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Wireless Link Module

WLM

Serial (RS-485)
902-928MHz

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Serial (RS-485) 902-928MHz





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Table of Contents

	Page
Introduction	4
Loop Back Bench Test	4
Modem Configuration	5
Main Menu Option (0): Set Operation Mode	6
Main Menu Option (1): Set Baud Rate	8
Main Menu Option (2): Edit Call Book	9
Main Menu Option (3): Edit Radio Transmission Characteristics	12
Main Menu Option (4): Show Radio Statistics	17
Main Menu Option (5): Edit Multi-Point Parameters	19
Main Menu Option (8): Password	22
Modem Location	24
Using an External Antenna	25
Modem Front Panel LED's	26
Sample Data Communication Links	27
Technical Specifications	29
Troubleshooting	30
Appendix A	31

Introduction

The WLM transceiver modems are high performance wireless radio modems designed for heavy-duty industrial data communications in the 902-928 MHz license-free band. It employs advanced spread spectrum frequency hopping and error detection technology to achieve very reliable, noise and interference immune operation. A high data RF rate of 144Kbps and superior sensitivity provide ultra reliable data integrity at data rates from 1200 to 230.4Kbps. Full duplex operation at data rates up to 57.6Kbps provide the fast response times needed for polling communications. The WLM has a rated range of up to 25 miles (40 km) and an installed range of up to 35 miles (56 km) in optimal conditions with line-of-sight and an omni directional antenna. This can also be extended further with repeaters or higher gain antenna.

The WLM can be operated in a number of different modes to satisfy a broad range of communications requirements. It can be configured for point-to-point or multi-point operation with a unlimited number of remote sites on a single master depending on data throughput requirements. Repeaters can be used in the system to extend range and eliminate dead RF zones that are blocked by obstructions.

External antennas can be used with up to two hundred feet of coax. Consult the factory if cable lengths longer than two hundred feet are required. This provides a boost in signal strength and decreases induced noise levels. With external antennas, radio modems can be located inside buildings or metallic enclosures.

The WLM will operate in virtually any environment where RS485 data communications are required. The transceiver RS485 interface is a standard DB9-F connector that is configured for Data Communications Equipment (DCE) operation. The WLM will connect with a straight through RS485 cable to a device configured for Data Terminal Equipment (DTE) operation.

The user guide covers the operating modes and configurations that are available to users of the WLM. It also provides the user with bench testing instructions, technical information and specifications for the WLM.

In most applications, the WLM's come pre-configured for the application in which they are going to be used. Generally no other configuration is required. If you are unsure if the modem needs further configuration, please contact Moore Industries-International, Inc.

Loop Back Bench Test

Due to the fundamental nature of half-duplex communication, a loop back test cannot be performed through RS485.

To bench test in place of 1 PC and loop back jumper, use 2 PC's with RS485 support, RS485 to RS232 converters and alternate typing characters from one PC to the other, verifying communications.

WLM Configuration

The WLM allows you to set several parameters to suit your particular application. All adjustments are done through the WLM setup program, a user interface that eliminates the need for setup diskettes, DIP switch settings or custom software.

To access the configuration menu, connect the radio modem to any terminal program with port settings of 19.2Kbaud, 8 data bits, no parity and one stop bit. With the modem connected to the PC running the terminal program, press the Configure button located behind the pinhole next to the DB-9 connector on the front of the modem. While any terminal program that can be set to 19200 baud will work, examples for this user guide were generated using the Microsoft Windows 2000 application "HyperTerminal."

Note: When using HyperTerminal, set Handshaking to none.

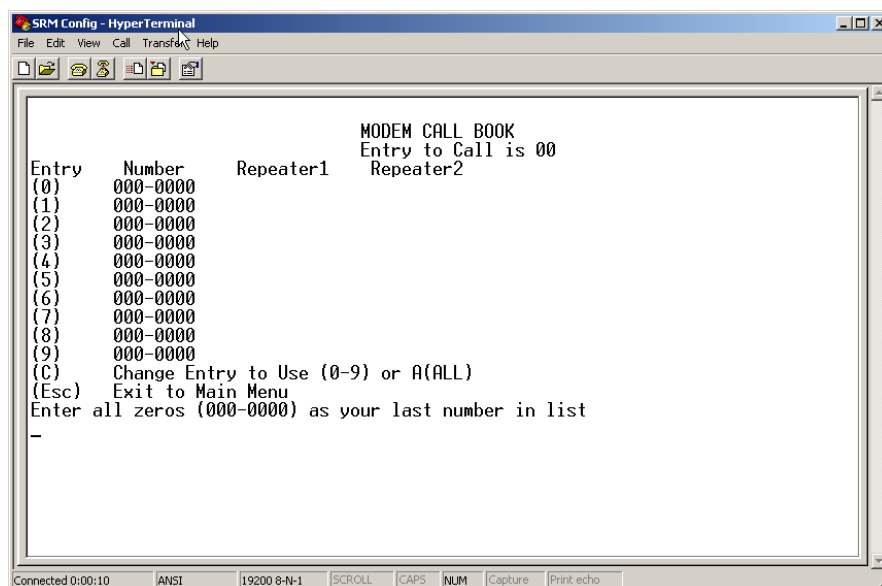
Table 1: Terminal Settings

Parameter	Setting
Baud Rate	19200
Data Bits	8
Parity	None
Stop Bits	1
Flow Control	None

When the setup program is invoked, the "O" LED on the WLM front panel will flash once when the Configure button is pressed and the "C" LED will remain on for the entire time the radio modem is in setup mode.

The main menu provides the radio modem's unique call book number and the set of choices for editing the operational parameters and viewing the performance data.

Figure 1: Main Menu

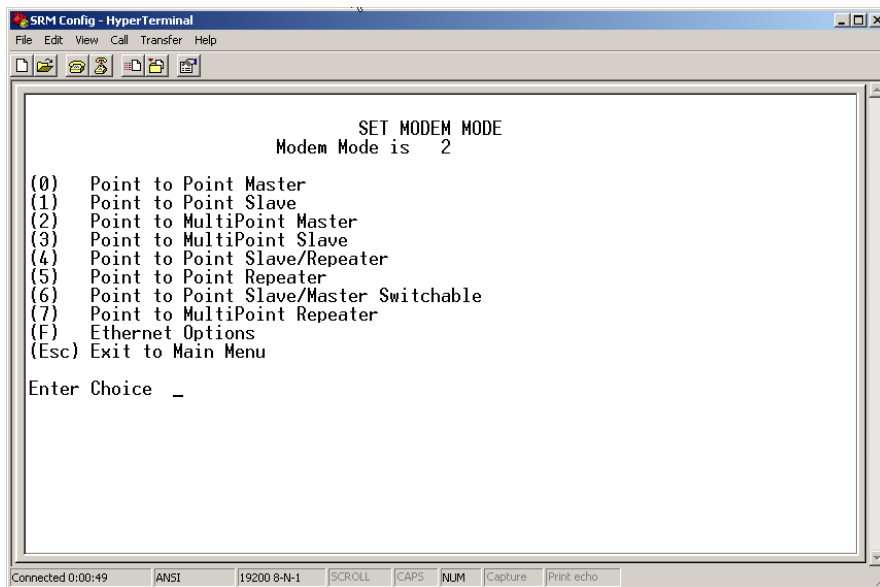


Main Menu Option (0): Set Operation Mode

When item (0) is selected, the Operation Mode Menu appears as shown in figure 2. The Operation Mode option is used to designate the method in which the particular WLM will be used. The WLM operates in a master to remote configuration; therefore, any radio modems that are intended to operate together must be set up as such. In a point-to-point setup, either the master or remote may be used on either end of the communications link. One consideration when setting up the radio modems is that a number of parameters are controlled by the settings in the master; therefore, you may wish to deploy the master on the communications end where you will have easier access to the radio modem.

Figure 2: Mode Menu

Shown below are example settings. Please refer to supplied configuration sheets for your modem's configuration.



(0) Point-to-point Master

The WLM operates in a master/remote configuration. When designated as a master in point-to-point mode, the radio modem will call any or all remotes it is instructed to call in the call book. The master determines the settings used for all Radio Transmission Characteristics, regardless of the settings in the remotes and/or repeaters.

(1) Point-to-Point Remote

When set up as a point-to-point remote, an WLM will communicate with any master in its call book, either directly or through one or two repeaters. When functioning as a remote, the Entry to Call feature in the radio modem's call book (Figure 3) is not operational. The remote will communicate with any master on the list that calls.

(2) Point-to-Multi-Point Master

The WLM may be set to run in multi-point mode, which allows one master to simultaneously be in communication with numerous remotes. A point-to-multi-point master will communicate only with other radio modems designated as point-to-multi-point remotes or point-to-multi-point repeaters.

(3) Point-to-Multi-Point Remote

Setting (3) allows the radio modem to operate as a remote in a multi-point network.

Please refer to the section entitled multi-point Operation, for more information on running a multi-point network.

(4) Point-to-Point Remote/Repeater

Option 4 allows you to designate the radio modem to act as either a remote or a repeater, depending upon the instructions received from the master for the specific communications session. When a radio modem is placed in an ideal location, this setting offers the flexibility of using that radio modem as an end point in the communications link (remote) or to extend the link to a point further (repeater). These functions are not, however, available simultaneously (the radio modem cannot act as both a remote and a repeater at the same time).

