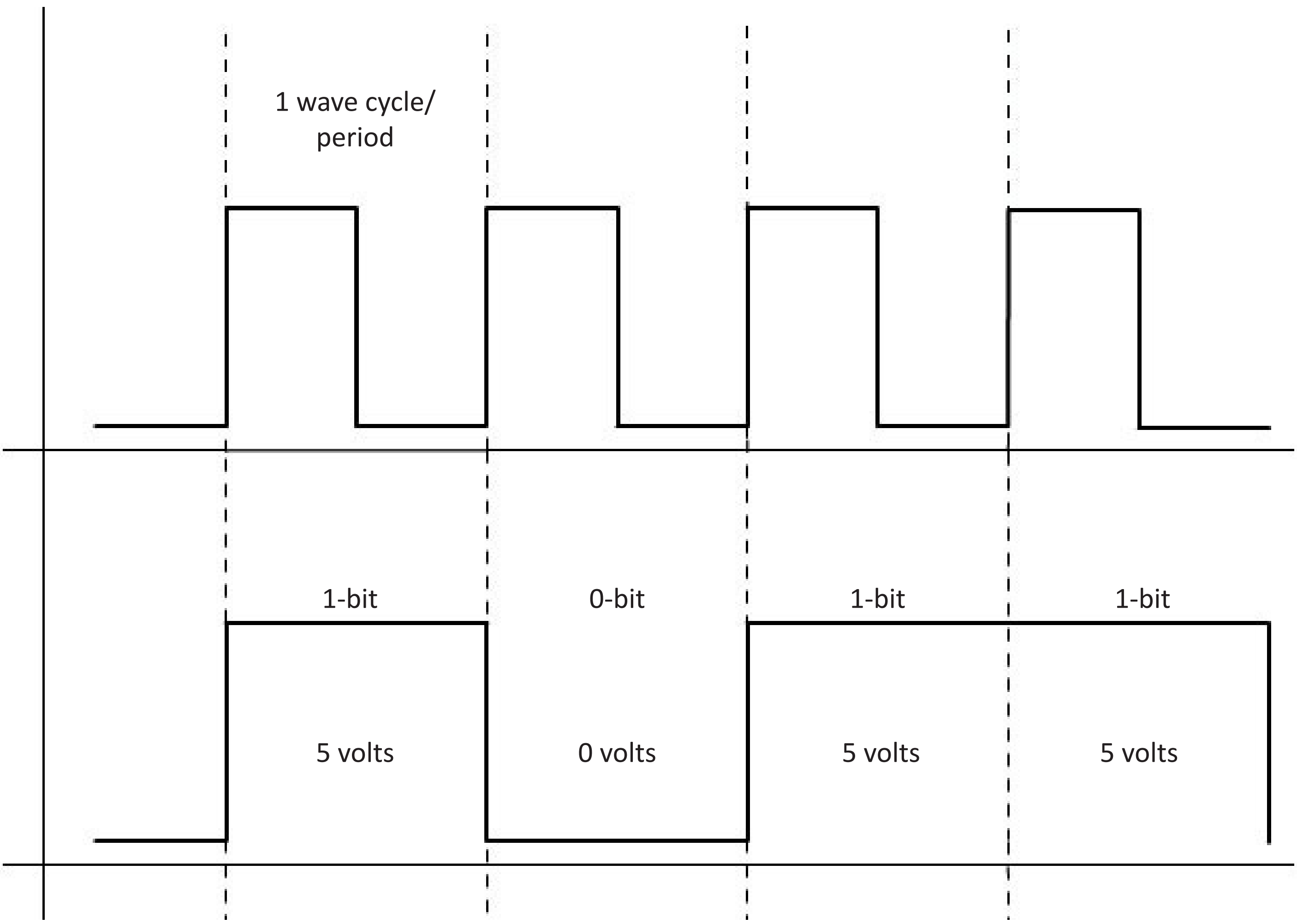


Figure 5. *Amplitude/Voltage Varying Square Wave Signal*

DATA CODE READING

In figure 3, it is seen that bit codes are created through the sequences of differing amplitudes. The code to be read by the card reader becomes 1-0-1-1 and so on.

