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Linx TECHNOLOGIES

MS Series
Remote Control Encoder
Data Guide

Wireless made simple®

Warning: Some customers may want Linx radio frequency ("RF") products to control machinery or devices remotely, including machinery or devices that can cause death, bodily injuries, and/or property damage if improperly or inadvertently triggered, particularly in industrial settings or other applications implicating life-safety concerns ("Life and Property Safety Situations").

NO OEM LINX REMOTE CONTROL OR FUNCTION MODULE SHOULD EVER BE USED IN LIFE AND PROPERTY SAFETY SITUATIONS. No OEM Linx Remote Control or Function Module should be modified for Life and Property Safety Situations. Such modification cannot provide sufficient safety and will void the product's regulatory certification and warranty.

Customers may use our (non-Function) Modules, Antenna and Connectors as part of other systems in Life Safety Situations, but only with necessary and industry appropriate redundancies and in compliance with applicable safety standards, including without limitation, ANSI and NFPA standards. It is solely the responsibility of any Linx customer who uses one or more of these products to incorporate appropriate redundancies and safety standards for the Life and Property Safety Situation application.

Do not use this or any Linx product to trigger an action directly from the data line or RSSI lines without a protocol or encoder/decoder to validate the data. Without validation, any signal from another unrelated transmitter in the environment received by the module could inadvertently trigger the action.

All RF products are susceptible to RF interference that can prevent communication. RF products without frequency agility or hopping implemented are more subject to interference. This module does not have a frequency hopping protocol built in.

Do not use any Linx product over the limits in this data guide. Excessive voltage or extended operation at the maximum voltage could cause product failure. Exceeding the reflow temperature profile could cause product failure which is not immediately evident.

Do not make any physical or electrical modifications to any Linx product. This will void the warranty and regulatory and UL certifications and may cause product failure which is not immediately evident.

Table of Contents

MS Series Remote Control 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.

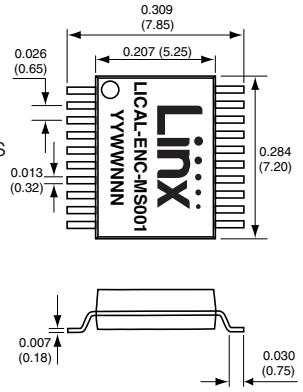

Figure 1: Package Dimensions

Features

- Secure 2^{24} 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

- Keyless entry
- Door and gate openers
- Security systems
- Remote device control
- Car alarms / starters
- Home / industrial automation
- Remote status monitoring
- Lighting control

Revised 3/18/2015

Ordering Information

Ordering Information	
Part Number	**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	

Figure 2: Ordering Information

Absolute Maximum Ratings

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 Input Pins		25		mA
Max. Current Into V_{CC}		250		mA
Max. Current Out Of GND		300		mA
Operating Temperature	–40	to	+85	°C
Storage Temperature	–65	to	+150	°C
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.				

Figure 3: Absolute Maximum Ratings

Timings

Encoder SEND to Decoder Activation Times (ms)			
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

Figure 4: Encoder SEND to Decoder Activation Times (ms)

Electrical Specifications

MS Series Enccoder Specifications						
Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Notes**
Power Supply						
Operating Voltage	V_{CC}	2.0		5.5	VDC	
Supply Current	I_{CC}					
At 2.0V V_{CC}			240	300	µA	1
At 3.0V V_{CC}			370	470	µA	1
At 5.0V V_{CC}			670	780	µA	1
Power Down Current	I_{PDN}					
At 2.0V V_{CC}			0.10	0.80	µA	
At 3.0V V_{CC}			0.10	0.85	µA	
At 5.0V V_{CC}			0.20	0.95	µA	
Encoder Section						
Input Low	V_{IL}	0.0		0.15 x V_{CC}	V	2
Input High	V_{IH}	0.8 x 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	
Environmental						
Operating Temperature Range		–40		+85	°C	

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

Figure 5: Electrical Specifications

Warning: This product incorporates numerous static-sensitive components. 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 module damage or failure.

