



## MS SERIES ENCODER DATA GUIDE

### DESCRIPTION

MS Series encoders and decoders are designed for remote control applications. They allow the status of up to eight buttons or contacts to be securely transferred via a wireless link. The large, twenty-four bit address size makes transmissions highly unique, minimizing the possibility of multiple devices having conflicting addresses. The MS Series decoder allows the recognition of individual output lines to be easily defined for each transmitter by the manufacturer or the user. This enables the creation of unique user groups and relationships. The decoder also identifies and outputs the originating encoder ID for logging or identification. Housed in a tiny 20-pin SSOP package, MS Series encoders feature low supply voltage and current consumption. Selectable baud rates and latched or momentary outputs make the MS Series truly versatile.

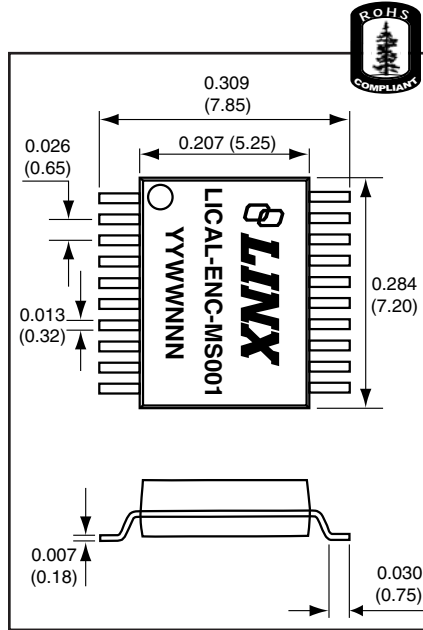


Figure 1: Package Dimensions

### FEATURES

- Secure 2<sup>24</sup> possible addresses
- 8 data lines
- Low 2.0 to 5.5V operating voltage
- Low supply current (370µA @ 3V)
- Ultra-low 0.1µA standby current
- Definable recognition authority
- True serial encoding
- Excellent noise immunity
- Selectable baud rates
- No programmer required
- Direct serial interface
- Small SMD package
- Latched or momentary outputs
- Encoder ID output by decoder

### APPLICATIONS INCLUDE

- Keyless Entry
- Door and Gate Openers
- Security Systems
- Remote Device Control
- Car Alarms / Starters
- Home / Industrial Automation
- Remote Status Monitoring
- Lighting Control

### ORDERING INFORMATION

PART #	DESCRIPTION
LICAL-ENC-MS001	MS Encoder
LICAL-DEC-MS001	MS Decoder
MDEV-LICAL-MS	MS Master Development System

MS encoders are shipped in reels of 1,600

## ELECTRICAL SPECIFICATIONS

Parameter	Designation	Min.	Typical	Max.	Units	Notes
<b>POWER SUPPLY</b>						
Operating Voltage	$V_{CC}$	2.0	–	5.5	VDC	–
Supply Current:	$I_{CC}$					
At 2.0V $V_{CC}$		–	240	300	$\mu A$	1
At 3.0V $V_{CC}$		–	370	470	$\mu A$	1
At 5.0V $V_{CC}$		–	670	780	$\mu A$	1
Power-Down Current:	$I_{PDN}$					
At 2.0V $V_{CC}$		–	0.10	0.80	$\mu A$	–
At 3.0V $V_{CC}$		–	0.10	0.85	$\mu A$	–
At 5.0V $V_{CC}$		–	0.20	0.95	$\mu A$	–
<b>ENCODER SECTION</b>						
Input Low	$V_{IL}$	0.0	–	$0.15 \times V_{CC}$	V	2
Input High	$V_{IH}$	$0.8 \times V_{CC}$	–	$V_{CC}$	V	3
Output Low	$V_{OL}$	–	–	0.6	V	–
Output High	$V_{OH}$	$V_{CC} - 0.7$	–	–	V	–
Input Sink Current	–	–	–	25	mA	–
Output Drive Current	–	–	–	25	mA	–
SEND High to DATA_OUT	–	–	1.64	–	mS	–
<b>ENVIRONMENTAL</b>						
Operating Temperature Range	–	-40	–	+125	$^{\circ}C$	–

Table 1: Electrical Specifications

### Notes

1. Current consumption with no active loads.
2. For 3V supply,  $(0.15 \times 3.0) = 0.45V$  max.
3. For 3V supply,  $(0.8 \times 3.0) = 2.4V$  min.