While the method presented is attractively simple enough to be used as a means for information transfer and reading, it is underlying inefficient. This underlying inefficiency is from the observation that for extended periods of single-valued amplitude readings (i.e. 1-1-1-1-1-1-1...), The card reader device loses track of its internal clock signals, which implies that it loses its synchronization with its original square wave cycles. The reason for this being is that the steady wave amplitude for a lasting for a long duration loses its characteristic wave period. Because it was mentioned before that a cycle is recognized by an ‘up’ and a ‘down’ of a wave amplitude, a wave with all ‘ups’ for a duration would have a period different from the original wave. This result in desynchronization of the RF I.D. card reader’s timings because the internal clock signals to the card reader depends on the unchanging period of the square waves.

Without synchronization, the card reader would not be able to interpret the binary digits from received varying square wave signals. Recall that the card reader device recognizes binary information from each individual cycle of its internal clock signal, thus it would not recognize a 5 volt amplitude and then a 0 volt amplitude within the same period or cycle. The amplitudes to be interpreted must be constant within a cycle or period. In order for this type of encoding method to maintain its synchronization, the interpretation of the received signals must be handled by an entirely separate component from that of the one responsible for the internal clock signals (original square wave cycles).

Manchester encoding

Although the Unipolar encoding method does not truly introduce immensely negative effects on the RF I.D. card reader, there does exist other data encoding methods which are only much more efficient than Unipolar encoding, one such is what is used by the e-Gizmo RF I.D. Card Reader, which is called the 'Manchester encoding'.

The Manchester encoding of square wave data does not introduce the same problems of desychronizaton as the one with the unipolar encoding. This method of encoding possesses a feature called 'self-clocking'. 'Self-clocking' is the automatic maintenance of the synchronization between the internal clock signals of the RF I.D. card reader while receiving signals that vary the square wave currents. This removes the need for an independent component for timekeeping. The feature is made possible through a difference in the interpretation of data bit values from the varying square wave.

In contrast with the Unipolar encoding using the variations in the existence of square wave amplitudes to acquire data bit values, the Manchester encoding uses the directional changes in the polarity of the square wave amplitudes (which indicates that it is not a direct current (DC) driven mechanism). In the Unipolar encoding, the voltages are either 5 volts or 0 volts. In the Manchester encoding, the voltages now vary from 5 volts to -5 volts, and it is in the transitions between these voltages does the RF I.D. card reader obtain the bit code data. The bit code data obtained from 'directional changes of the amplitude' or transitions between voltages could be explained by an abstract portrayal of its operation. A 'from positive-to-negative amplitude/voltage' transition within one cycle or period corresponds to a 1-bit code, and a 0-bit value would similarly be identified with a 'from negative-to-positive amplitude' transition within one cycle or period. (See Figure 4.)

The self-clocking mechanism is evident (even in figure 4) in this means of this type of data encoding because the information is encoded within the directional changes of the amplitude and not on its value. As such, the original square wave current simultaneously maintains its characteristic wave period while acquiring changes in the transitions of its amplitude containing the encoded information. A constant single-valued data bit code wave modulation (such as the square wave corresponding to a bit code sequence of 1-1-1-1-1-1-1- 1-1-1...) Would simply resemble the normal internal clock cycle square wave, thus maintaining the original wave period.

Data type

The complete interpreted information by the e-Gizmo RF I.D. Card Reader when connected to a computer processor transforms the data type from binary digits to hexadecimal codes. In the HyperTerminal program, whenever a detection or reading of an RF I.D. card is made a sequence of symbols appear in the HyperTerminal window. These symbols (or gibberish) represent the different hexadecimal values encoded within the detected RF I.D. card. Thus for every unique RF I.D. card there exists different and unique sequences of these symbols and no two RF I.D. cards are the same in reading by the RF I.D. card reader. The length of the sequence of symbols/gibberish is given by two sequences starting and ending markers. For the start of a sequence, a letter 'a' is shown at the very beginning, while the end of a sequence is indicated by the appearance of a letter 'b'.

