



## MS SERIES DECODER 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 parts feature low supply voltage and current consumption. Selectable baud rates and latched or momentary outputs make the MS Series truly versatile.

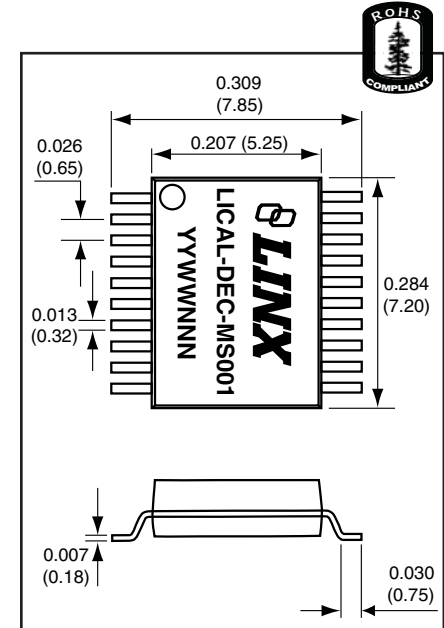


Figure 1: Package Dimensions

### FEATURES

- Secure  $2^{24}$  possible addresses
- 8 data lines
- Direct serial interface
- Latched or momentary outputs
- Definable recognition authority
- Encoder ID output by decoder
- Low 2.0 to 5.5V operating voltage
- Low supply current ( $370\mu\text{A}$  @ 3V)
- Ultra-low  $0.1\mu\text{A}$  standby current
- True serial encoding
- Excellent noise immunity
- Selectable baud rates
- No programming required
- Small SMD package

### 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 decoders 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>DECODER 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	–	+85	$^{\circ}C$	–

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	+85	$^{\circ}C$
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.

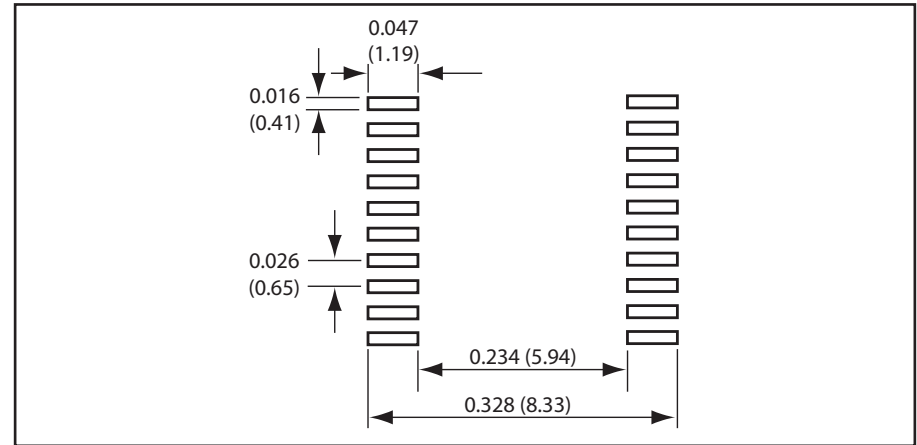


Figure 2: PCB Layout Dimensions

## 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.

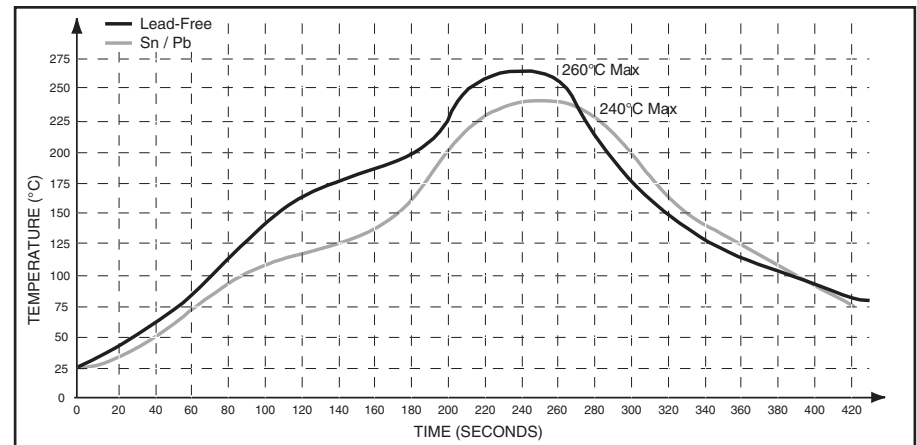
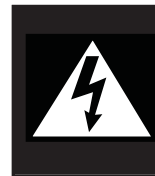