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage $V_{CC}$	-0.3	to	+6.5	VDC
Any Input or Output Pin	-0.3	to	$V_{CC} + 0.3$	VDC
Max. Current Sourced By Output Pins			25	mA
Max. Current Sunk By Output Pins			25	mA
Max. Current Into $V_{CC}$			250	mA
Max. Current Out Of GND			300	mA
Operating Temperature	-40	to	+125	$^{\circ}C$
Storage Temperature	-65	to	+150	$^{\circ}C$

**\*NOTE\*** Exceeding any of the limits of this section may lead to permanent damage to the device. Furthermore, extended operation at these maximum ratings may reduce the life of this device.

## TIMINGS

Baud Rate	Initial Start-up	After Valid Rx	With RX_PDN (Worst Case)
2,400	72.62	38.62	600+72.62
9,600	22.42	12.42	300+22.42
19,200	13.80	7.30	150+13.80
28,800	11.00	6.00	150+11.00

Table 2: Encoder SEND to Decoder Activation Times (mS)

## RECOMMENDED PAD LAYOUT

The MS Series encoders and decoders are implemented in an industry standard 20-pin Shrink Small Outline Package (20-SSOP). The recommended layout dimensions are shown below.

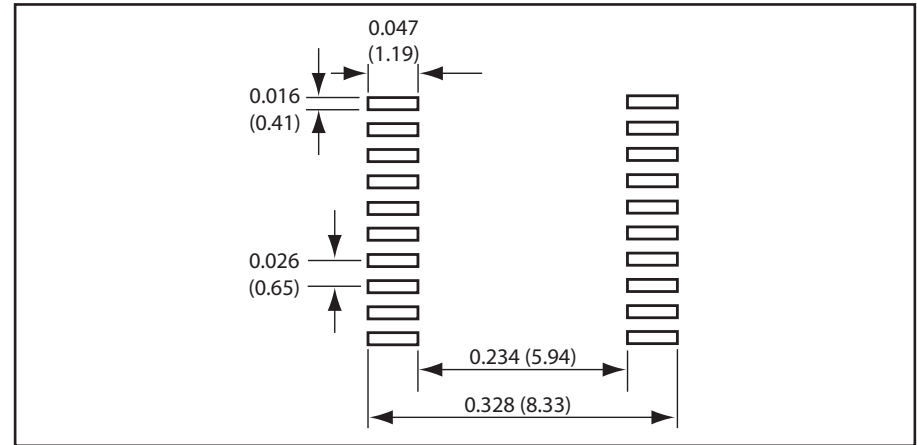


Figure 2: PCB Layout Dimensions

## PRODUCTION CONSIDERATIONS

These surface-mount components are designed to comply with standard reflow production methods. The recommended reflow profile is shown below and should not be exceeded, as permanent damage to the part may result.

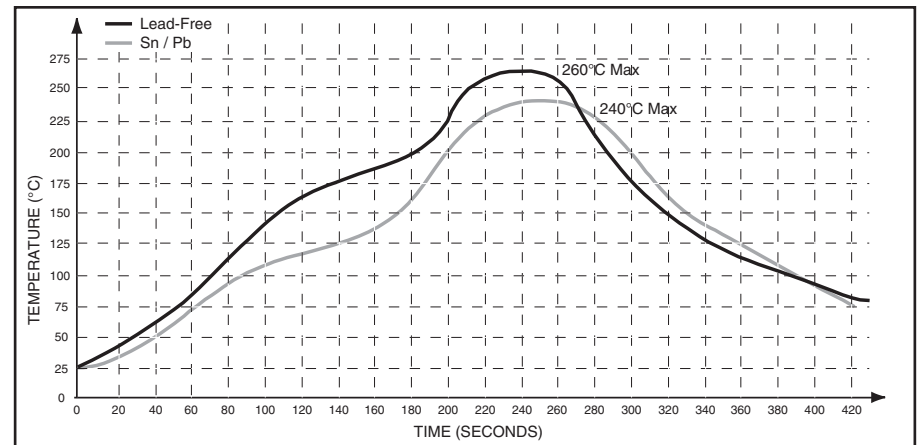
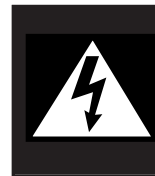


Figure 3: MS Series Reflow Profile



### \*CAUTION\*

This product is a static-sensitive component. Always wear an ESD wrist strap and observe proper ESD handling procedures when working with this device. Failure to observe this precaution may result in device damage or failure.

