Encoder and Decoder Comparison

Application Note AN-00310

Introduction

Encoders and decoders are an ideal way of sending on/off data such as button presses to a remote location. When a line on the encoder is taken high, it will create a data stream that is sent to the decoder. The decoder will interpret the data stream and take a corresponding data line high to replicate the state of the encoder. This document gives an overview of encoder/decoder ICs and explains the differences between Linx encoders and decoders and those offered by other manufacturers.

What is an Encoder/Decoder?

Encoders and decoders are designed to transfer the status of an input such as a switch or contact closure over a wireless link. The encoder encodes the status of an input(s) into a Pulse Width Modulated (PWM) or serial data stream intended for transmission via an RF or infrared link. Once received, the decoder decodes, error checks, and analyzes the transmission. Often, address or ID information will be included for uniqueness and/or security. If the transmission is verified, the decoder's output lines are set to replicate the status of the lines on the transmitter.

A Brief History

The early days of encoders and decoders were dominated by fixed-address devices such as those offered by Holtek. Who doesn't remember a car fob or garage door remote with its formidable bank of DIP switches that were hopefully set to some reasonably unique address (and perhaps changed when your neighbors garage opened too)? Then came the broad recognition that a transmission could be captured and later used to compromise the system. "Code grabbing," as the process was called, seemed to capture the grim specter of a robber crouching in the bushes waiting for you to press your remote so the transmission could be captured and used by a thief at a later time.

A solution to this very real (but perhaps over-hyped) threat was provided by Nanoteq of South Africa, which developed the Keeloq encoder/decoder, which focused on security and utilized encryption to guard against code cracking or grabbing. In November 1995, Microchip Technologies, maker of the popular PIC microcontroller, acquired the Keeloq and became the sole owner of the technology. Today, this product dominates markets requiring high security, but fixed-address technologies continue to co-exist because of several advantages, which we will outline later. The entrance of Linx Technologies into the encoder/decoder market represents another milestone moment. Let's take a more in-depth look at how the Linx AirLok solution combines the strengths of previous approaches and adds entirely new benefits as well.

Transmission Methods

The method and speed of transmission is an important and often overlooked factor in determining both the range and responsiveness of a link. Two of the most common methods of sending data are Pulse Width Modulation (PWM) and serial bit stream.

PWM is a method of sending data as a series of pulses of a specific duration or width. A '0' is one width and a '1' is a different width. The receiver will start a timer on the rising edge of the pulse and stop it on the falling edge. It will then interpret this time as either a '1' or a '0'.

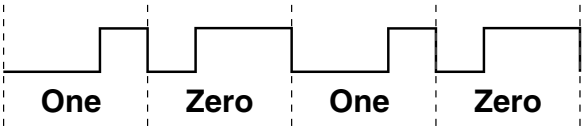

Figure 1: Pulse Width Modulated Data Stream

A serial bit stream will interpret a '1' as a high voltage and a '0' as a low voltage. Some systems can have this inverted, but we will focus only on this method for the sake of simplicity. The concept is the same in either method. The receiver will then look for the rising edge of the first bit, wait ½ bit time to get to the center of the bit, then wait 1 bit time to sample each bit in its center. It will monitor the voltage level of each sample and interpret a high voltage as a '1' and a low voltage as a '0'.

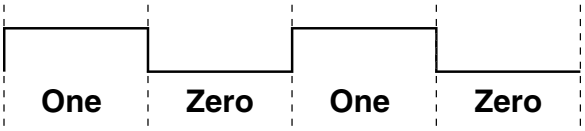

Figure 2: Serial Data Stream

Both methods offer advantages and disadvantages. PWM makes it easier to achieve a lower duty cycle (which will be discussed later), but the serial bit stream is more noise tolerant. This noise tolerance is what makes the serial bit stream a better choice for wireless communication.

When pulses are sent over a wireless link, they typically suffer from something called edge jitter. This is when the pulses are stretched or shortened by the radios used to transmit the data or the wireless environment. It is a common occurrence and requires that PWM schemes have very wide margins built into their timing. Since the serial bit stream is sampled at the center of each bit, jitter at the edges will not have any effect on the interpretation of the bit.