Figure 3: MS Series Reflow Profile



### \*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-DEC-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	LATCH		D1	14
8	RX_CNTL		D0	13
9	TX_ID	DATA_IN		12
10	MODE_IND	LEARN		11

Figure 4: MS Series Decoder Pin Assignments

Pin Name	Pin Number	I/O	Description
D0-D7	1, 2, 13, 14, 17-20	O	Data Output Lines
SEL_BAUD0	3	I	Baud Rate Selection Line
SEL_BAUD1	4	I	Baud Rate Selection Line
GND	5, 6	—	Ground
LATCH	7	I	Set Latched Outputs
RX_CNTL	8	I/O	External Receiver Control Line
TX_ID	9	O	Transmitter ID Output Line
MODE_IND	10	O	Mode Indicator Output
LEARN	11	I	Learn Mode Activation Line
DATA_IN	12	I	Data Input 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. These lines will reproduce the state of the encoder's data lines upon reception of a valid packet.

### 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 decoder will not recognize any change in the baud rate setting after it is on.

### GND

These lines are connected to ground.

### LATCH

If this line is set low, then the data outputs will be unlatched, meaning they will only be active for as long as a valid signal is received. If this line is set high, the outputs will be latched, meaning that when a signal is received to make a particular data line high, it will remain high until another transmission is received to make it go low.

### RX\_CNTL

This line can be used to automatically power on and off a receiver. It will power the receiver down for ten times as long as it is powered on. The times are determined by the selected baud rate.

### TX\_ID

A unique ID number for each transmitter is stored in the decoder's memory. A byte is output as serial data on this line to indicate which transmitter a transmission came from. This line can be connected to a processor or PC for logging, display, or other evaluation.

### MODE\_IND

This line will switch when a valid transmission is received, when Learn Mode is entered, and when the memory is cleared. This allows for the connection of a LED to indicate to the user that these events have taken place.

### LEARN

When this line goes high, the decoder will enter Learn Mode to accept a Code Word from an encoder and store it in memory. If it is held high for ten seconds, the decoder will clear all stored codes from memory.

### DATA\_IN

This line will accept the encoded serial data stream from the receiver.

### 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 Decoders
<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" Decoders
<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 Decoders
<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: Decoder Comparison Table

## DECODER OPERATION

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When the decoder first powers up, it will set the baud rate and check the state of the RX\_CNTL line. If this line is pulled high, then the decoder will go into Receiver Control Mode. If the line is low, it will go to sleep until a rising edge (low to high transition) on the DATA\_IN line puts it into Receive Mode or a high signal on the LEARN line puts it into Learn Mode.

## RECEIVE MODE

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When a rising edge is seen on the DATA\_IN line, the decoder enters Receive Mode. The decoder will begin by looking for a valid packet, meaning that there are no errors and that the received Code Word matches one that is saved in memory. If there is a match, then the decoder will reproduce the states of the encoder's data lines on its own data lines. It will also output the ID of the encoder once, on reception of the first valid packet. It will then look for the next valid data packet. If, at any time, an error or an unknown Code Word is detected, then the decoder will ignore the packet and look for the next one.