## PIN ASSIGNMENTS

1	D6	LICAL-ENC-MS001	D5	20
2	D7		D4	19
3	SEL_BAUD0		D3	18
4	SEL_BAUD1		D2	17
5	GND		VCC	16
6	GND		VCC	15
7	GND		D1	14
8	TX_CNTL		D0	13
9	DATA_OUT		SEND	12
10	MODE_IND	CREATE_ADDR		11

Figure 4: MS Series Encoder Pin Assignments

Pin Name	Pin Number	I/O	Description
D0-D7	1, 2, 13, 14, 17-20	I	Data Input Lines
SEL_BAUD0	3	I	Baud Rate Selection Line
SEL_BAUD1	4	I	Baud Rate Selection Line
GND	5, 6, 7	—	Ground
TX_CNTL	8	O	External Transmitter Control Line
DATA_OUT	9	O	Serial Data Output
MODE_IND	10	O	Mode Indicator Output
CREATE_ADDR	11	I	Create Mode Selection Line
SEND	12	I	Encoder Send Data Line
V <sub>CC</sub>	15, 16	—	Positive Power Supply

### NOTE:

None of the input lines have internal pull-up or pull-down resistors. The input lines must always be in a known state (either GND or V<sub>CC</sub>) at all times or the operation may not be predictable. The designer must ensure that the input lines are never floating, either by using external resistors, by tying the lines directly to GND or V<sub>CC</sub>, or by use of other circuits to control the line state.

## PIN DESCRIPTIONS

### Data Lines

The encoder has eight data lines, D0 through D7. The state of these lines are captured when the SEND line goes high and encoded for transmission. Upon successful reception, these states are reproduced on the outputs of the decoder.

### SEL\_BAUD0 and SEL\_BAUD1

These lines are used to select the baud rate of the serial data stream. The state of the lines allows the selection of one of four possible baud rates, as shown in the table.

SEL_BAUD1	SEL_BAUD0	Baud Rate (bps)
0	0	2,400
0	1	9,600
1	0	19,200
1	1	28,800

Table 3: Baud Rate Selection Table

The baud rate must be set before power up. The encoder will not recognize a change in the baud rate setting after it is on.

### GND

These lines are connected to ground.

### TX\_CNTL

This line goes high when the SEND line goes high, and low when the SEND line goes low. This can be used to power up an external RF or infrared transmitter when the encoder is sending data, and power it down when the encoder is asleep. It can also be used to drive a LED for visual transmit indication.

### DATA\_OUT

The encoder will output a serial data stream on this line. This line can directly interface with all Linx RF transmitter modules.

### MODE\_IND

This line is activated while the encoder is in Create Mode, allowing the connection of a LED indicator. The LED will stay on for the entire time the encoder is in Create Mode, indicating that the encoder is creating a new Code Word.

### CREATE\_ADDR

When this line is taken high, the encoder will enter Create Mode and randomly generate a new Code Word. This word will be continuously randomized while this line is high, and will be saved as soon as this line is taken low.

### SEND

When this line goes high, the encoder will record the states of the data lines, retrieve the secure Code Word from memory, assemble the packet, and send it as a serial bit stream out of the DATA\_OUT line at the baud rate selected by the states of the SEL\_BAUD lines.

### V<sub>CC</sub>

This is the positive power supply.

## DESIGN CONSIDERATIONS

The Linx MS Series encoders and decoders are designed for remote control applications. They provide an easy way to securely register button presses or switch closures over a wireless link. The encoder side turns the status of eight parallel input lines into a secure, encoded, serial bit-stream output intended for transmission via an RF or infrared link. Once received, the decoder decodes, error checks, and analyzes the transmission. If the transmission is authenticated, the output lines are set to replicate the status of the lines on the encoder.

Prior to the arrival of the Linx MS Series, encoders and decoders typically fell into one of two categories. First were older generation, low-security devices that transmitted a fixed address code, usually set manually with a DIP switch. These address lines frequently caused the user confusion when trying to match a transmitter to a receiver. Another disadvantage was the possibility that address information could be captured and later used to compromise the system.