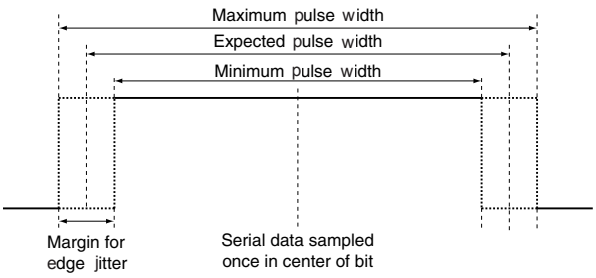

Figure 3: Edge Jitter

Most of the encoder/decoder ICs offered today use analog methods such as PWM to represent the digital data. Because RF links introduce jitter and commonly alter timing, this method is problematic and impacts range and reliability. The best performance is yielded when data is sent in serial fashion, which lessens the impact of jitter and bit alteration.

Responsiveness can also be an important factor in many applications. As used here, responsiveness refers to the lag time between input and output. To put it more practically, it is the time between when a user pushes a button and something happens on the other end. This may be a concern simply because of the user's perception or a more significant factor such as safety. Responsiveness is determined by multiple factors, including the speed of the encoder and RF link, the packet size, redundancy and error checking, and decoding/decryption time.

Another commonly overlooked factor is the legal aspect of the data stream's duty cycle. The FCC allows the transmitter's output power to be averaged over 100ms. Many Amplitude Shift Key (ASK) transmitters work by turning the transmitter on for a '1' and turning it off for a '0'. The result is that a data stream with more '0's will have a lower average output power over that 100mS time. This allows the output power of the transmitter to be increased and still be legal. The increase in power results in an increase in range and better performance within that range. The FCC will allow the output power of an AM link to be up to 20 times the legal limit, provided the data stream average of high bits over the 100ms time frame results in an average that meets the legal limit.

Most encoders and decoders will target a 50% duty cycle (equal numbers of '0's and '1's). This is generally the best compromise between data volume and output power.

All Linx encoder and decoders utilize a serial data protocol designed for maximum efficiency and incorporate error detection and balance optimization. This allows products based on AirLok devices to achieve superior range and immunity from interference, edge jitter and other adverse external influences.

Feature Set

Status/Data Lines

All encoders provide at least one input line that is normally connected to a switch or contact. Often it is advantageous to have multiple buttons or even a keypad matrix. All Linx AirLok encoders provide eight data lines for maximum versatility.

Addressing

Most encoder/decoder ICs provide a mechanism for ensuring that a transmission is both valid and intended for a specific receiver. This is accomplished by giving each encoder an address that can, in some cases, uniquely identify it. Creating the address has typically been done in one of two ways.

Low-security devices usually have an address set manually with a DIP switch or cut traces. The user must set the address on the encoder and the decoder the same in order for them to communicate. These address lines frequently cause the user confusion when trying to match a transmitter to a receiver. Given that there must be extra hardware easily accessible by the user, there are a limited number of lines (typically 8 to 10), which offer a limited number of addresses.

The second way, typically used by the higher-security devices, is to "seed" each encoder with an address during the manufacturing process. These devices can have large numbers (typically 32 or 64 bits) making each encoder unique, but it is an additional step in the manufacturing process and requires special programmers to load the number into each encoder. While they are an improvement over manual switches, they impose limitations of their own. The transmitter and receiver can become desynchronized and creating relationships and associations among groups of transmitters and receivers is difficult or impossible.

By combining unprecedented ease of use with high security, the Linx AirLok product line offers the best of all worlds. The MS Series uses a large address (24 bits) that is created in the encoder by a random number generator that is activated by simply taking one of the lines high. The large number of bits means that there is a great deal of uniqueness and security. The random number generator allows the encoder address to be set with the press of a button, eliminating the need for a programmer. The address is learned by the decoder by the press of another button. This makes creating a unique association by the user or manufacturer fast and straightforward.

Permissions and Associations

It is often useful to create various relationships and permissions between system components. At this point, it will become clear why Linx AirLok ICs represent a milestone in encoder/decoder development, since they are the first parts to allow a user or manufacturer to create groups and relationships. Here are two practical examples.