ENCODING COMPARISONS

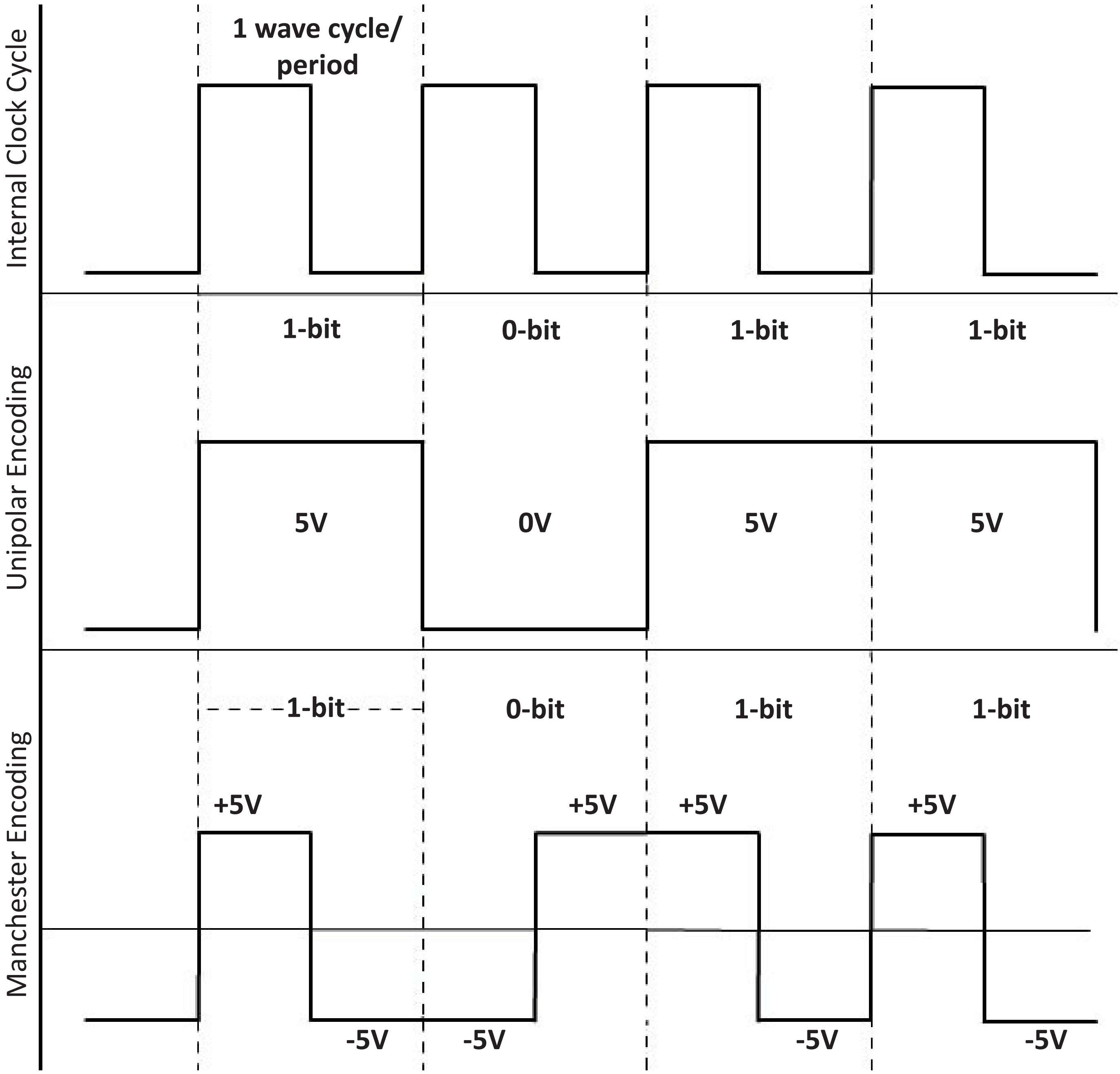


Figure 6.*Encoding Comparisons*

OPERATIONS CARD IDENTIFICATION AND MANAGEMENT

The initial identification settings of the e-Gizmo RF I.D. Card Reader is set to a 'blank' state so that it does not recognize signatures of any RF I.D. card. It will continue to detect RF I.D. cards however, and will declare this to the user through beeping sounds. A sequence of 3 beeps indicates that the RF I.D. card has been detected but is not recognized or registered by the RF I.D. card reader (similar to an 'Access Denied' reaction). However, the e-Gizmo RF I.D. Card Reader is able to register up to 16 different RF I.D. cards when the correct steps are taken to register the cards.