These concerns resulted in the development of a second type of encoder / decoder that focused on security and utilized encryption to guard against code cracking or code grabbing. Typically, the encoding of each transmission changes based on complex mathematical algorithms to prevent someone from replicating a transmission. These devices gained rapid popularity due to their high security and the elimination of manual switches; however, they imposed some limitations of their own. Such devices typically offer a limited number of inputs, the transmitter and receiver can become desynchronized, and creating relationships and associations between groups of transmitters and receivers is difficult.

The Linx product line, which includes the MS and HS Series, is the first product line to offer the best of all worlds. Both series accept up to eight inputs, allowing a large number of buttons or contacts to be connected. The devices also allow relationships among multiple encoders and decoders to be easily created. Security is well provided for. The MS Series uses a random fixed word with  $2^{24}$  possible combinations to give a high level of uniqueness and a reasonable level of security. For applications requiring the highest security, the HS Series, which employs tri-level, maximum-security encryption, should be considered.

Encoder transmission protocol and methodology is a critical but often overlooked factor in range and noise immunity. The MS and HS products utilize a true serial data stream rather than the PWM schemes employed by many competitive devices. This allows products based on MS or HS devices to achieve superior range and immunity from interference, edge jitter, and other adverse external influences.

One of the most important features unique to the MS and HS products is their ability to establish a unique user identity and profile for the device containing the encoder. In conventional designs, all encoded transmissions are either recognized or denied based on the address. In cases where encoder and decoder addresses match, the state of all data lines is recognized and output. Linx products uniquely allow a user or manufacturer to define which encoder inputs will be acknowledged by each decoder. MS series decoders can store up to 40 system users and unique profiles for each. This allows for an incredible variety of unique relationships among multiple system components and opens the door to product features not previously possible.

## A PRACTICAL EXAMPLE

Consider this practical example: a three door 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 MS-based system, the keyfobs could easily be configured to open only certain doors (guess which one Son gets to open!) The MS Series also allows for component 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, the MS Series uniquely combines security and simplicity with the power to create groups and relationships.

Manual Address Encoders
<b>Advantages</b> ☺ High number of button inputs
<b>Disadvantages</b> ☹ Low-security fixed code Confusing manual addressing Low number of addresses PWM data output High security vulnerabilities
"Rolling Code" Encoders
<b>Advantages</b> ☺ Highly secure Eliminates manual address settings
<b>Disadvantages</b> ☹ Low number of button inputs Encoder and decoder can become unsynchronized Difficult or impossible to create relationships Security vulnerabilities
Linx Encoders
<b>Advantages</b> ☺ High number of button inputs Highly unique (MS) Highest security available on the market (HS) Eliminates manual address settings Allows for associative relationships Cannot unsynchronize Serial data output Encoder ID is output by the decoder Latched or momentary outputs (MS) External transmitter and receiver control lines
<b>Disadvantages</b> ☹ Slightly higher cost for some basic applications Security vulnerabilities (MS only)

Figure 5: Encoder Comparison Table

## ENCODER OPERATION

Upon power up, the encoder will set the baud rate based on the state of the SEL\_BAUD lines and then check the SEND line. If it is high, the encoder will go directly to Send Mode. Otherwise, it will pull the TX\_CNTL line low and go into low-power sleep mode. It will remain asleep until either the CREATE\_ADDR or SEND line goes high. These lines will place the encoder in either Create Mode or Send Mode as described in the following sections.

## CREATE MODE

The Create Mode allows the generation of a unique address to ensure the security of transmission and prevent unintentional operation of devices. The MS encoder allows 16,777,216 ( $2^{24}$ ) possible addresses. Creating the address is remarkably straightforward.

When the CREATE\_ADDR line is pulled high, the encoder randomizes the Code Word continuously until the CREATE\_ADDR line is pulled low. Once the encoder registers the low line, the Code Word is saved and the encoder will begin to toggle the MODE\_IND line. This will indicate to the user that the encoder is ready to accept the Control Permissions. Control Permissions are set by activating the data lines that the user wants the encoder to have the authority to operate. Pulling the CREATE\_ADDR line high again will cause the encoder to save the Control Permissions and go back to sleep. The Code Word will be sent with every transmission when the SEND line is pulled high, but the encoder can only activate the decoder data lines that are authorized by the Control Permissions.

The Code Word is learned by an MS Series decoder by placing the decoder into Learn Mode and sending a transmission from the encoder. Please refer to the MS Series Decoder Data Guide for full details.

The CREATE\_ADDR line can be tied to a button or contact point accessible by the user. With a simple press, the user will generate a unique address that should never again require changing. Some designers may prefer to set a code during production and not provide for change by the user.