A word of caution: Configured as a repeater, a radio modem has no security features as explained below. When a radio modem is designated as a point-to-point remote/repeater, it will allow any master to use it as a repeater.

(5) Point-to-Point Repeater

WLM radio modems allow the use of up to two repeaters in a communications link, significantly extending the operating range. When designated as a repeater, a radio modem behaves as a pass-through link. All settings for the call book, baud rates, and radio transmission characteristics are disabled. A repeater will connect with any master that calls it (the repeater must still be set up in the master's call book).

The use of one repeater in a communications link will reduce the top data throughput available when compared to a direct master to remote link (generally on the order of 50%). This impact is generally noticed only when using the radio modems at 115.2 Kbaud. The throughput does not decrease further if two repeaters are used.

(6) Point-to-Point Remote/Master Switchable

Mode 6 is a versatile option that allows the radio modem to be controlled entirely through software commands. When in mode 6, a number of key parameters in the radio modem's user interface may be changed either directly (as if using the Windows Terminal program) or through the use of script files. In addition, when the radio modem is in mode 6 and not calling a remote, it will be a remote itself and accept any appropriate calls from other radio modems.

In mode 6:

- The radio modem remains in remote mode until called by another radio modem in its Call Book or instructed to call another radio modem through an ATDT command. The master will disconnect when DTR goes low..
- The user may change settings in the user interface without using the reset button (this may be of particular value if the radio modem is not in an easily accessible location).
- Predetermined script files may be used which allow some of the radio modem's settings to be changed upon execution of that file. This, in turn, allows the user to establish command sets that will instruct the radio modem to call a predetermined remote.

Note: For a detailed explanation covering the features of Mode 6, please contact the factory.

(7) Point-to-Multi-Point Repeater

Setting (7) allows the radio modem to operate as a repeater in a multi-point network.

Please refer to the section titled, "Multi-Point Operation", for more information on running a multi-point network.

(F) Ethernet Options

This menu is only needed for the WLM 902-928MHz modems. When using the WLM, this setting should be left at factory default.

Main Menu Option (1): Set Baud Rate

When option (1) is selected you will be able to change the radio modem's RS485 baud rate. This is the communication rate between the radio modem and the instrument to which it is connected. It is important to note that this is independent of the baud rate for the other radio modem(s) in the communication loop. For example, WLMs may be used in an application to send data from remote process instrumentation to an engineer's computer. In this application, the baud rate for the radio modem on the instrumentation might be set to 9600, and the radio modem on the computer might be set to 57,600 or 115,200.

In general, it is desirable to set the baud rate to the highest level supported by the device to which it is connected. However, please note that this may actually result in slower data communications if the UART chipset of the connected device does not support higher data rates.

ModBus RTU and various data word sizes and parity configurations

The additional features are support for ModBus RTU and support various data word lengths and parity. These features are available under selection options (A) and (B).

There are six data word length and parity configurations available. In the Set Baud Rate menu select (A) and type in the number corresponding to the configuration below. The default setting is 0 (8,N,1) and is the most commonly used serial communications protocol.

Table 2: Available data word length and parity selections

Menu Setting	Data Bits	Parity	Stop Bits
0	8	None	1
1	7	Even	1
2	7	Odd	1
3	8	None	2
4	8	Even	1
5	8	Odd	1

ModBus RTU

Support for ModBus RTU protocol is available. The default for the ModBus RTU setting is (0) not enabled.

To enable the ModBus RTU mode:

1. In the "Set Baud Rate" menu enter (B) and then select (1)
2. In the "Set Multi Point Parameters" menu, set Master Packet Repeat to (3).

Note: When using the WLM's in ModBus RTU mode the Master Packet Repeat must be set to (3) regardless of whether the modems are being used in point-to-point or multi-point mode. If a setting that is higher than (3) is required, it can be done, but the throughput speed will be decreased. (A higher Master Packet Repeat setting may need to be used when the radios are in a high noise environment or at long ranges).

RS232/485 and Turnoff delay

These settings do not pertain to the WLM modem

Flow control

This setting allows for the use of hardware handshaking. Most applications do not require handshaking when using the WLM. The default setting is 0 (no handshaking)

Menu Setting	Port
0	None
1	RTS
2	DTR

Main Menu Option (2): Edit Call Book

The Call Book is an innovative feature in the WLM that offers both security and flexibility in use. The Call Book accomplishes this by allowing the user to determine with which other WLMs a given radio modem will communicate, based on the Call Book numbers for both the master and remote. The radio modem's Call Book number is encoded in the microprocessor and identified on a label on the modem. The instructions provided in this section are for point-to-point mode only. Use of the Call Book for multi-point systems is explained later in this chapter. For two WLM radio modems to communicate in point-to-point mode, three events must occur:

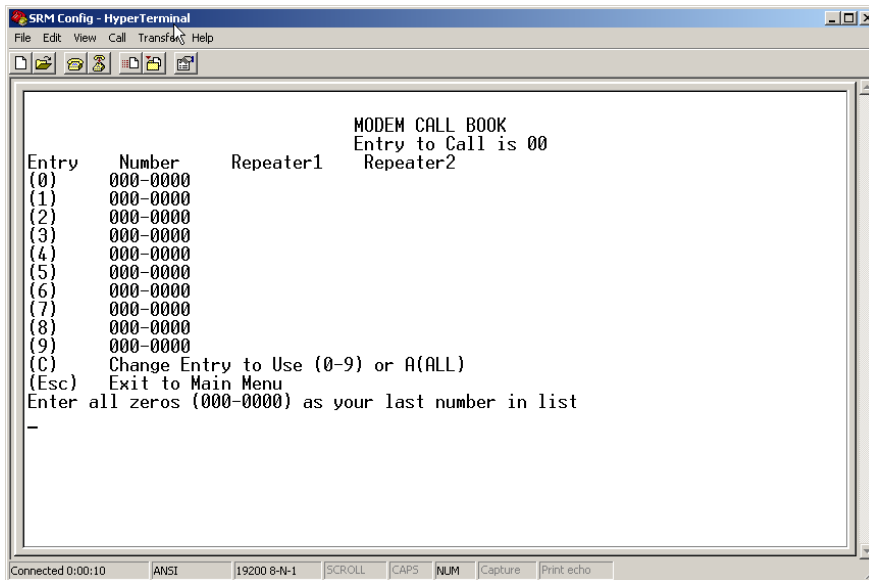
1. The call book number for the master must be listed in the Remote's Call Book.
2. The call book number for the remote must be listed in the master's Call Book.
3. The master must be programmed to call the remote.

As shown in figure 3, the Call Book allows users to set up a list of up to 10 WLMs to communicate with. Designate up to 2 repeaters to be used in communicating with a given radio modem, and tell the master which remote to call. To direct the master to call a remote, the Remote must be in the Call Book Menu. A specific remote may be called by entering (C) at the prompt, followed by the menu number corresponding to that remote. To call any available remote in the list, the user should enter C and then A (for All).

Note: To call a remote through one or two repeaters, you must call that remote directly (as opposed to using the Call All option). When Call All is selected the master is not able to connect with any remotes through repeaters. This is because the master calls every remote in the list when instructed to call all and will connect with the first remote to respond. When calling through a repeater, the master must first call that repeater and establish a communications link with it prior to making contact with the remote.

Figure 3: Call Book Menu

Shown below are example settings. Please refer to supplied configuration sheets for your modem's configuration.



Entering or Modifying Numbers in the Call Book

Entering or modifying call book numbers in the Call Book is a straightforward process. When in the Call Book menu, select the entry number (0 – 9) you wish to edit. You will be prompted for the new number (formatting is automatic, you do not need to enter the dash). Once the number is entered (unless it is 000-0000) you will be asked for the call number of the first repeater to be used. If no repeater is to be used, enter the escape key; your entry will be complete and you will be back in the Call Book menu screen. If you enter a repeater number, you will then be prompted for the call number of the second repeater to use. If a second repeater is being used, enter the call number at this time; if not, enter the escape key. Once again, the radio modem will retain your entries, as shown in the updated Call Book menu screen.

Note: It is important that the Call Book slots (0 – 9) are filled sequentially beginning with 0, the first slot in the book. Call Book numbers do not need to be entered in numerical order; however, there must not be any 000-0000 numbers in the middle of the list of good Call Book numbers. The reason for this is that when a master is instructed to Call All available remotes, it will call all remotes listed until it reaches the first number of 000-0000. If a valid call book number is entered after the all zero number, it will not be recognized as a valid number to be called by the master.

Edit Call Book in Multi-Point Systems

In a multi-point system, the remotes and repeaters are not listed in the master's Call Book. When establishing such a system, it is necessary only to have the master's Call Book number in each remote's and repeater's Call Book, and to have each repeater's Call Book number in the Call Book of each remote which may potentially communicate through it.