Pin Assignments

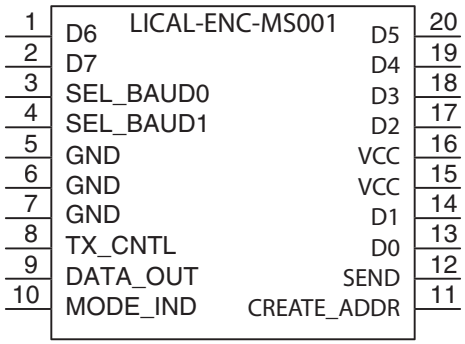

Figure 6: MS Series Encoder Pin Assignments

Pin Descriptions

Pin Number	Name	I/O	Description
1, 2, 13, 14, 17–20	DO–D7	I	Data Input Lines. 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.
3	SEL_BAUD0	I	Baud Rate Selection Line 0. This line along with SEL_BAUD1 sets the baud rate of the serial data stream to one of 4 possible rates. The rate must be set before power on.
4	SEL_BAUD1	I	Baud Rate Selection Line 1. This line along with SEL_BAUD0 sets the baud rate of the serial data stream to one of 4 possible rates. The rate must be set before power on.
5, 6, 7	GND		Ground
8	TX_CNTL	0	External Transmitter Control Line. 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.
9	DATA_OUT	0	Serial Data Output. The encoder outputs a serial data stream on this line. This line can directly interface with all Linx RF transmitter modules.
10	MODE_IND	O	Mode Indicator Output. This line is activated while the encoder is in Create Mode, allowing the connection of an LED. The line is high for the entire time the encoder is in Create Mode, indicating that it is creating a new Address.
11	CREATE_ADDR	I	Create Mode Selection Line. When this line is taken high, the encoder enters Create Mode and randomly generates a new Address. The Address continuously randomized while this line is high, and is saved as soon as the line is taken low.
12	SEND	I	Encoder Send Data Line. When this line goes high, the encoder records the states of the data lines, retrieves the Address from memory, assemble sthe packet, and outputs it as a serial bit stream on the DATA_OUT line at the baud rate selected by the states of the SEL_BAUD lines.
15, 16	V_{CC}		Supply Voltage

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_{CC}) 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_{CC}, or by use of other circuits to control the line state.

Figure 7: Pin Descriptions

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 are 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. The MS Series uniquely combines security and simplicity with the power to create groups and relationships. Figure 8 compares the advantages and disadvantages of different encoders.

Encoder Comparison Table	
Manual Address Encoders	
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" Encoders	
Advantages Highly secure Eliminates manual address settings	**Disadvantages** Low number of button inputs Encoder and decoder can become unsynchronized Difficult or impossible to create relationships Security vulnerabilities
Linx Encoders	
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 unsynchronize 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 8: Encoder Comparison Table

Baud Rate Selection

SEL_BAUD0 and SEL_BAUD1 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 Figure 9.

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

Figure 9: 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.

Encoder Operation

Upon power up, the encoder sets the baud rate based on the state of the SEL_BAUD lines and then checks the SEND line. If it is high, the encoder enters Send Mode. Otherwise, it pulls the TX_CTNL line low and goes into low-power sleep mode. It remains asleep until either the CREATE_ADDR or SEND lines goes high. These lines place the encoder in either Create Mode or Send Mode as described in the following sections.

SEND Mode

When the SEND line goes high the encoder enters Send Mode. The encoder pulls the TX_CNTL line high to activate the transmitter, records the states of the data lines, assembles the packet, and sends it through the DATA_OUT line. It continues 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 finishes the current transmission, pulls TX_CNTL low to deactivate the transmitter, and goes 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 are necessary to prevent voltage on one data line from activating all of the data lines. The Typical Application section demonstrates the use of diodes for this purpose.

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. Each encoder is shipped with a unique address that is set at the factory. If a new Address is desired, creating it is remarkably straightforward.

When the CREATE_ADDR line is pulled high, the encoder randomizes the Address continuously until the CREATE_ADDR line is pulled low. Once the encoder registers the low line, the Address is saved and the encoder begins to toggle the MODE_IND line. This indicates to the user that the encoder is ready to accept the Control Permissions.

Control Permissions are set by activating the data lines that the encoder is to have the authority to operate. Each desired data line is activated individually or simultaneously, in any order. Pulling the CREATE_ADDR line high again or waiting for a 15-second timeout to expire causes the encoder to save the Control Permissions and go back to sleep.