The MODE\_IND line allows for the connection of a LED or other device to indicate to the user that the encoder is in Create Mode. Once the CREATE\_ADDR line goes high and the encoder enters Create Mode, the MODE\_IND line will go high and stay high until the CREATE\_ADDR line goes low. The MODE\_IND line is capable of sourcing up to 25mA of current.

## SEND MODE

When the SEND line goes high the encoder will enter Send Mode. The encoder will pull the TX\_CNTL line high to activate the transmitter, record the state of the data lines, assemble the packet, and send it through the DATA\_OUT line. It will continue doing this for as long as the SEND line is high, updating the state of the data lines with each transmission. Once SEND is pulled low the encoder will finish the current transmission, pull TX\_CNTL low to deactivate the transmitter, and go to sleep.

For simple applications that require only a single input, SEND can be tied directly to the data input line, allowing a single connection. If additional lines are used in this manner, diodes or dual contact switches will be necessary to prevent voltage on one data line from activating all of the data lines. The Application Example section demonstrates the use of diodes for this purpose.

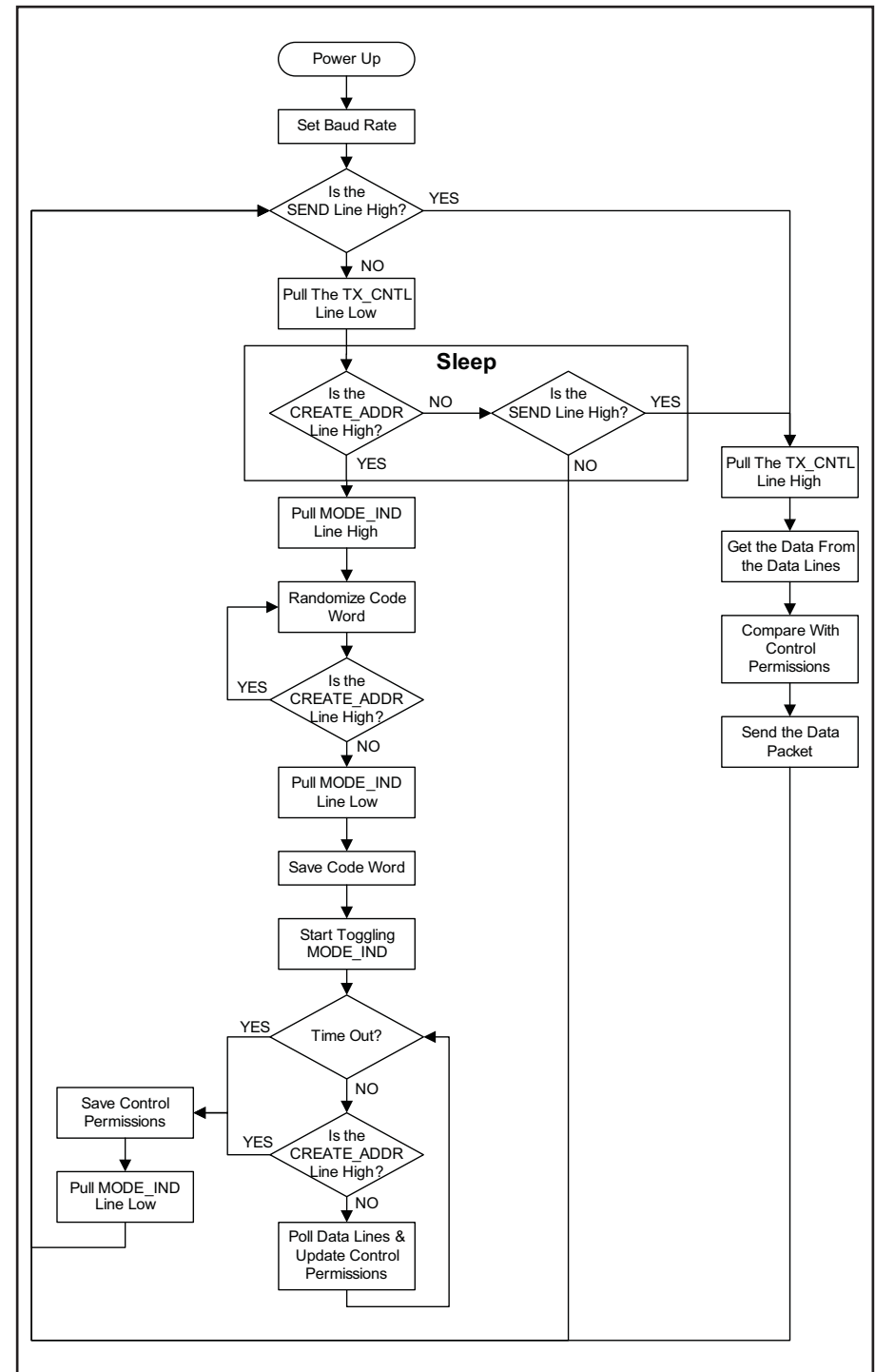


Figure 6: MS Series Encoder Flowchart

## APPLICATION EXAMPLE

The MS encoder is ideal for registering button presses in remote control applications. An example application circuit is shown in the figure below.

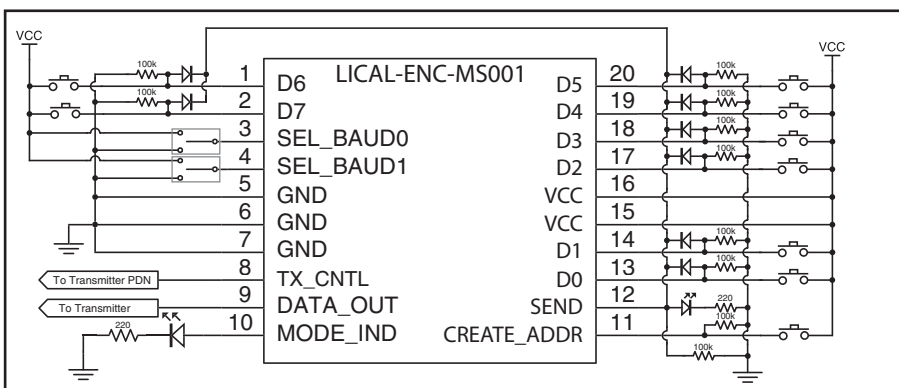


Figure 7: MS Series Encoder Application Circuit

In this circuit, SPDT switches are used to select the baud rate so that pull-down resistors are not needed. The data lines are connected to buttons and when any button is pressed, the SEND line is pulled high and causes the encoder to transmit. The diodes are used to prevent the voltage on one data line from appearing on another data line.

If only one data line is needed, then it can be tied directly to the SEND line without the need for the diodes.

None of the inputs have pull-up or pull-down resistors internally, so 100kΩ pull-down resistors are used on the data lines, SEND, and CREATE\_ADDR. These resistors are used to pull the lines to ground when the buttons are not being pressed and ensure that they are always in a known state and not floating. Without these resistors, the state of the lines could not be guaranteed and encoder operation may not be predictable.