The following example shows the Call Books of a multi-point system comprised of a master, repeater and remote in which the remote can communicate either through the repeater or directly to the master:

Multi-Point Master Call Book (Unit Call Book number 555-0001)

Entry	Number	Repeater 1	Repeater 2
(0)	000-0000		
(1)	000-0000		

No call book number entries are necessary in the master's Call Book

The master's Call Book may be programmed to call any entry

Multi-Point Repeater Call Book (Unit Call Book number 555-0002)

Entry	Number	Repeater 1	Repeater 2
(0)	555-0001		
(1)	000-0000		

Multi-Point Remote Call Book (Unit Call Book number 555-0003)

Entry	Number	Repeater 1	Repeater 2
(0)	555-0001		
(1)	555-0002		
(2)	000-0000		

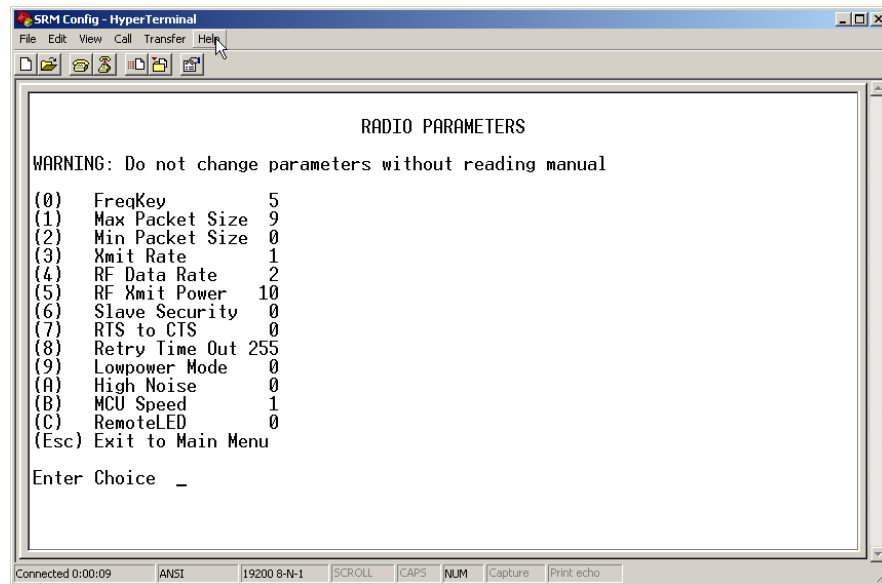
Main Menu Option (3): Edit Radio Transmission Characteristics

When option (3) is selected in the main menu the screen in figure 4 appears, which allows the user to modify the radio transmission characteristics of the radio modems. As stated in the warning, these parameters are for the experienced user who has a good understanding of the principles of radio data transmission. They should be changed only after consulting this user guide.

It is important to note that the radio parameters between any radio modems in communication will be determined by the settings for the master (except when in multi-point mode, see (4) RF Data Rate below). While the settings may be modified for the remote(s) and/or repeaters, they will be overridden by the master's parameters.

Figure 4: Radio Parameters Menu

Shown below are example settings. Please refer to supplied configuration sheets for your modem's configuration.



(0) FreqKey

Selection (0) in the Radio Parameters menu allows the user to modify the hopping patterns of the radio modems to minimize the interference with other WLM radio modems in operation in the area. For instance, if there were 10 pairs of WLMs in operation within a factory or refinery, changing the Frequency Key would ensure that they would not jump onto the same frequencies at the same time for the same length of time.

There are 15 choices available for the Frequency Key (0-9 and A-E). It is recommended that a list be maintained of the settings for each master to ensure that each is set to a different hopping pattern.

(1) Max Packet Size and (2) Min Packet Size Selections

(1) and (2) allow the user to designate the size of the packets (in bytes) used by the radio modem in its communication link. This may be of particular value when using the WLM with different communications software packages; you may find that throughput is optimized when packet sizes are restricted by the radio modem.

Packet size is determined by a combination of the settings entered by the user and the RF Data Rate. In addition, the Max Packet Size is a function of the setting selected for the Min Packet Size. Tables 2, 3 and 4 provide the packet sizes for each different combination of settings.

Table 3: Minimum Packet Size Settings (bytes)

Setting	Min Packet Size RF Data Rate = 2	Setting	Min Packet Size RF Data Rate = 3
0	16	0	8
1	21	1	12
2	26	2	16
3	32	3	20
4	37	4	24
5	42	5	28
6	48	6	32
7	53	7	36
8	58	8	40
9	64	9	44

Table 4: Maximum Packet Size Settings where RF Data Rate=3

Maximum Setting

	0	1	2	3	4	5	6	7	8	9
0	8	24	40	56	72	88	104	120	136	152
1	12	28	44	60	76	92	108	124	140	156
2	16	32	48	64	80	96	112	128	144	160
3	20	36	52	68	84	100	116	132	148	164
4	24	40	56	72	88	104	120	136	152	168
5	28	44	60	76	92	108	124	140	156	172
6	32	48	64	80	96	112	128	144	160	176
7	36	52	68	84	100	116	132	148	164	180
8	40	56	72	88	104	140	136	152	168	184
9	44	60	76	92	108	124	140	156	172	188

Table 5: Maximum Packet Size Settings where RF Data Rate=2

		Maximum Setting									
		0	1	2	3	4	5	6	7	8	9
Minimum Setting	0	15	36	58	79	100	121	143	164	185	206
	1	20	42	63	84	105	127	148	169	190	212
	2	26	47	68	90	111	132	153	175	196	217
	3	31	52	74	95	116	137	159	180	201	222
	4	36	58	79	100	121	143	164	185	206	228
	5	42	63	84	105	127	148	169	190	212	233
	6	47	68	90	111	132	153	175	196	217	238
	7	52	74	95	116	137	159	180	201	222	244
	8	58	79	100	121	143	164	185	206	228	249
	9	63	84	95	127	148	169	190	212	233	254

(3) Xmit Rate

There are two settings for the Transmit Rate parameter. For normal operation the WLM should be set at Transmit Rate 1. Transmit Rate 0 is useful to qualitatively gauge signal strength. When set to Transmit Rate 0 the radio modems will transmit data back and forth continuously, and the strength of the signal may be gauged by viewing the Show Radio Statistics option.

Due to the fact that the radio modems transmit continuously when Transmit Rate is set to 0 (whether or not they have data to send) they use radio frequency spectrum unnecessarily. Therefore, Transmit Rate 0 should be used only as a diagnostic tool and not for normal operation.

(4) RF Data Rate

The WLM has two settings for the RF Data Rate (not to be confused with the RS485 Baud Rate). Setting 2 should be used when the radio modems are close together and data throughput is to be optimized. Setting 3 should be used when the radio modems are farther away and a solid data link is preferred over data throughput.

Note: The RF Data Rate setting must be identical for all units in the system. Any radio modem with a different RF Data Rate than the master will not establish a communication link.

(5) RF Xmit Power

The WLM offers users the ability to modify the Transmission Power of the radio modem. There are 10 power settings available (1-10) which are roughly linear. Therefore a setting of 10 is full power (or 1 Watt) and 1 is 10% power (or 100 mw). The following guidelines should be followed when setting the RF Transmission Power:

Table 6: Power Transmit Settings

Setting	Power Level	Used When
1-3	Low	Pair of pairs of radio modems operating within the same or adjoining rooms.
4-6	Medium	More than one pair of radio modems operating withi the same facility.
7-10	Full	Normal operation extending beyond a facility.

(6) Remote Security

With option 6 the user may disable the radio modem's security so it will accept a call from any other WLM. The default setting is 0 where security is enforced (the caller's call book number must be in the remote's Call Book). With a setting of 1 security is disabled.

As mentioned in mode 6, Remote Security must be set to 1 when the unit is operating in a point-to-point system where it may need to accept calls from more than 10 different WLMs. However, it is important to note that when Remote Security is set to 1, the radio modem will accept calls from any other WLM, and additional system security measures should be taken to prevent unauthorized access.

(7) RTS to CTS

Menu selection 7 in the Radio Parameters provides the option of allowing the RTS line (pin 7) on the master radio modem to control the CTS line (pin 8) of the remote. This pass-through control can be enabled in point-to-point mode as well as point-to-multi-point. In the latter, the master RTS line will control all remotes' CTS lines. When this mode is enabled the CTS line ceases to function as flow control. Therefore it is not recommended to enable this feature when operating at RS-232 speeds above 38.4 KB.

To enable this mode, enter 7 in the Radio Parameters menu. An entry of (1) will enable the RTS-CTS control a (0) will disable it.

(8) Retry Time Out

The Retry Time Out parameter allows the use to determine when a remote will drop a connection to a master or repeater in multi-point mode. The default setting is 255, meaning that if one packet in 255 from the master is sent successfully to the remote, it will maintain a link. The lowest setting is 8, at which a remote will drop a connection much faster.

The Retry Time Out parameter is useful when a multi-point system is used with a moving master or remotes. As the link gets weaker, a lower setting will allow a remote to drop it's link and search for a stronger connection.

While intended primarily for multi-point systems, the Retry Time Out parameter may also be modified in point-to-point systems. In point-to-point mode the Retry Time Out should not be set to a value of less than 151.

(9) Lowpower Mode

The Lowpower Mode is an option that, when enabled, allows the WLM to use less power when set as a multi-point remote.