The Address is 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 Address 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 generates a unique address that should never again require changing. Some designers may prefer to set an Address during production and not provide for change by the user.

The MODE_IND line allows for the connection of an 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 goes high and stays high until the CREATE_ADDR line goes low. The MODE_IND line is capable of sourcing up to 25mA of current.

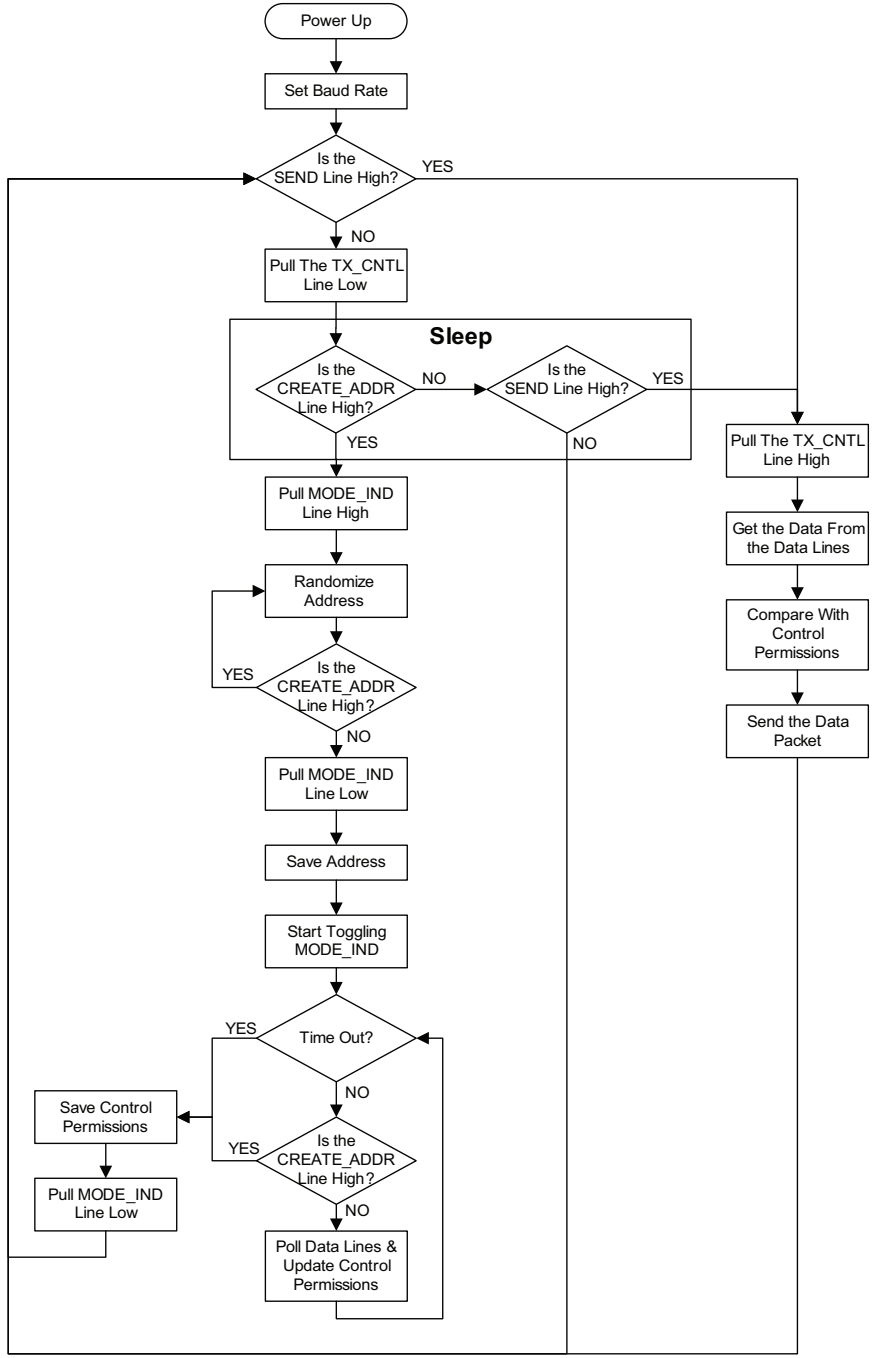

Figure 10: MS Series Encoder Flowchart

Typical Applications

The MS encoder is ideal for registering button presses in remote control applications. An example application circuit is shown in Figure 11.