A LED indicator is attached to the MODE\_IND line to provide visual feedback to the user that an operation is taking place. This line will source a maximum of 25mA, so the limiting resistor may not be needed, depending on the LED chosen and the brightness desired.

Outgoing encoded data will be sent out of the DATA\_OUT line at the baud rate determined by the state of the SEL\_BAUD lines. This line can be connected directly to the DATA\_IN line of a Linx transmitter, used to modulate an infrared diode, or connected to any other serial transmission medium.

The TX\_CNTL line is connected to the PDN line of a Linx transmitter so that the module will enter a low power state when not in use. A LED can also be connected to the TX\_CNTL line to provide visual indication that the encoder is sending data.

In this example, the data lines are pulled high by simple pushbutton switches, but many other methods may be employed. Trace contacts, reed switches or microcontrollers are just some examples of other ways of pulling the data lines high. The flexibility of the encoder combined with the associative options of the matching decoder opens a whole new world of options for creative designers.

## SYSTEM EXAMPLE

The first step in using the encoder is to set the baud rate using the SPDT switches. Next, a unique Code Word is created by pressing and holding the button connected to the CREATE\_ADDR line for as long as desired. While the button is held, the LED will be on indicating that the Code Word is being created. Once the button is released, the LED will start flashing. The data buttons that the encoder is to access are now pressed. Pressing the CREATE\_ADDR button again makes the encoder save the new Code Word and Control Permissions, turn off the LED, and go to sleep.

The decoder must now learn the Code Word for the system to be operational. Please see the decoder design guide for instructions on how to do this. The MS Series Master Development System implements this system, so please see the User's Guide for the kit for more system information and circuit schematics.

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