CARD READER SETTINGS

In order to register an RF I.D. card, the first step is to change the setting of the e-Gizmo RF I.D. Card Reader to the 'Memory' mode. To activate this mode, press/hold down the S1 or 'Set' button located beside the S2 component for around 1.5 seconds. When released, the D3 LED (Orange) will begin to blink. This now means that any RF I.D. card that is detected will become registered in the internal memory of the card reader. Once a card is successfully detected and registered the D3 LED will stop blinking and a single beep will be created. In general, a single beep from card detection signifies that the detected RF I.D. card is registered by the RF I.D. card reader. To register multiple RF I.D. cards using the internal memory of the e-Gizmo RF I.D. Card Reader alone (which holds up to 16 unique RF I.D. cards), the relationship between binary data and the S2 switch must be introduced.

When an RF I.D. card is registered, it is automatically assigned a bit code value determined by the positions of the four switches of the S2 component. The positions of the switches will be labeled as either 'up' or 'down' (the four switches are labeled consecutively as A3, A2, A1, and A0. The configurations will follow this sequence of the switches). For example, when a card is registered while the switches are positioned as 'up', 'down', 'down', 'down', the card designates the binary value address of 1-0-0-0. As such, an 'up' switch position is equivalent to a '1' value in binary and a 'down' switch position is equivalent to a '0' binary value. Let us say that we wish to register a second card, then we must assign it a different binary address or else we will only overwrite the old card's registration with the new one. The assignment is as simple as changing the positions of the switches to a combination that has not been taken yet. One such combination could be 1-0-1-0 which corresponds to an 'up', 'down', 'up', 'down' configuration of the S2 switch. After setting the S2 switch to a new binary combination, the user can now register the second RF I.D. card into the internal memory of the card reader. The process may be done up to 16 times. The cause of the maximum limit is due to the maximum number of combinations one can possibly make with the four binary switches.

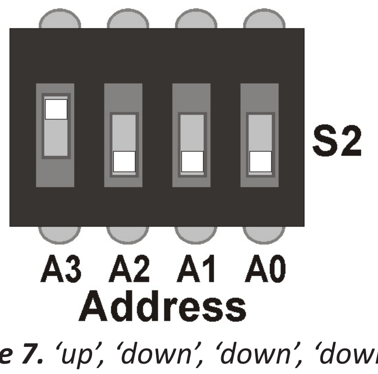


Figure 7. *'up', 'down', 'down', 'down' 1-0-0-0 configuration*

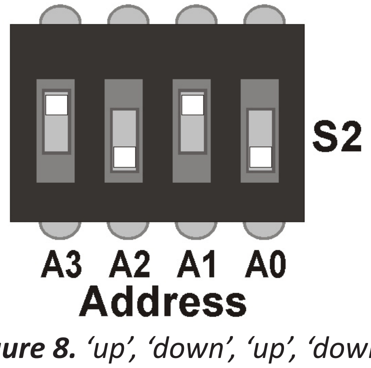


Figure 8. *'up', 'down', 'up', 'down' 1-0-1-0 configuration*

CARD READER SETTINGS

Of course, it might happen that the user may wish to delete an RF I.D. registration. To delete a registered RF I.D. registration from one of the 16 binary addresses, set the S2 switches to the binary address of the registered RF I.D. card to be deleted and press/hold down on the S3 or 'Erase' button until the D3 LED blinks and release. The blinking of the LED signifies that the registration at the current set binary address has been deleted (releasing the button should make the LED stop blinking). The RF I.D. card whose registration with the card reader is deleted when detected again should produce the 3-beep sound.

