Operation Manual

Mine Net Smart Reader

Part Number
180-0593
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Introduction

This manual provides an overview of functional operation of the Mine Net Intrinsically Safe (IS) Smart Reader. Auxiliary system components including MSHA Approved Mine Net Tags (Approval # 23-A070007-0), Power Supply Repeater/Splitter, Antennas, etc., typically ordered with this unit are found in **Appendix A**. The Smart Reader is designed to communicate with both AMR RF Tags and AMR Text Messenger devices, and convey the applicable RF data to the surface station via four conductor copper dual twisted pair. On Board software can be easily updated to facilitate communication protocol changes and inclusion of new or revised products. Variations of Smart Reader installations incorporating fiber optic cabled communications are not covered in this manual. Additional information can be found on our website at ***AmericanMineResearch.com/SmartReader***. Additional technical specifications are found in **Appendix B.**

System Description

The Mine Net Smart Reader is based on operation through AMR's Mine Net Software. The software polls the Smart Readers which handle the reception of RF transmissions from our line of RF Tags (on 315MHz) and the bi-directional communications to and from our line of Text Messengers (on 418MHz) through 4 antenna ports and respective processing channels. Channel configurations allow uses to specify number of Tag receivers and Messenger transceivers per unit.

The surface base station running the Mine Net software controls the system over RS-485 copper 4 conductor, providing a data log of events, alarms, and is the primary interface to RF Smart Tagging and Messaging operations. The software allows composition, sending and receiving of messages to the Smart Readers, tracks received positions of the Messengers, and issues any special instructions with Messenger units and records, displays, and shows dynamics with respect to RF Smart Tag units.

Each Smart Reader is numbered with a unique address, allowing numbered units to be described by physical location, (i.e. Address 45: Belt drive 4). Similarly, Tag and Messenger units have their own unique addresses as well, allowing these devices to be assigned specifically to a person, position, equipment or task. Once installed, Mine Net will allow system operators to quickly assign units to each unique number/address associated to a person or a location and quickly update a unit's assignment if moved.

Unit Description

The Smart Reader is a self contained communications portal between a Mine Net System over copper cable and up to 4 RF channels. It translates between the Mine Net System controller and RF elements in a mine (tags or messenger units). AMR's Smart Reader is typically housed in a stand alone fiberglass (either orange or grey colored) NEMA-4 front panel opening enclosure, but can be configured to have its electronic modules mounted inside a secondary enclosure also housing a local Smart Repeater/Splitter for direct connection as part of an "All-In-One" enclosure approach. Typical applications of a "Stand-Alone" unit only require a 4 conductor cable to function as an extension of the Mine Net System. Further, Smart Reader modules can be daisy chained to allow multiple readers to be connected in either the same enclosure or along a long string of stand alone units along thousands of feet of mine travelways. Similarly, two or three IS Smart Reader electronics module sets can be mounted in a single enclosure wired as a daisy chain of individual readers, but effectively providing a functional 8 or 12 channel device. Such an implementation is useful for areas of high traffic and speed travel to increase coverage redundancy or a place that is a center for several separate corridors.

A typical "Stand Alone" application features a compact fiberglass enclosure. The enclosure is accessed through a lockable side latch. The front panel contains a multi-element display for title and naming as well as indicator LED display. The enclosure features a common 4 conductor wired interface with access holes on the right side of the enclosure for two sets of cables (typically source side and downstream side). Cables are mounted through standard cord grip style connectors. Two sets of marked terminal blocks allow for both "In and Out" style cabling. A fifth terminal space is provided inside the enclosure for a cable shield conductor. Three circuit boards are used, mounted on the front door panel fixed rear panel and rear panel space on the bottom.