With a setting of 2 through 63, the WLM will sleep between slots. For example, at a setting of 2, the WLM sleeps 1 out of 2 slots, at a setting of 3, the WLM sleeps 2 out of 3 slots, and so on.

Note:

1. The Lowpower mode is for use only in point to multi-point systems and only on the multi-point remotes. The power savings occur when the option is enabled and the remote has a link to its master or repeater. There are no power consumption savings when the remote is transmitting data back to the master. Designed primarily for SCADA systems, the Lowpower Mode is of little value when significant amounts of data is being sent from the remote to the master.
2. Because the Lowpower mode puts the transceiver to sleep, a latency will be introduced before it becomes fully linked to the master. This latency can range from 6 ms to 2.5 seconds.

(A) High Noise

Use the menu to indicate if the modem will be operated in an environment with a high degree of radio noise and interference.

With a setting of 1, the rejection of interference is improved, at the cost of reduced range and/or throughput.

(B) MCU speed

Use this menu to set the speed of the MCU (processor) in the modem.

Note: Only needed when the WLM is set to 115.2Kbaud (or above) and/or if LincView (diagnostics) is being used.

Setting	Description	Notes
0	Low speed	Reduces current consumption
1	High speed	Required for 230Kbaud

Main Menu Option (4): Show Radio Statistics

Option (4) in the main menu allows the user to view data transmission statistics, which have been gathered by the Transceiver during the most recent session. Statistics are gathered during each data link and are reset when the next link begins. Ideally, noise levels should be below 30, and the difference between the average signal level and average noise level should be 15 or more. High noise levels tend to indicate other sources of RF interference, while low signal levels indicate a weak link. The "Local" stats are the statistics that are being gathered by the modem you are connected to while "Remote1, Remote2, and Remote3" are the stats of the repeater(s) that the modem you are attached to is using to get back to the master modem. The following sections provide information useful to the process of troubleshooting and improving radio links.

Average Noise Level

The average noise level indicates the level of background noise and interference at this modem and at each of the modems used as repeaters in the link. The number is an average of the noise levels measured at each frequency in the modems' frequency hop table. The individual measurement values at each frequency hop channel are shown in the frequency table. The frequency table is accessed by pressing the ENTER key on the computer when the radio statistics menu is displayed. Average noise levels will typically fall in the range of 15 to 30. Average noise levels significantly higher than this are an indication of a high level of interference that may degrade the performance of the link. High noise levels can often be improved with bandpass filters, antenna placement or antenna polarization. Please contact Moore Industries-International, Inc. for more information.

Average Signal Level

The average signal level indicates the level of received signal at this modem and at each of the modems used as repeaters in the link. For each of these, the signal source is the modem that transmits to it. The number is an average of the received signal levels measured at each frequency in the modem's frequency hop table. The individual measurement values at each frequency hop channel are shown in the frequency table. The frequency table is accessed by pressing the ENTER key on the computer when the radio statistics menu is displayed.

For a reliable link, the average signal level should be at least 30 higher than the average noise level reading. The table below provides an approximate conversion of average signal level values into the more common dBm (decibel milliwatts). Low Average Signal Levels can often be corrected with higher gain antennas, antenna placement, and use of repeaters. Contact Moore Industries-International, Inc. for more information.

Average Signal Level	41	49	60	66	85
Level in dBm	-110	-100	-60	-80	-70

Overall Rcv Rate (%)

The Overall Rcv Rate measures the percentage of data packets that were successfully transmitted from the master to the remote on the first attempt without requiring retransmission. A number of 75 or higher indicates a robust link that will provide very good performance even at high data transmission rates. A number of 25 or lower indicates a weak or marginal link that will provide lower data throughput. An Overall Rcv Rate of 100% will provide approximately 100 Kbaud of bandwidth with an RF data rate of 3 (Radio Transmission Parameters Menu) and approximately 150 Kbaud of bandwidth with an RF Data Rate of 2. These numbers are reduced approximately 50% if there are one or more repeaters in the network.

Number of Disconnects

If, during the course of performing a link test, the link between the master and the remote is broken, and the radios lose carrier detect, the occurrence is recorded in the Number of Disconnects value. The value indicates the total number of disconnects that have occurred from the time the link test started until the radio was put into config mode. Under normal operating conditions, the number of disconnects should be 0. One or more disconnects may indicate a very weak link, the presence of severe interference problems or loss of DC power to the Master or Repeater if one is present.

Note: a remote and/or repeater will record a disconnect if the system master is placed into configuration mode or has power interrupted while the remote and/or repeater is linked to the master

Radio Temperature

The radio temperature value is the current operating temperature of the radio in degrees C (Celsius.) For proper operation, WLM radio modems must be in the range of -40° to 75° C.

Multi-Point Operation

In a multi-point system, a radio modem designated as a master is able to simultaneously be in communication with numerous remotes. In its simplest form, a multi-point network functions with the master broadcasting its messages to all remotes and the remotes responding to the master as appropriate.

Traditionally, a multi-point network is used in applications where data is collected from many instruments and reported back to one central site. As such, the architecture of such a system is completely different from point-to-point applications. The theoretical maximum number of remotes that can be configured into a multi-point network is a function of the data throughput needed from each of the remotes. For example, if the network will be polling remotes once a day to retrieve sparse data, several hundred remotes could be configured to a single master. If, on the other hand, each remote will be transmitting data at greater levels then fewer remotes may be connected to the master (the overall system will be closer to capacity with fewer remotes).

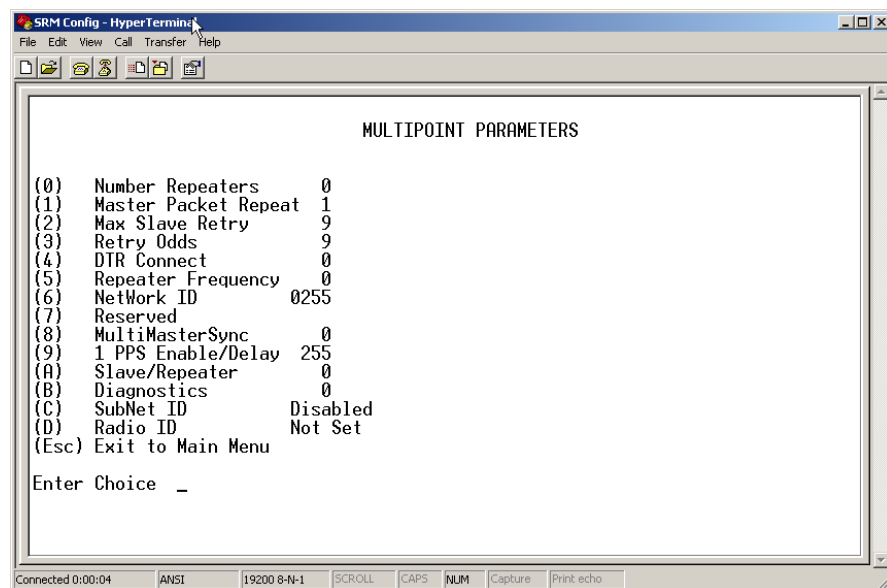
The theoretical limit of a multi-point system is influenced by the following parameters:

- Size of the blocks of data—the longer the data blocks the greater the system capacity
- RS485 baud rate
- The amount of contention between remotes
- Use of repeaters—a single repeater in a multi-point network will decrease overall system capacity by 50%; more than one repeater does not further decrease network capacity.

Main Menu Option (5): Edit Multi-Point Parameters

Figure 5: Multi-Point Parameters

Shown below are example settings. Please refer to supplied configuration sheets for your modem's configuration.



In a multi-point network, it is critical to know how many radio modems are being used as repeaters. Any radio modem that is used as a repeater essentially becomes a master to the remotes and other repeaters to which it is communicating. Therefore, the user must first identify how many repeaters are connected to the master by assigning a value in parameter **(0) Number Repeaters**. This parameter must also be set for each repeater in the system (i.e., in the event that a repeater is connected to one or more other repeaters). This parameter does need to be set for multi-point remotes.

In point-to-point operation, the WLM radio modems acknowledge every data packet transmitted. In a multi-point network, the remotes do not acknowledge transmissions from a master to the remotes. This is to prevent system overload. If the remotes acknowledged all data transmissions from the master in a large multi-point system, then all system capacity would be spent having the master listen for acknowledgments from the remotes. Because the transmission is not acknowledged by the remotes, 100% confidence does not exist that every remote has received every message from the master. To address this issue, the user may modify option **(1) Master Packet Repeat**, assigning a value between 0 (the packet is transmitted once) to 9 (the packet is repeated 9 times). For networks with solid RF links, this parameter would be set at the lower end of the scale (0-1). If the network has some weak or marginal links, it would be set toward the higher values. If a remote receives a packet from a master more than once, it will discard the repeated packets received.

While packets transmitted from the master to the remotes in a multi-point network are not acknowledged, packets transmitted from remotes to the master are. However, it is possible that more than one remote will attempt to transmit to the master at the same time, and it is therefore important that a protocol exists to resolve contention for the master between remotes.

This is addressed through parameters **(2) Max Remote Retry** and **(3) Retry Odds**. The Max Remote Retry setting defines how many times (0 to 9) the remote will attempt to retransmit a packet to the master before beginning to use a back-off algorithm. Once the remote has unsuccessfully attempted to transmit the packet the number of times specified in Max Remote Retry, it will attempt to transmit to the master on a random basis.