If the timer runs out, then the decoder will go back to sleep. This time is dependent upon the baud rate selected by the user. It is 131mS for 2,400bps and 9,600bps, and 65mS for 19,200bps and 28,800bps.

## LEARN MODE

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In order for the decoder to accept transmissions from an encoder, it must first learn the encoder's Code Word. This is done by taking the LEARN line high to place the decoder into Learn Mode. Once in Learn Mode, the MODE\_IND line will start switching, allowing for connection of a LED to provide visual indication that the decoder is ready to accept a new Code Word. This will continue until the LEARN line goes high again, or until a time-out after 17 seconds.

The decoder will look for a valid transmission from an MS Series encoder. It can store up to forty Code Words in its memory. If a new encoder is learned while the memory is full, then the decoder will write the new word over the first word in memory. The decoder will flash the MODE\_IND line five times as an indication that the memory is full and the next code learned will overwrite the first. The memory will retain all of the learned Code Words if power is removed.

If the LEARN line is held high for ten seconds, then the decoder will erase all of the stored Code Words from memory. The MODE\_IND line will be high for as long as the LEARN line is high, but after the ten seconds it will go low. Once the LEARN line is pulled low again, the MODE\_IND line will go high for two seconds to indicate that the memory has been cleared.

## LATCH MODE

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The MS Series decoder has two output options based on the state of the LATCH line. If it is low, then the data lines will be momentary, meaning that they will only be high for as long as a valid signal is received. Once the signal stops and the decoder times out, the lines are pulled low.

If the LATCH line is high, the decoder will pull a data line high upon reception of a valid signal and hold it high until the signal is received a second time, at which point the decoder will pull it low. The decoder must see a break and time out between valid transmissions before it will toggle the outputs. The minimum required time-out periods are listed in the Receive Mode section.

## RECEIVER CONTROL MODE

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If the RX\_CNTL line is pulled high when the decoder initially powers on, then the decoder will enter Receiver Control Mode. Once in this mode, the RX\_CNTL line becomes an output that can be attached to the PDN or V<sub>CC</sub> line of a Linx receiver or a similar input on another receiver. This allows the decoder to power down the receiver when it is not required, thereby reducing current consumption and prolonging battery life. The decoder draws full current in this mode, but an active receiver will typically draw much more than the decoder, so a savings is realized.

The decoder will activate the receiver for approximately one packet's time plus 10mS for the receiver to power up, so the actual "on" time depends on the baud rate chosen by the user. This time can be calculated in milliseconds as (60/Baud Rate)(1000) + 10. The "off" time is nine times the "on" time, resulting in a 10% duty cycle, greatly reducing the receiver's current consumption. However, there may be a lag time from when the encoder activates to when the decoder responds. The decoder will enter Receive Mode when it sees a valid packet, so there would only be a lag for the first packet. This can be reduced by selecting a higher baud rate.

If this feature is not going to be used, then this pin should be tied to ground. If it is tied to V<sub>CC</sub>, then the decoder will create a short when it pulls the line to ground while trying to power down the receiver. This mode is appropriate for receivers that have a high internal pull-up resistance, such as those offered by Linx. If the intended receiver does not have a pull-up, then a 100kΩ or larger resistor to V<sub>CC</sub> can be added to the RX\_CNTL line to activate this mode.

## TX ID

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The TX\_ID line will output an eight-bit binary number to identify which learned encoder sent the transmission. The number is output at the baud rate set by the SEL\_BAUD lines and will normally correspond to the order in which the decoder learned the encoder, so the first encoder learned will get number '1', the second will get number '2', and so on. An exception arises when the memory is full, in which case the first numbers are overwritten as described in the Learn Mode section. Application Note AN-00156 shows some example software to read the TX\_ID and associate it with a particular encoder. The C and Visual Basic code is well documented so that it can be modified for a specific application.