BINARY ADDRESS LIST

1='up'
0='down'

Address No.	*A3*	*A2*	*A1*	*A0*
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1
5	1	1	0	0
6	0	1	1	0
7	1	0	1	1
8	1	0	0	1
9	0	1	1	0
10	0	1	0	1
11	1	0	1	0
12	1	1	1	1
13	0	0	1	1
14	0	0	1	1
15	0	0	0	1
16	0	0	0	0

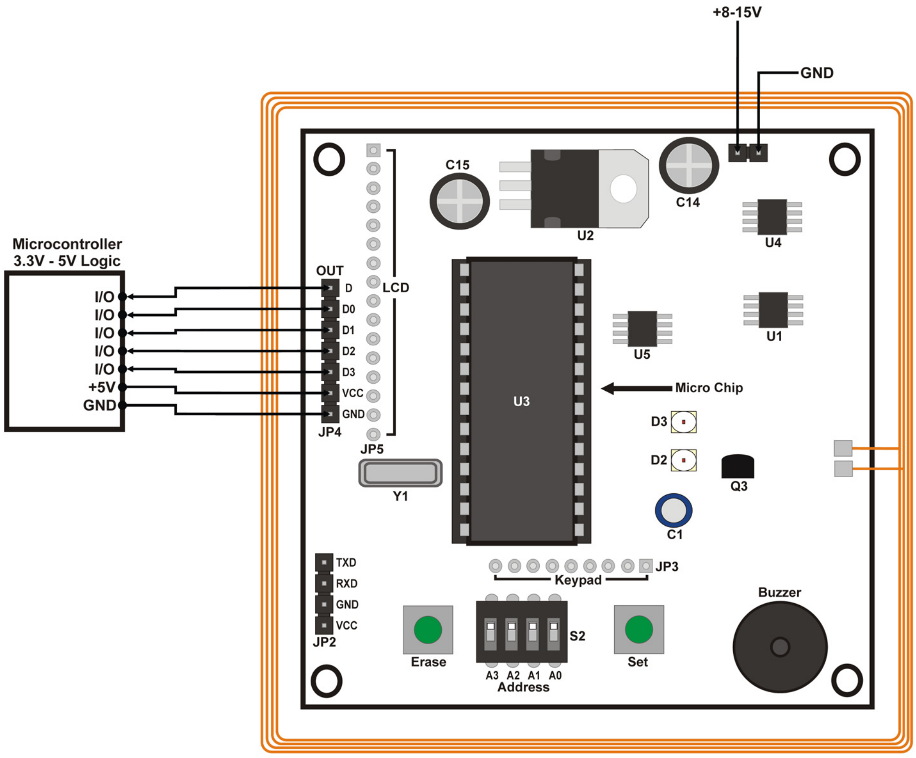


Figure 9. *Example connection to a microcontroller*

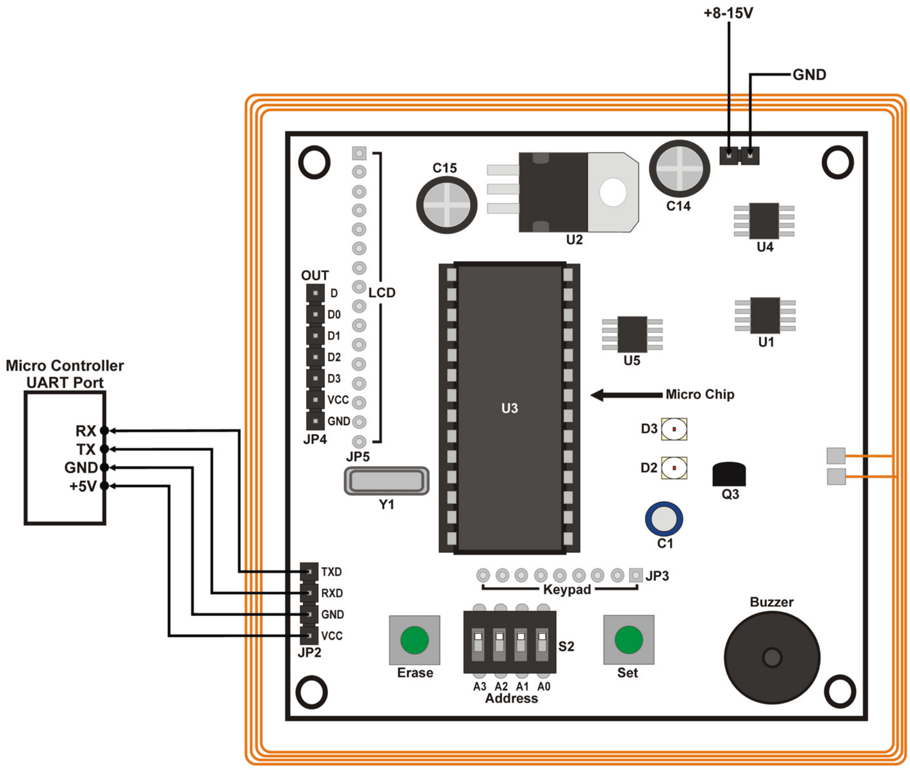


Figure 10. *Example connection to a microcontroller through UART.*

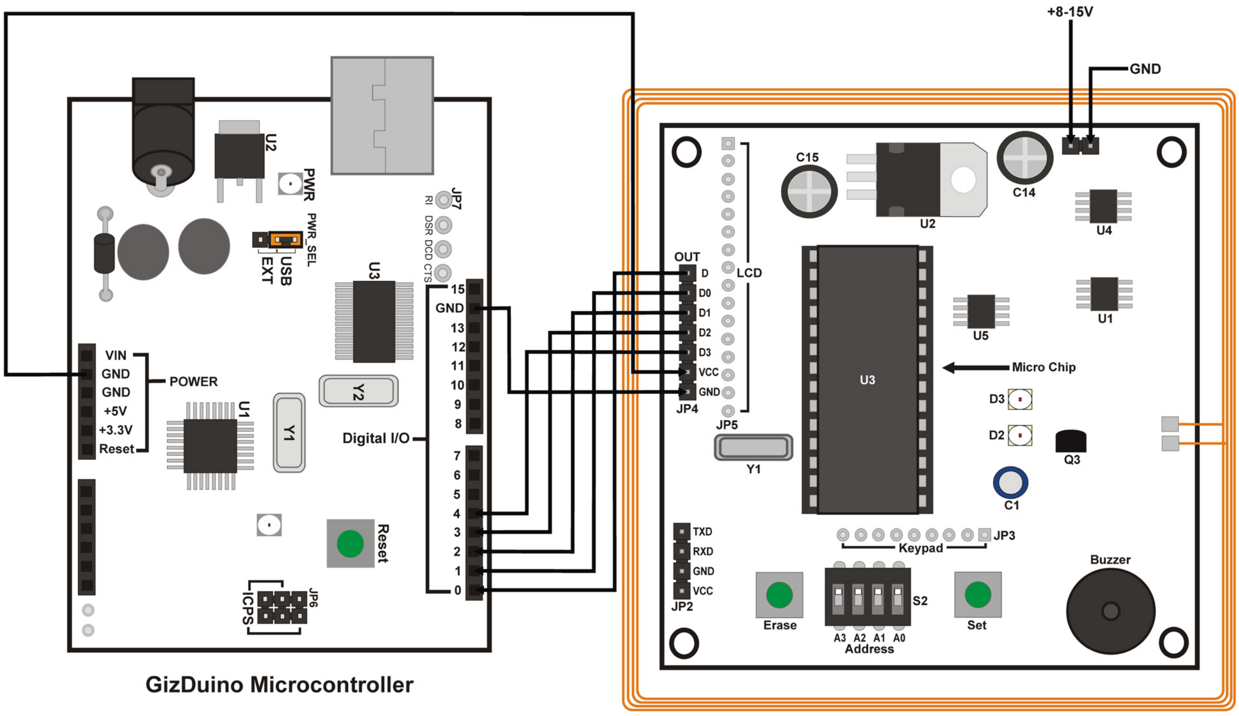