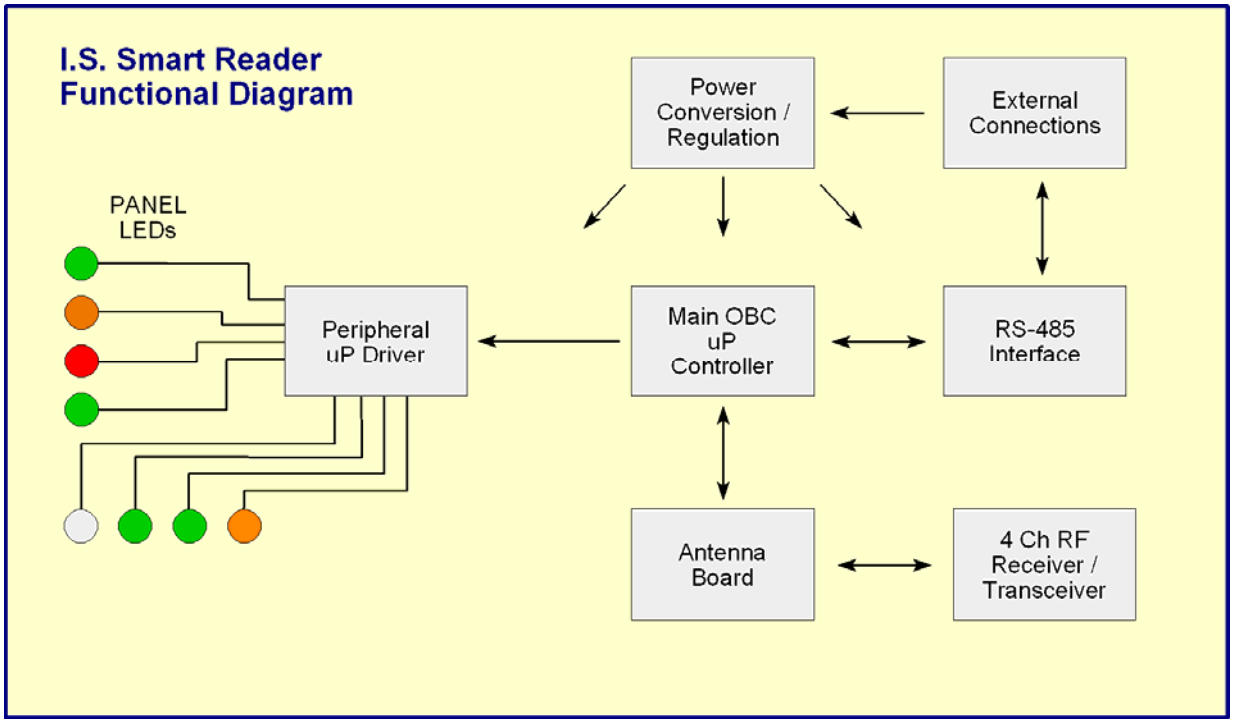
All user wiring from external lines is done onto the Back Panel Board (#253-0387) where the two terminal bocks are located. To the left of the terminal strips is where an optional battery pack is mounted. The battery pack has a self contained current limiting resistor, package overwrap, and wire connections intended for direct soldering to terminal holes at the top of the Back Panel Board. Primary connection between the Back Panel Board and the Main Processing On-Board Controller (OBC) Board is a 5 position polarized connector containing wires for Ground, Line Power, Positive Battery Power, Positive Comm and Negative Comm (based on a RS-485 protocol). The Back Panel Board also contains three (green-ceramic) 250mA fuses; two for external communications lines, and one for primary power voltage, as well as a zener diode for high voltage conditions on the communications lines.

Underneath the Back Panel Circuit Board on the bottom of the enclosure is the Antenna Board (#253-0404-X). The Antenna Board allows primary interface with RF modules through 4 RP-SMA antenna port connectors which hang out the bottom. The antenna board is arranged in 4 channels with a common power stage to allow individual interface between the channels and the OBC board. The Antenna Board's primary connection to the OBC board is through a 14 pin ribbon cable, with sockets on each end. This cable allows for power, board selection, and communications.

Antenna Boards interface directly with RF Tags and Messengers, each with their own protocol and circuitry requirements. Due to the need for different applications and conditions per mine and per application, AMR offers Antenna Boards in three configurations. These allow the greatest amount of flexibility in the implementation of tags and messenger devices. The three configurations are

numbered from the number of tag receivers per antenna board. A 253-0404-4 board or 4:0 version, has no messenger interface channels. A 253-0404-3 board or 3:1 version has three Tag receiver channels and one messenger channels. A 253-0404-2 board or 2:2 version, has 2 Channels of both Tag Receiver and Messenger. A single resistor as well as the auto-ID features in the main board primary OBC software program provides the recognition of if there is an Antenna board present and what its configuration is.

The OBC Board (#253-0403) is the main processing board and gets its functional connections from the other two boards as well as an external temperature input module. It is mounted on the front panel door and has 8 bi-color LEDs that extend to the panel face for display purposes. It contains all power conversion, regulation, and battery recharging circuitry, device control and memory, LED driving, system interface, and other ancillary functions. Pin sockets for interface with the Back Panel board and Antenna board as well as a future expansion are provided. Several sets of pins (J4, J6, and J7) with specific voltages and signals are provided for troubleshooting and operating references for repair and diagnostics. As the main board in the system, all system functions can be directed through it as depicted in the following illustration.



The OBC Board contains three groups of switches for different purposes. At the top left of the circuit board are two BCD rotary dip switches which allow operators to set the devices address. All IS Smart Readers are set up as system remotes with a total address range of 1 -199. An inch below the address switches are mode switches comprised of 4 linear dip channels. Space ‘4’ (SW4) controls the hundreds digit of the address. The other three are software mappable and explained in user-specific documentation. An individual switch is located above the top-right mounting screw (SW5), it “jump-starts” battery power to the system if it was in the off state and if the battery had enough voltage to initiate the starting sequence of the device. This is used in the case where power is removed by surface

command, the unit is ‘OFF’, no line power is present, and an individual wants to manually start the unit based on available battery power. Once ‘On”, the unit will wait to hear a valid address ‘ping’ from the system controller while storing tag and message data in memory.

Operationally, the front panel LEDs indicate the state of operation. Additional system information can be obtained by observation of the two internal red surface mount LEDs mounted at the middle-lower right. Typical responses follow a call-and-respond format for both the antenna and OBC boards. Total system function as coordinated by the Mine Net System should be obvious by sequence at the reader and response at the Mine Net System base station.