## SYSTEM EXAMPLE

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The first step in using the decoder is to set the baud rate and determine if the outputs should be latched or momentary. Next, the decoder will need to learn the encoder's Code Word. This is done by momentarily pressing the button connected to the LEARN line. The LED connected to the MODE\_IND line will begin to flash to indicate that the decoder is ready to learn a new Code Word. One of the buttons on the transmitter is pressed to send a signal to the decoder. Once this is done, the LEARN button is pressed again to exit Learn Mode.

Now, when a button is pressed on the encoder, the corresponding line on the decoder will activate. If the LATCH line is high, the data line will remain high until the encoder button is pressed again, telling the decoder to pull the line low.

To clear the memory of the decoder, the LEARN button is pressed and held for ten seconds, until the LED turns off. Once the button is released, the LED will light for two seconds to indicate that the memory has been cleared.

## TYPICAL APPLICATIONS

The MS Series decoder is ideal for replicating button presses for remote control applications. An example application circuit is shown below.

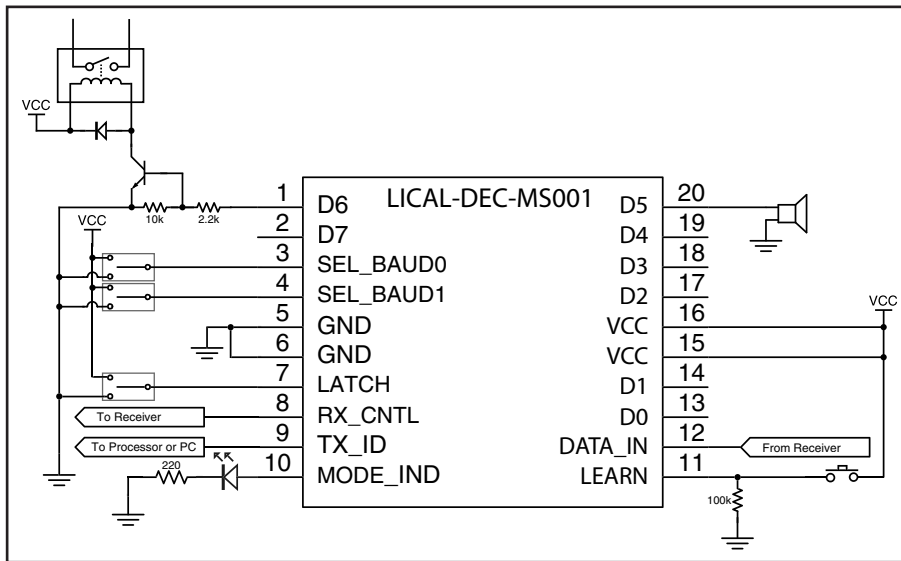


Figure 6: MS Series Decoder Application Circuit

SPDT switches are used to select the baud rate and set the latch mode so that pull-down resistors are not needed.

The RX\_CNTL line can be connected to the PDN line of the receiver or it can be connected directly to ground.

TX\_ID can be connected to a microprocessor or a PC to record the transmitter identity. Application Note AN-00156 has sample code that will read the transmitter ID and display the ID number on a LCD screen.

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.

The LEARN line is connected to a button that will pull the line high when pressed. Since the line does not have an internal pull-down resistor, a 100kΩ resistor is used to pull the line to ground when not in use.

The DATA\_IN line is connected directly to the data output of the receiver.

Data Lines D0 through D7 can be connected directly to the external circuitry that needs to be activated remotely. In this example, D5 is connected directly to a piezoelectric buzzer. This will cause the buzzer to sound when the D5 line on the encoder goes high. Line D6 will activate a relay through a transistor buffer when it goes high. A buffer like this may be needed if the load requires more than 25mA of current or a higher voltage source to activate. The decoder will turn on the transistor, which can be selected to provide the appropriate drive levels to activate the relay.

