



## 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.

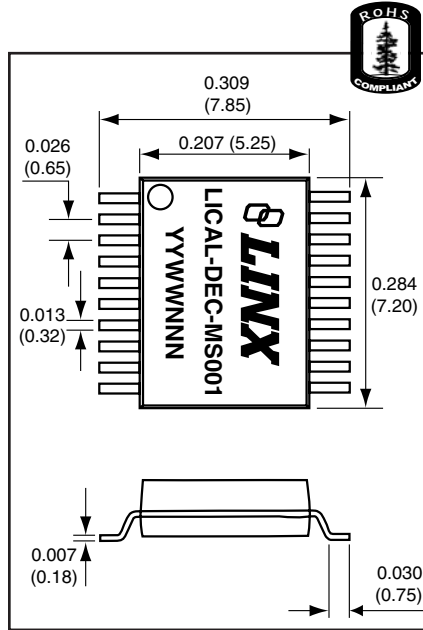


Figure 1: Package Dimensions

### FEATURES

- Secure 2<sup>24</sup> 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 (370µA @ 3V)
- Ultra-low 0.1µA 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                 | –       | +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.

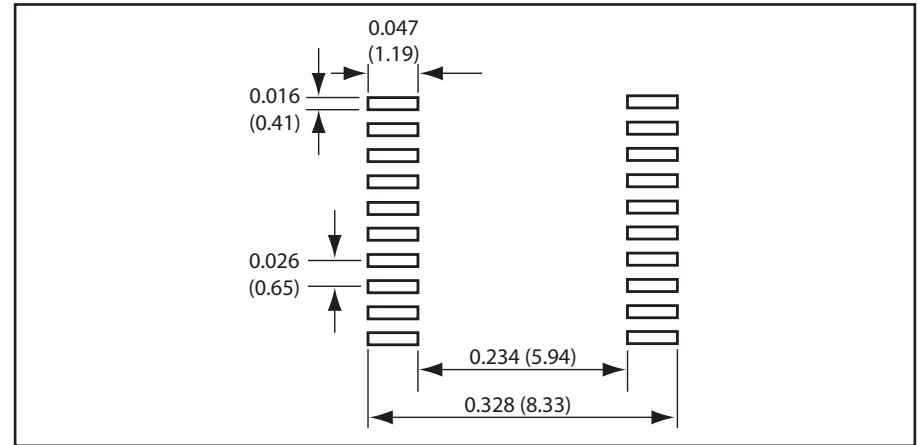


Figure 2: PCB Layout Dimensions

## 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.

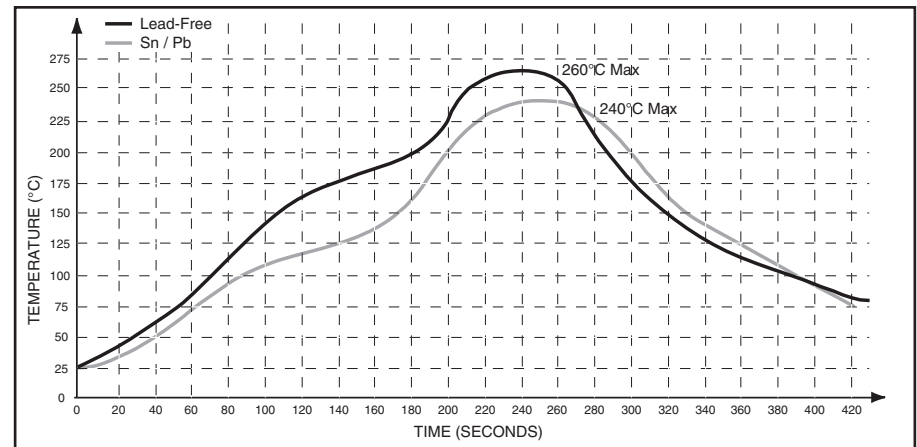
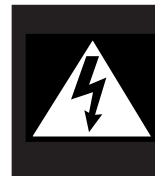


Figure 3: MS Series Reflow Profile



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

Figure 5: Decoder Comparison Table

## DECODER OPERATION

---

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

---

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

---

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

---

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

---

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

---

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

---

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.





## U.S. CORPORATE HEADQUARTERS

### **LINX TECHNOLOGIES, INC.**

**159 ORT LANE  
MERLIN, OR 97532**

**PHONE: (541) 471-6256**

**FAX: (541) 471-6251**

**[www.linxtechnologies.com](http://www.linxtechnologies.com)**

### **Disclaimer**

Linx Technologies is continually striving to improve the quality and function of its products. For this reason, we reserve the right to make changes to our products without notice. The information contained in this Overview Guide is believed to be accurate as of the time of publication. Specifications are based on representative lot samples. Values may vary from lot-to-lot and are not guaranteed. "Typical" parameters can and do vary over lots and application. Linx Technologies makes no guarantee, warranty, or representation regarding the suitability of any product for use in any specific application. It is the customer's responsibility to verify the suitability of the part for the intended application. NO LINX PRODUCT IS INTENDED FOR USE IN ANY APPLICATION WHERE THE SAFETY OF LIFE OR PROPERTY IS AT RISK.

Linx Technologies DISCLAIMS ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL LINX TECHNOLOGIES BE LIABLE FOR ANY OF CUSTOMER'S INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING IN ANY WAY FROM ANY DEFECTIVE OR NON-CONFORMING PRODUCTS OR FOR ANY OTHER BREACH OF CONTRACT BY LINX TECHNOLOGIES. The limitations on Linx Technologies' liability are applicable to any and all claims or theories of recovery asserted by Customer, including, without limitation, breach of contract, breach of warranty, strict liability, or negligence. Customer assumes all liability (including, without limitation, liability for injury to person or property, economic loss, or business interruption) for all claims, including claims from third parties, arising from the use of the Products. The Customer will indemnify, defend, protect, and hold harmless Linx Technologies and its officers, employees, subsidiaries, affiliates, distributors, and representatives from and against all claims, damages, actions, suits, proceedings, demands, assessments, adjustments, costs, and expenses incurred by Linx Technologies as a result of or arising from any Products sold by Linx Technologies to Customer. Under no conditions will Linx Technologies be responsible for losses arising from the use or failure of the device in any application, other than the repair, replacement, or refund limited to the original product purchase price. Devices described in this publication may contain proprietary, patented, or copyrighted techniques, components, or materials. Under no circumstances shall any user be conveyed any license or right to the use or ownership of such items.