The Retry Odds parameter determines the probability that the remote will attempt to retransmit the packet to the master; a low setting will assign low odds to the remote attempting to transmit and conversely a high setting will assign high odds. An example of how this parameter might be used would be when considering two different remotes in a multi-point network, one close in with a strong RF link and the other far from the master with a weak link. It may be desirable to assign a higher Retry Odd to the remote with the weaker link to give it a better chance of competing with the closer remote for the master's attention.

Another parameter in a multi-point network is **(4) DTR Connect**. When set at (1), the remote will connect to the master if it is free when the DTR line goes high on the 9-pin RS485 connector. In setting (2), the radio modem will accumulate data in its buffer and transmit in a burst when the buffer is full. This mode is valuable when a network has many low data rate devices and it is desirable to increase overall network capacity. In setting (0), the radio modem will transmit when RS485 data is received.

The repeater's hopping pattern must also be set in a multi-point network; this is accomplished with parameter **(5) Repeater Frequency**. Setting this parameter is in contrast with point-to-point mode where the repeater automatically uses the master's hopping pattern. The repeater may be programmed to either use the master's hopping pattern selection (0) or its own selection (1).

Option **(6) NetWork ID** allows multi-point networks to be established without the use of the Call Book. If the NetWork ID is set to any value lower than the default (255), the remotes in the multi-point network will communicate with the first multi-point master or repeater heard with the same NetWork ID. When the NetWork ID is used, multi-point masters and repeaters may be replaced without reprogramming all of the remotes in the network. In addition, this allows a remote to establish communications with different masters (though not at the same time) without having the call book numbers in the Call Book. This is very useful in mobile multi-point applications. **(8) MultiMaster Synch** is reserved for multi-point applications with concentrations of master units where it is necessary to reduce interference between the masters. Please contact the factory for more information on the use of this feature. The **(9) 1PPS Enable/Delay** This setting should not be changed from its default of 255. Contact the factory for further information.

(A) Remote/Repeater

The remote/repeater mode allows a WLM in a multi-point system to simultaneously act as a remote and a repeater. When in this mode, a WLM will repeat any packets sent from a master as well as send them out the RS485 port. This allows a WLM set as a repeater to act as a remote at the same time. 0 disables this mode, 1 enables it. For this feature to work, the modem must be configured as a point-to-multipoint repeater.

(B) Diagnostics

The WLM has the ability to run a diagnostic program while in normal operations. Contact the factory for additional information.

(C) SubNet ID

The default setting is "Disabled." Please see the SubNet ID section of this user guide.

(D) Radio ID

Used with the Diagnostics. Contact the factory for additional information.

SubNet ID

The WLM series modems offer a SubNet ID system for use in multi-point networks using Network ID. This feature allows the users to dictate what path a given repeater or remote will use to achieve a link to the network master. For example, if a remote modem in a given network has line of sight to the network master and one or more repeaters, but only one repeater is close to that remote, SubNet ID can be used to link that master with the proper repeater only.

Note: This feature can only be used in networks using Network ID with one or more repeaters.

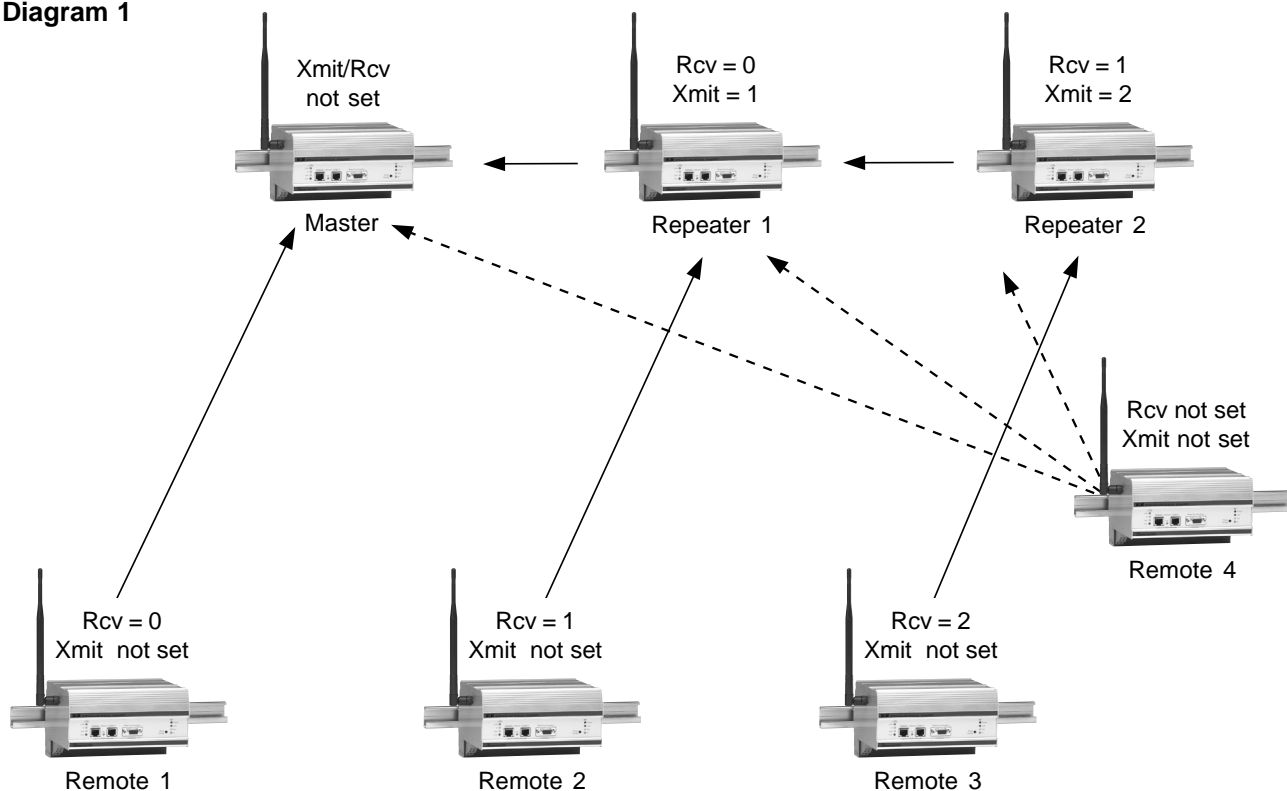
There are two components to SubNet ID. The first is the Xmit (transmit) SubNet ID, and the second is Rcv (receive) SubNet ID. The Xmit SubNet ID is used only by repeaters and is the ID that a repeater sends out when sending data to other repeaters or remotes. The Rcv SubNet ID is the ID that repeaters or remotes look for to receive data.

Note: The master is not affected by these settings. Only repeaters and remotes use these settings. Remotes only use Rcv SubNet ID

Modem configurations are as follows (see diagram 1 below):

- Master** No setting used
- Repeaters** Any repeater that should be linked directly to the master should have the Rcv SubNet ID set to 0. Any repeater using another repeater as its link, needs the Rcv SubNet ID set to the Xmit SubNet ID of that repeater. The Xmit SubNet ID can be set to anything from 1 to E.
- Remotes** Any remote that should be linked directly to the master should have the Rcv SubNet ID set to 0. Any remote using a repeater as its link should have the Rcv SubNet ID set to the Xmit SubNet ID of that repeater

Diagram 1



Main Menu Option (8): Password

Caution: If the password feature is enabled and you cannot remember the password, the radio modem will have to be returned to Data-Linc Group to have the password disabled. Use with caution.

Option (8) in the Main Menu allows the user to set a password, which will prevent unauthorized users to change the configuration of the modem.

Setting a Password

To enable the Password feature choose (8) from the Main Menu. You will be prompted with "New PW?" (<esc> to exit)

To back out of the process and not enable the password, hit escape. To set a password, type in exactly 4 characters. At any point in the process you can cancel by hitting the escape key. Once the 4 characters have been entered, you will be prompted with "<enter> to accept, <esc> to quit".

At this point, if you wish to accept the password entered and enable the feature, press the enter key. The password that you have chosen is displayed on the line above (please note that the password is case sensitive). To quit the process and not enable the password, press escape.

Changing a Password

Once the password feature has been enabled, it is possible to change to a new password. To enter a new password select (8) from the Main Menu. You will be prompted with "Enter Security Code". Enter the current password. Once the password has been entered correctly (it is case sensitive) you will be prompted to enter the new password. At any point this process may be cancelled by pressing escape.

Disabling Password

The process to disable the password is similar to the process to change the password. However, when prompted to enter the new password, the following procedure needs to be followed:

1. Hold the "Alt" key down and using the number key pad (not the numbers across the top of the key board) type "0255"
2. Release the "Alt" key
3. Repeat steps 1 and 2 three more times (this will enter 0255 a total of four times).
4. You will be prompted with "<Enter> to accept, <esc> to quit.
5. Hit the "Enter" key to disable the password or hit the escape key to keep the password

Special Application Jumper Settings

The WLM in standard configuration needs no jumper settings other than the factory default settings. For certain applications, the WLM can be set to utilize features using jumper settings (see "jumper diagram").