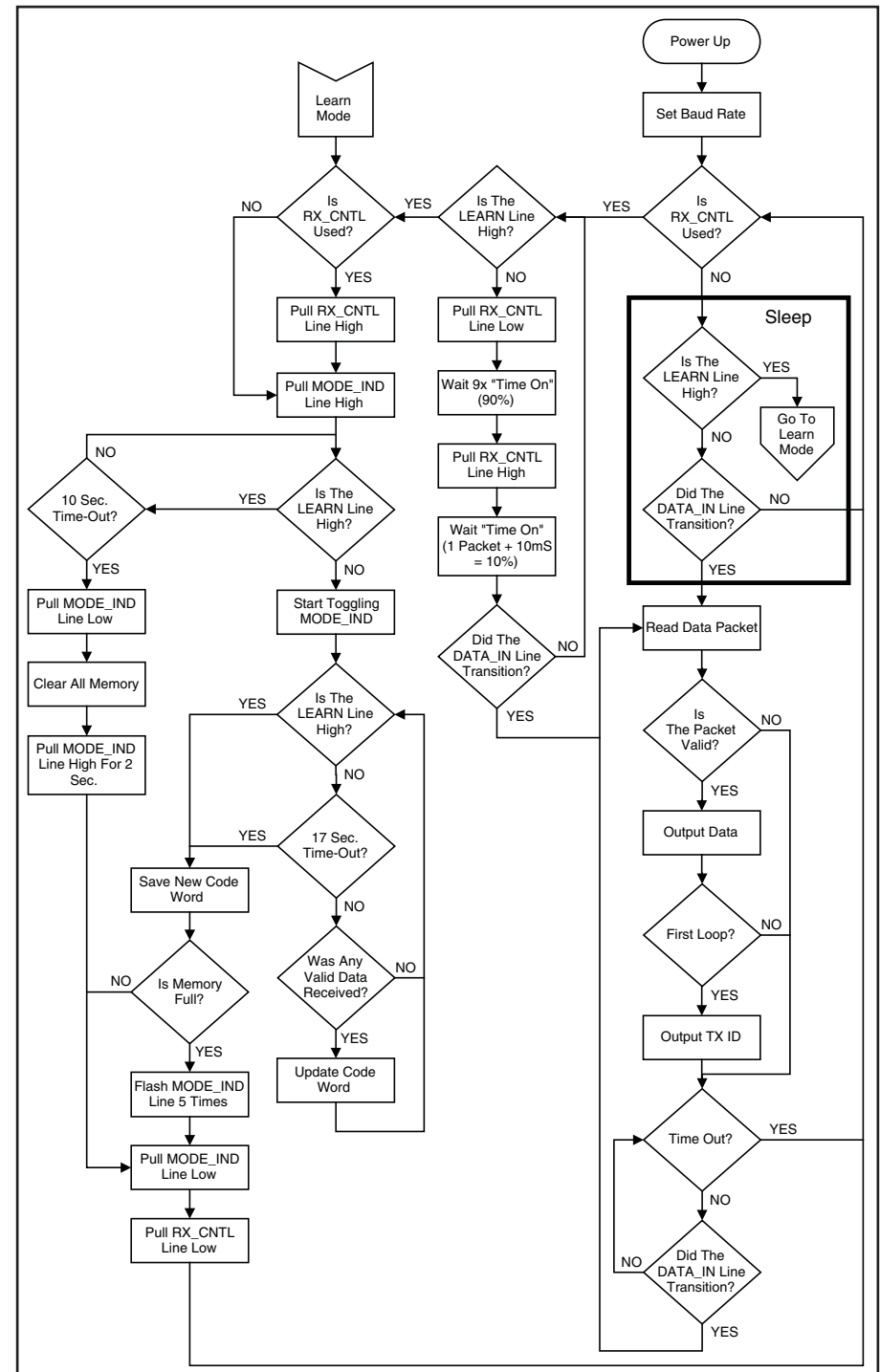


Figure 7: MS Series Decoder Flowchart



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