This example demonstrates the value of permissions: A three-car garage houses dad's Corvette, mom's Mercedes, and Son's Yugo. With most competitive products, any user's keyfob could open any garage door as long as the addresses match. In a Linx AirLok system, the keyfobs could easily be configured by the user to open only certain doors. (Guess which one Son gets to open!)

This example illustrates the value of grouping. Imagine a remote control designed for use in a woodshop. One button could turn on a vacuum, one an air cleaner, and another a light. Yet another button could then be user configured to turn on all of them with a single touch.

As you can see, Linx Airlok's user permission and association capabilities open the door to a whole new range of possible product features.

Origination ID

Another unique and important feature of Linx AirLok decoders is their ability to identify the transmitting encoder. In conventional designs, all encoded transmissions are either recognized or denied based on the address. If, for example, someone pushed a button in a nurse call system, there would be no way to know which patient sent the signal. In an AirLok-based system, the transmitter's unique ID would be available from the decoder.

Security

The success of the Microchip Keeloq line illustrates the significant concern many manufacturers have for security. Even in applications where a high level of security is not necessary, the marketing appeal is often undeniable.

It is important to distinguish between security and uniqueness. A part offering a large number of addresses will have increased uniqueness, meaning there will be little potential for two devices in proximity unintentionally having the same address.

Security might be thought of as the mechanisms whereby an encoder/decoder relationship is protected against attack. Typically, the encoding of each transmission changes based on complex mathematical algorithms. This makes it extremely difficult to predict what the next code will be and is designed to prevent someone from replicating a transmission. The larger the key and block cipher, the more codes

are possible and the lower the probability that the correct one can be found without knowledge of the algorithm and initial conditions.

If an application is not concerned with the potential for malicious grabbing of a transmission but needs to ensure that there is little chance of two devices in proximity having the same address, the Linx MS Series is an ideal choice. The MS offers over 16 million possible addresses that are pseudo-randomly generated without awkward DIP switches or cut traces. This address is fixed and the same for each transmission.

For applications requiring high security, the HS Series combines the feature set of the MS Series with a level of security unprecedented in the market.

An in-depth comparison with the popular Keeloq is beyond the scope of this document. In brief, Keeloq uses a 64-bit key, 32-bit block, one-dimensional algorithm while the HS Series utilizes an 80-bit key, 64-bit block algorithm with a random key generated by the user. The code for Keeloq will change with each transmission. The code for the HS will change continuously during each transmission.

Development Systems

Development systems are generally intended to quickly illustrate the capability and correct application of encoder and decoder ICs. Usefulness varies depending on the manufacturer, but a well thought out system can be of significant help in utilizing the product in a design. Linx master development systems contain all of the tools necessary to fully explore the capabilities of Linx's new AirLok Series encoders and decoders.

The master development system features pre-assembled evaluation boards complete with Linx RF modules, which allow the encoder and decoder to be quickly tested in a wireless environment. Demonstration software and an onboard USB interface allow connection to a PC. When ready to begin development, a large prototyping area with breakout headers and a regulated power supply allows for the addition of application-specific circuitry.

Summary

It is our belief that when objectively compared to other available solutions, Linx encoder/decoder ICs will be found to offer:

- Greater ease of use and setup
- Greatest flexibility
- Superior feature set
- Highest security

Whatever your product choice, we trust this application note provided information useful to your success.

Manual Address Decoders

Advantages
High number of button inputs

Disadvantages
Low-security fixed code
Confusing manual addressing
Low number of addresses
PWM data output
High security vulnerabilities

"Rolling Code" Decoders

Advantages
Highly secure
Eliminates manual address settings

Disadvantages
Low number of button inputs
Encoder and decoder can become desynchronized
Difficult or impossible to create relationships
Security vulnerabilities

Linx AirLok Decoders

Advantages
High number of button inputs
Highly unique (MS)
Highest security available on the market (HS)
Eliminates manual address settings
Allows for associative relationships
Cannot desynchronize
Serial data output
Encoder ID is output by the decoder
Latched or momentary outputs (MS)
External transmitter and receiver control lines

Disadvantages
Slightly higher cost for some basic applications
Security vulnerabilities (MS only)

Figure 4

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