Note: The WLM's come from the factory pre-configured. These settings do not need to be changed unless a change in the system that the modems are operating in is needed, or the modems were ordered non-configured. See diagram 3 for jumper locations.

Jumpers JP5 and JP7 are used for configuring the serial port. JP5 sets the port up as a DTE or a DCE port (the default is DCE). JP7 is used for the RTS and CTS lines.

JP5 Chart

DTE	Short pins 3 to 5 & 4 to 6
DCE (default)	Short pins 1 to 3 & 2 to 4

JP7 Chart

Normal RTS/CTC operation* (default)	Short pins 1 to 3 & 2 to 4
RTS looped to CTS	Short pins 3 to 5 & 4 to 6

Note: The WLM does not need the RTS or CTS line to operate. These lines are offered in the event that the attached equipment needs these lines to work correctly.

On standard WLM's, JP3 and JP4 are shorted and cannot be changed. On special application units where U1, U3 and U4 are used, JP3 and JP4 need to be removed in order for these chips to work correctly. If an WLM is ordered from the factory as a standard unit, these chips will not be installed. If an WLM is ordered from the factory for a special application, it can be re-configured for standard use. To do this, short JP3 pins 1 & 2 and JP4 pins 1 & 2. The special usage chips and their jumper settings will be bypassed.

JP2 is used for special applications when U1, U3 and U4 are used and JP3 pins 1&2 and JP4 pins 1&2 are not shorted. Pins 1 through 6 are used for baud rate control of the special usage chips and pins 7 through 10 are used to set the chips up for what they are going to be used for (see JP2 chart)

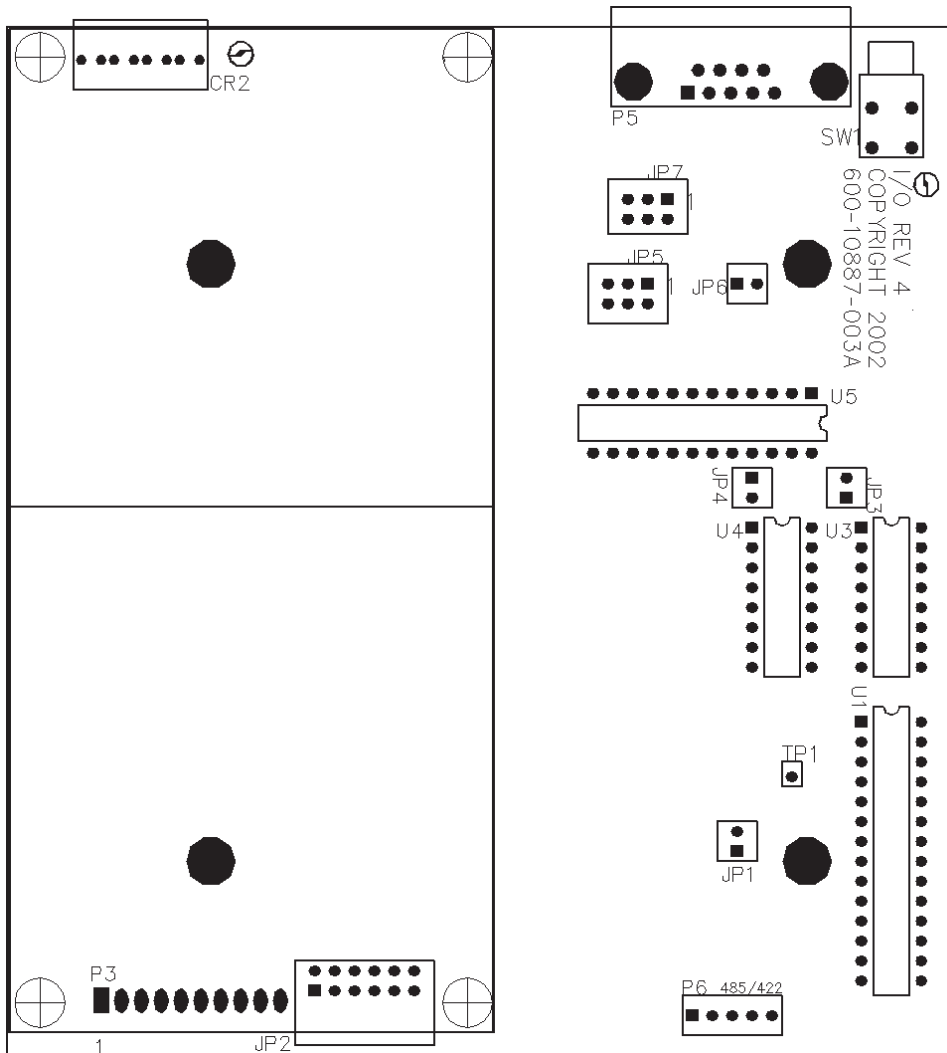
JP2 Chart/Baud Rate

Pins 1-2	Pins 3-4	Pins 5-6	Baud Rate
Off	Off	Off	19.2
Off	Off	On	115.2
Off	On	Off	57.6
Off	On	On	38.4
On	Off	Off	9600
On	Off	On	4800
On	On	Off	2400
On	On	On	1200

JP2 Chart/Chip Operation

Pins 7-8	Pins 9-10	Chip Operation
Off	Off	Connect master (always 10 bit word)
Off	On	Break pulse 10 bit word
On	On	Break pulse 11 bit word

Diagram 2



WLM Location

Placement of your WLM is likely to have a significant impact on its performance. In general, the rule of thumb with the WLM is that the higher the placement of the antenna, the better the communication. In practice you should also place the radio modem itself away from computers, telephones, answering machines, and other similar equipment. A 6-foot RS485 cable will usually provide ample room for placement away from other equipment. To improve the data link, Moore Industries-International, Inc. offers directional and omni directional antennas with cable lengths ranging from 10 to 200 feet. Consult the factory if cable lengths longer than 200 feet are required.

When using an external antenna, placement of that antenna is critical to a solid data link. Other antennas in close proximity are a potential source of interference. It is also possible that slight adjustments in antenna placement (as little as 2 feet) will solve noise problems. In extreme cases, such as when the radio modem is located close to pager or cellular telephone transmission towers, Moore Industries-International, Inc. offers a band pass filter to reduce the out of band noise.

Using an External Antenna

In certain circumstances it may be desirable to extend the range of the WLM radio modem by using an external antenna in place of the standard whip antenna. The radio modem is equipped with a standard SMA external jack. This allows the use of external omni directional or yagi antennas. These are part of kits provided by Moore Industries-International, Inc. and include coax cable. These antennas allow versatility in the WLM's deployment, extending its range and allowing it to get around obstructions.

The use of an external antenna may radically improve the results obtained with WLM radio modems. It is imperative to obtain line of sight with the antennas, and changes in placement height of as few as a couple of feet may make the difference between no link and one that is solid and reliable.

If external directional antennas are used, FCC regulations concerning effective radiated power limitations must be followed.

Caution: Any antenna placed outdoors must be properly grounded. It is required by FCC regulations that qualified personnel experienced in antenna installation and familiar with local codes and regulations complete the antenna installation. It is also required by FCC regulations that only approved antennas be used. Use extreme caution when installing antennas and follow all instructions included with the antennas.

The use of an external antenna subjects the radio modem to greater exposure to direct lightning strikes. It is strongly recommended that a lightning arrestor be used on all outdoor antenna installations.

Long RS485 cable runs should also be avoided in areas with increased lightning activity or static electricity unless they are properly isolated from the radio modem. Nearby lightning strikes or elevated levels of static electricity may lead to voltage spikes on the line, causing failure in the radio modem's RS485 interface. It is also recommended that the RS485 data cable not be located near high voltage power lines as this can cause interference in data communications, damage the WLM as well as an increase in risk of personal injury.

WLM Front Panel LEDs

The LEDs on the WLM's front panel provide important information on the operation of the radio modem. Compare the status of a radio modem's LEDs with the tables below to aid you in the troubleshooting process.