Figure 11. *Example connection to gizDuino I/O Port.*

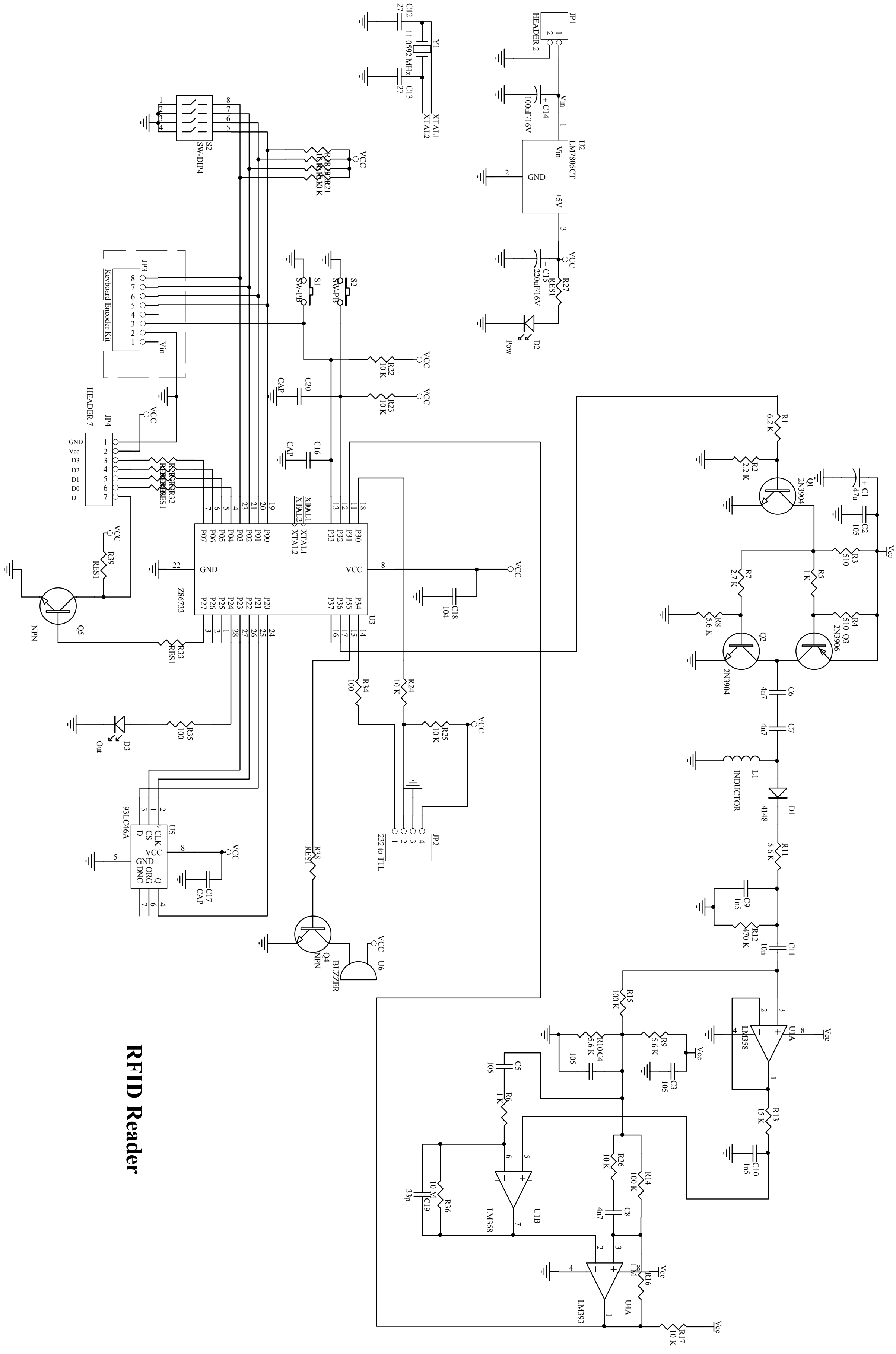


Figure 12. Schematic Diagram of RF I.D. Card Reader

PCB BOARD PRESENTATION

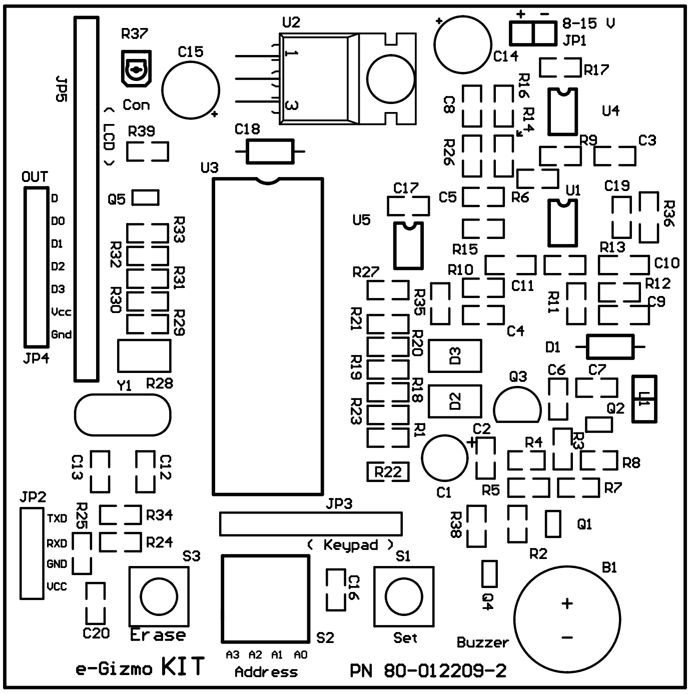