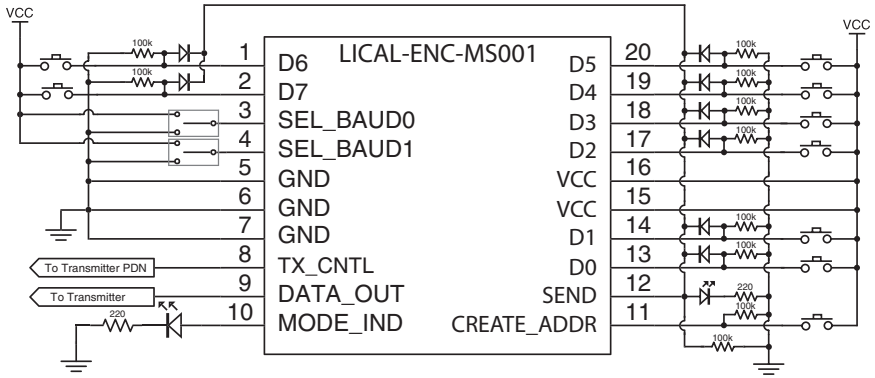

Figure 11: MS Series Encoder Application Circuit

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.

An LED is attached to the MODE_IND line to provide visual feedback to the user that an operation is taking place. This line sources a maximum of 25mA.

Outgoing encoded data is 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. This is used to place the transmitter into a low power state when not in use. An 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 or simply tying the lines to supply or ground. Next, a unique Address 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 is on indicating that the Address is being created. Once the button is released, the LED starts 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 Address and Control Permissions, turn off the LED, and go to sleep.

The decoder must now learn the Address for the system to be operational. Please see the decoder data 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 more system information and circuit schematics.

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 in Figure 12.

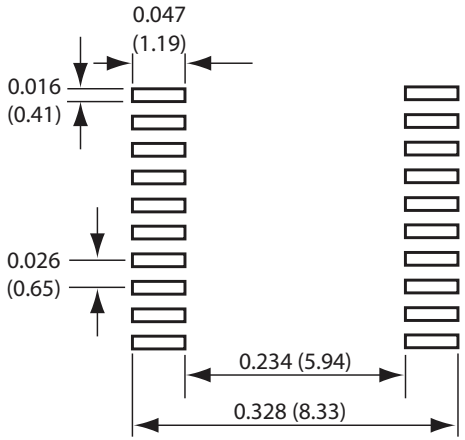

Figure 12: PCB Layout Dimensions

Production Considerations

These surface-mount components are designed to comply with standard reflow production methods. The recommended reflow profile is shown in Figure 13 and should not be exceeded, as permanent damage to the part may result.

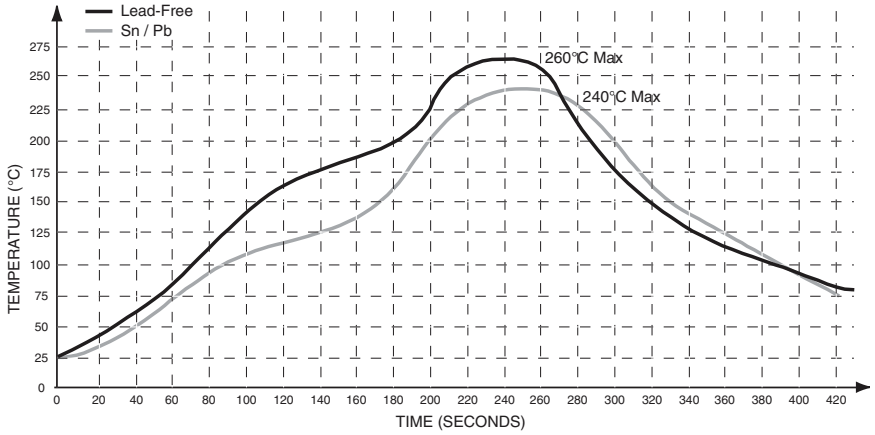

Figure 13: MS Series Reflow Profile

Resources

Support

For technical support, product documentation, application notes, regulatory guidelines and software updates, visit www.linxtechnologies.com

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