Table 7: LED Status in Point-to-Point

LED Indicators	P=power				C=carrier detect				I=data in				O=data out			
	P	C	I	O	P	C	I	O	P	C	I	O	P	C	I	O
Powered, no RF link	SR	O	O	O	SR	O	O	O	SR	O	O	O	SR	O	O	O
RF link established	SR	O	O	O	SR	SA	O	O	SR	O	O	O	SR	O	O	O
Data flow master to remote	SR	FA	FY	O	SR	SA	O	FG	SR	SA	O	O	SR	SA	O	O
Data remote to master	SR	FA	O	FG	SR	SA	FY	O	SR	SA	O	O	SR	SA	O	O
Configuration Mode	SR	SA	O	MG	SR	SA	O	MG	SR	SA	O	MG	SR	SA	O	MG

SR	Solid Red
FA	Flashing Amber
FY	Flashing Yellow
FG	Flashing Green
MG	Momentary Green
O	Off
SA	Solid Amber

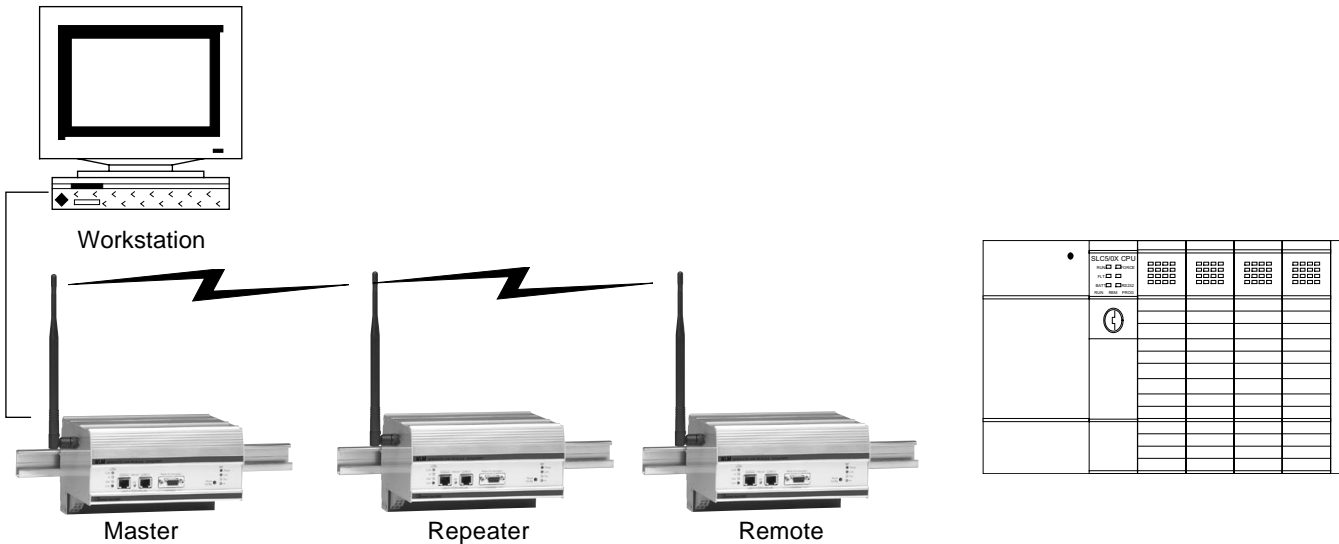
Table 8: LED Status in Multi-Point Mode

Configuration	Master				Remote				Repeater			
	P	C	I	O	P	C	I	O	P	C	I	O
Powered, no RF link	SR	O	O	O	SR	O	O	O	SR	O	O	O
RF link established	SR	SA	O	O	SR	SA	O	O	SR	O	O	O
Data flow master to remote	SR	SA	FY	O	SR	SA	O	FG	SR	SA	O	O
Data remote to master	SR	SA	O	FG	SR	SA	FY	O	SR	SA	O	O
Configuration Mode	SR	SA	O	MG	SR	SA	O	MG	SR	SA	O	MG

Data out LED lights momentarily when the configuration button is depressed.

Diagram 4 depicts how a link might be set up using a repeater. The repeater may be sitting on a hilltop or other elevated structure to link the master to the remote. In this setup, it may be desirable to use an external omni directional antenna on the repeater; to extend the range Yagi antennas could be used on either or both of the master and remote.

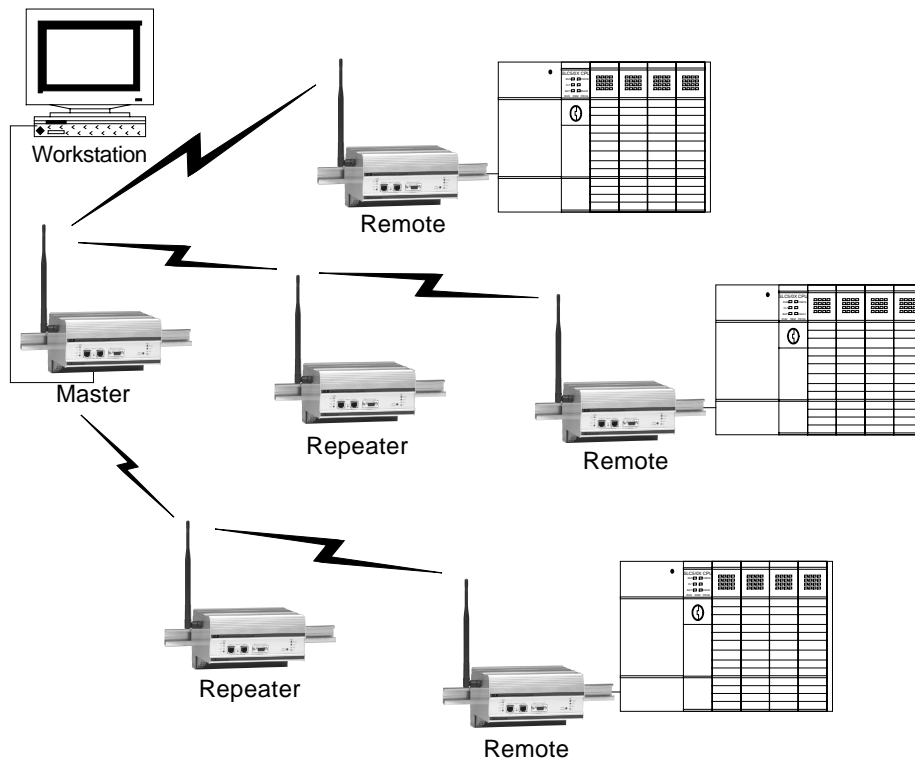
Diagram 4



When a repeater is used the RF speed is cut in half, making 115,200 KBaud uncompressed throughput unachievable. The baud rate, however, may still be set at 115,200.

Diagram 5 depicts an example of a point-to-multi-point system. In this example, any data sent from the master is broadcast to all three remotes, two of which receives it through a multi-point repeater. The data is in turn sent out of the RS485 port of each of the three remotes.

Diagram 5



Specifications

WLM Wireless Link Module Serial Interface

<p>Operating Frequency 902-928MHz</p> <p>Transmitter Range: Up to 25 miles (40km), line-of-sight distance using 902-928MHz units using omni directional antennas) Output Power: 1W maximum (10 programmable steps from 100mW to 1W) (+30dBm) for 902-928MHz units Modulation: Spread Spectrum, GFSK, 144-188kbps Spreading Code: Frequency Hopping Hop Patterns: 15 (user-selectable) Occupied Bandwidth: 230kHz</p> <p>Receiver Sensitivity: -108dBm@10-6 raw BER Selectivity: 40dB@fc ±230kHz System Gain: 140dB</p> <p>RF Data Transmission Error Correction: 32-Bit CRC</p>	<p>RF Data Transmission (continued) Data Encryption: Substitution Dynamic key RF Data Rate: 144-188kbps</p> <p>Interface 10Base-T (UTP); one straight, one cross-pinned (only one connector can be used at a time) Data Throughput: 115.2 kbps in point-to-point mode; Data throughput measured assuming 75% frequency availability Connectors: RS485 for communications; DB9 for configuration</p> <p>Antenna Standard thread SMA female; supplied bench test antenna; optional external omni directional or Yagi antenna available</p> <p>Power Input Voltage Requirements: 10-28Vdc RF Output Power: 0.1 to 1.0W for a 902-928MHz unit</p>	<p>Power (continued) Connector: Standard 24V connector Transmit Current (Peak): 650mA@12Vdc for 1W Receive Current: 100mA@12Vdc</p> <p>Operating Modes Point-to-Point, Point-to-Multi-Point, Store-and-Forward Repeater, Repeater/Remote</p> <p>Indicators Front Panel LEDs: Power, RF Link, RF In, RF Out, LAN In, LAN Out, LAN Link, LAN Collision, Overrun Error</p> <p>Diagnostics Serial Port Data: Stored signal strength, noise and disconnect information</p> <p>Operating Environment Standard Temperature: -40° to +75°C (-40° to +167°F) Humidity: 0 to 95% non-condensing humidity</p> <p>Weight 1.13 kg (2.5 lbs.)</p>
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Troubleshooting

“I have two radio modems, one configured as a master and the other as a remote. When they are plugged in, the LEDs indicate they are receiving power, and yet they will not connect. Why not?”

There are several reasons why this may occur:

1. The radio modems are running a full power and are too close to each other. If the radio modems are within 5-10 feet of each other and will not link, try either reducing the RF power to 0 on each or moving one unit to another room. (This problem occurred on the initial generation of product with the 555-call book number prefix. It has been addressed in radio modems with call book numbers 556 and higher).
2. The radio modems are not in each other's Call Books.
3. The number of the remote is in the master's Call Book, but the master's menu is not set to call that number.
4. The master is set to Call All and a setting of 000-0000 precedes the number of the radio modem with which you are trying to communicate.

“I am able to link to a remote unit within line of sight when the WLM I have is outside. However, as soon as I walk inside with it I lose the link, even if I place the radio modem by the window which faces the remote unit.”

Many modern buildings use energy efficient glass that wreaks havoc on RF signals. This glass contains a metal film that is very effective in blocking all radio waves. If your situation is as described above, the preferable solution is to install an antenna outdoors.

“I have several radio modems set up to communicate with each other in a point-to-multi-point mode, yet they are not establishing contact.”