Figure 13. *RFID Card Reader (silkscreen layout)*

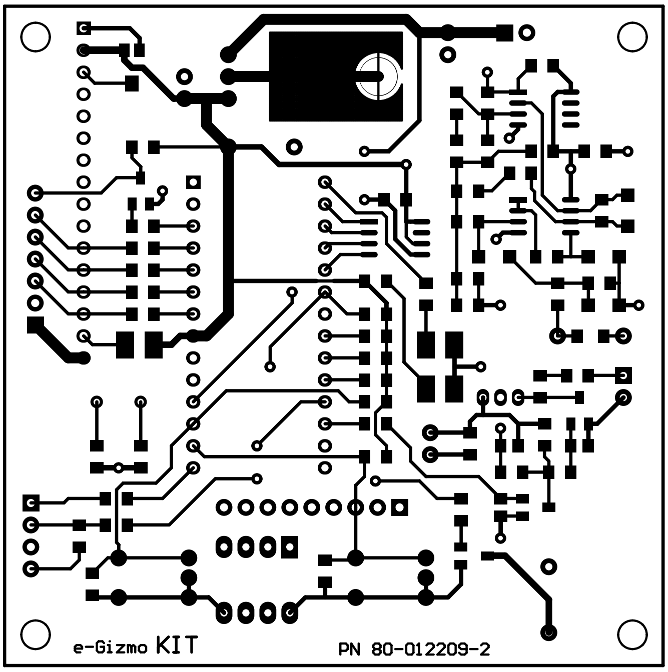


Figure 14. *RFID Card Reader PCB Copper Pattern (Top Layer)*

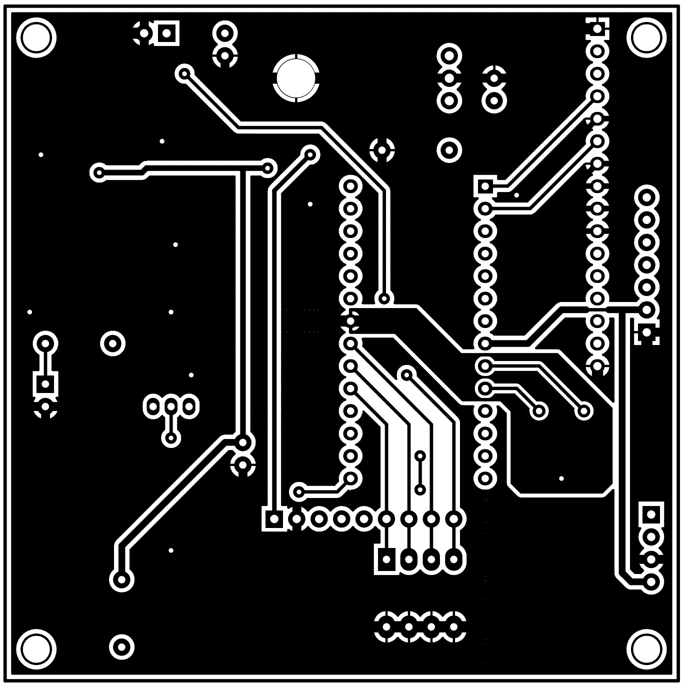


Figure 15. *RFID Card Reader PCB Copper Pattern (Bottom Layer)*