In a multi-point system there are two critical parameters which must be set correctly to establish a communications link:

1. The remote's Call Book must contain the call book number or Network ID of the master and/or repeaters to which it will be communicating.
2. All radios must be set to run at the same RF data rate. Remote modems must match the Masters RF data rate.

“In bench testing several units in a multi-point system, it appears that they are not communicating through the multi-point repeater. When all units are powered, the remotes' Carrier Detect lights are on, indicating a connection, yet when I unplug the repeater, those remotes set up to communicate through that repeater remain connected.”

In a multi-point system, a remote will attempt to communicate with any master or repeater (which looks like a master in a multi-point system) that is in its call book. Therefore, it may be that the remotes are communicating with the repeater when it is powered, and when it is unplugged they are establishing a link with the master. To test whether or not this is what is occurring, go into the call book of the remotes which are set up to communicate through the repeater and remove the master's call book number. When all units are powered, the remotes' Carrier Detect lights should be green. When the repeater is unplugged, the remotes should lose contact and Carrier Detect should turn red.

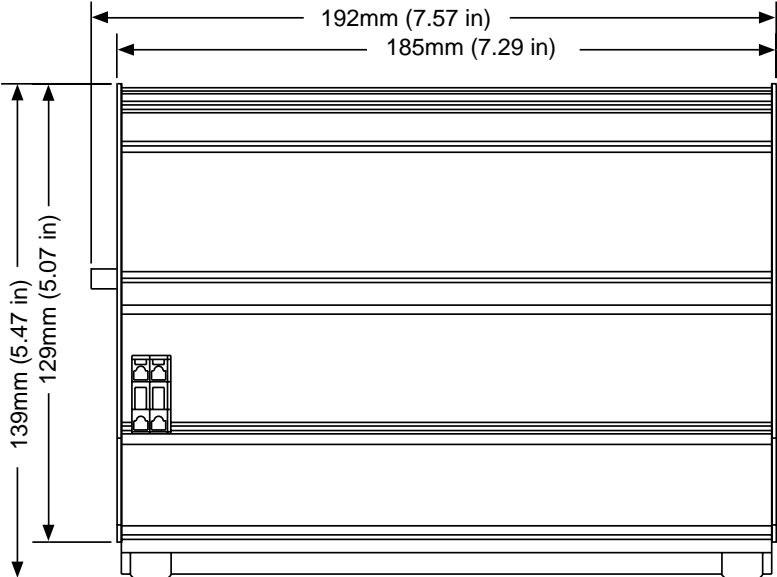
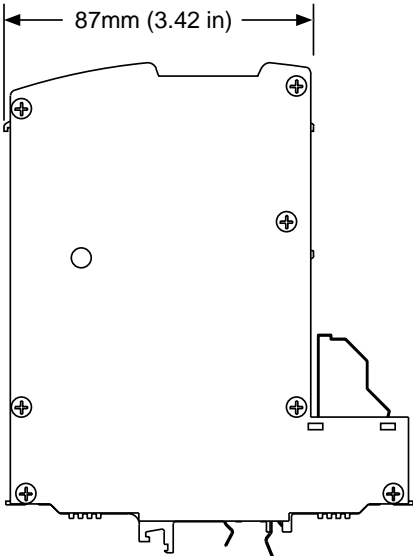
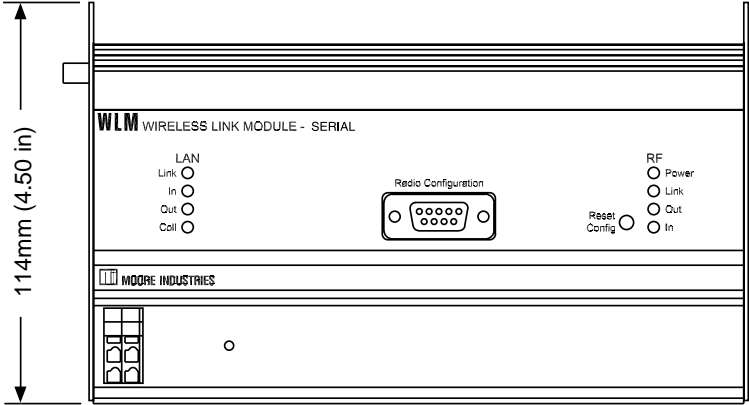
“My radio modems have established a solid connection as indicated by the LEDs, yet the application I am running is not transmitting and/or receiving data correctly.”

In most cases this is due to an incompatible port setting on one or both ends of the system. Ensure that each radio modem port setting and the device that it is connected to are set up the same.

It is also possible that the devices are not properly configured to communicate with each other. The quickest acid test in a situation like this is to try to get the application up and running using an RS232 null modem cable before deploying the WLM in the field. The WLM essentially functions as a null modem cable. If the application will not work with a hard wire connection then it will not work with the WLM, and the problem lies within the application or other hardware (such as the computer or PLC serial ports).

Appendix A

Enclosure Dimensions



RETURN PROCEDURES

To return equipment to Moore Industries for repair, follow these four steps:

1. Call Moore Industries and request a Returned Material Authorization (RMA) number.

Warranty Repair –

If you are unsure if your unit is still under warranty, we can use the unit's serial number to verify the warranty status for you over the phone. Be sure to include the RMA number on all documentation.

Non-Warranty Repair –

If your unit is out of warranty, be prepared to give us a Purchase Order number when you call. In most cases, we will be able to quote you the repair costs at that time. The repair price you are quoted will be a "Not To Exceed" price, which means that the actual repair costs may be less than the quote. Be sure to include the RMA number on all documentation.

2. Provide us with the following documentation:
 - a) A note listing the symptoms that indicate the unit needs repair
 - b) Complete shipping information for return of the equipment after repair
 - c) The name and phone number of the person to contact if questions arise at the factory
3. Use sufficient packing material and carefully pack the equipment in a sturdy shipping container.
4. Ship the equipment to the Moore Industries location nearest you.

The returned equipment will be inspected and tested at the factory. A Moore Industries representative will contact the person designated on your documentation if more information is needed. The repaired equipment, or its replacement, will be returned to you in accordance with the shipping instructions furnished in your documentation.

WARRANTY DISCLAIMER

THE COMPANY MAKES NO EXPRESS, IMPLIED OR STATUTORY WARRANTIES (INCLUDING ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE) WITH RESPECT TO ANY GOODS OR SERVICES SOLD BY THE COMPANY. THE COMPANY DISCLAIMS ALL WARRANTIES ARISING FROM ANY COURSE OF DEALING OR TRADE USAGE, AND ANY BUYER OF GOODS OR SERVICES FROM THE COMPANY ACKNOWLEDGES THAT THERE ARE NO WARRANTIES IMPLIED BY CUSTOM OR USAGE IN THE TRADE OF THE BUYER AND OF THE COMPANY, AND THAT ANY PRIOR DEALINGS OF THE BUYER WITH THE COMPANY DO NOT IMPLY THAT THE COMPANY WARRANTS THE GOODS OR SERVICES IN ANY WAY.

ANY BUYER OF GOODS OR SERVICES FROM THE COMPANY AGREES WITH THE COMPANY THAT THE SOLE AND EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONCERNING THE GOODS OR SERVICES SHALL BE FOR THE COMPANY, AT ITS OPTION, TO REPAIR OR REPLACE THE GOODS OR SERVICES OR REFUND THE PURCHASE PRICE. THE COMPANY SHALL IN NO EVENT BE LIABLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES EVEN IF THE COMPANY FAILS IN ANY ATTEMPT TO REMEDY DEFECTS IN THE GOODS OR SERVICES. BUT IN SUCH CASE THE BUYER SHALL BE ENTITLED TO NO MORE THAN A REFUND OF ALL MONIES PAID TO THE COMPANY BY THE BUYER FOR PURCHASE OF THE GOODS OR SERVICES.

ANY CAUSE OF ACTION FOR BREACH OF ANY WARRANTY BY THE COMPANY SHALL BE BARRED UNLESS THE COMPANY RECEIVES FROM THE BUYER A WRITTEN NOTICE OF THE ALLEGED DEFECT OR BREACH WITHIN TEN DAYS FROM THE EARLIEST DATE ON WHICH THE BUYER COULD REASONABLY HAVE DISCOVERED THE ALLEGED DEFECT OR BREACH, AND NO ACTION FOR THE BREACH OF ANY WARRANTY SHALL BE COMMENCED BY THE BUYER ANY LATER THAN TWELVE MONTHS FROM THE EARLIEST DATE ON WHICH THE BUYER COULD REASONABLY HAVE DISCOVERED THE ALLEGED DEFECT OR BREACH.

RETURN POLICY

For a period of thirty-six (36) months from the date of shipment, and under normal conditions of use and service, Moore Industries ("The Company") will at its option replace, repair or refund the purchase price for any of its manufactured products found, upon return to the Company (transportation charges prepaid and otherwise in accordance with the return procedures established by The Company), to be defective in material or workmanship. This policy extends to the original Buyer only and not to Buyer's customers or the users of Buyer's products, unless Buyer is an engineering contractor in which case the policy shall extend to Buyer's immediate customer only. This policy shall not apply if the product has been subject to alteration, misuse, accident, neglect or improper application, installation, or operation. THE COMPANY SHALL IN NO EVENT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.



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