Maintenance and Field Repair

The Smart Reader consists of three circuit boards and optional battery pack typically enclosed in a NEMA-4 fiberglass enclosure. After proper installation, address assignment, and testing, the only direct maintenance required is changing out of the battery pack if it is not holding charge, a process that is only done at the factory or approved field station. If the unit is not operating as expected, a review of power levels and connection points will typically bring a solution. It is possible that a fuse has blown, that those should be checked first and replaced as necessary. In the case of a board failure, various indicators explained in the Troubleshooting Guide should narrow in on the cause.

In the event that the Smart Reader is malfunctioning and that following the Troubleshooting Guide indicates that a board component is most likely the cause, it is the policy of AMR that all such readers be returned for OEM diagnostics and service. There is no user repairable components on the boards in the IS Smart Reader. Is some individual cases, a suspect board may be returned external to the enclosure. Although AMR does not support the field repair of any internal circuitry, special situations may permit a board to be exchanged in the field in fresh air. Suspect boards/battery pack should ONLY be extracted / reinstalled by qualified personnel only and sent directly to our repair department at:

12187 N Scenic Hwy, Rocky Gap, VA 24366

Signs of Battery Pack performance reduction are not obvious as most operational time will be spent under line power. The OBC board’s main controller IC coordinates recharging or “Topping Off” of the battery pack when possible from available line power. Occasionally, there will be a load test where the system will run under battery power solely to verify its charged status and to measure the voltage drop under this condition. Battery charge retention and voltage is reported to through the Mine Net System to the surface control base station. A large voltage drop under load is indication that the pack needs more recharging or is leaning to unfit service, service performance outside of its rated specification. It is important to verify battery pack fitness prior to relying on it in a power-off emergency. Although the battery becomes the primary source of power once line power is removed, the pack has a recharge rating of 500 deep cycles. The pack is expected to last a minimum of 5 years.

Changing out the battery pack requires the unit to be unsoldered from its mounting terminals, an operation best done outside mine conditions or at least in fresh air with a soldering device.

Initial Wiring

The device comes ready to wire with ports available for common 'daisy chained' connections to the Mine Net System through 4 conductor mine-rated and MSHA approved cable. Installation while 'Hot' is not recommended, but possible with care not to short the wires to each other or any other metal object inside or outside of the enclosure in any combination. Terminal blocks are provided that will accept ring terminals, spade terminals, or plain stripped wire ends. Measuring the voltage of cable assignments with a digital multimeter (DMM) is always recommended to insure the correct wire assignments, status, and polarities.

To wire and install a reader, follow the Installation Instructions manual. In brief and for discussion, a reduced procedure is described. First, open enclosure and unplug the primary Back Panel - OBC inter-board connector (5 position orange connector). Then, detach connector twist-tightening sleeves from the enclosure with its internal ring. Slide the twist off connector along with the ring down the cable, insert the cable from the outside to the inside of the enclosure, and pull through around 18". Strip the cable down 4"- 6", separate the conductors, and strip ends. Once a wire is stripped, it should be wired in place with a small amount of length for flexibility. Follow the installation notes on the Back Panel Board:

TB Position	Wire Assignment	Wire Type (typical)
1	POS/A Data	16 AWG Black
2	NEG/B Data	16 AWG White
3	Power +	12 AWG Red
4	Power-Ground	12 AWG White
5	Shield (bare typical)	16-22 AWG bare.

Normal Operation - Startup Sequence

Once the device is connected to the standard 4 conductor copper (2 line power, 2 Comm.) connections and their polarities are verified, plug in the 5 position orange connector. Observe a standard LED starting pattern as it cycles through Green / Orange / and Red LED indicators on the front panel and the two red LEDs on the OBC board it self. The opening LED sequence allows the line and other inputs to settle. Once the sequence is over, normal operation under line power provides that the front panel LEDs should portray all critical elements of operation. In the broadest sense, green is good, orange is questionable, and red is bad. The opening sequence ends with the address in memory, the OBC accepting periodic received signals from the Antenna Board, and waiting for its address to be called from the MMS to begin its call-and-respond based MMS interaction.

Panel mounted system display/status LEDs are divided into two groups; the vertical LEDs display aspects of device status, whereas the horizontal indicates RF Channel status and activity. Secondarily, there are two internal communications status LEDs in the lower right portion of the OBC board that respond to communication indicators. A working knowledge of the LEDs and their patterns is highly useful for diagnostics. When line power is removed, or the device receives proper command

instruction, the unit will enter into a descending low power mode operation. Upon low power operation, the luminous intensity of the LEDs will be reduced from 100% to 20%, to 5% and then off as a way to save energy. The primary power LED will remain lit at least 20% during all operations. As a diagnostic, Switch 3 may be used to manually force full operation of the LEDs even when in low power mode. A brief description of their function is provided below:

Vertical LEDs:

Power LED	Green	= Primary Power is 'ON'
	Blank	= Off
Line Power LED	Green	= Good, above warning threshold
	Orange	= Fair, between low and normal operation
	Red	= Low, below normal operations threshold
	Blank	= Off
Battery LED	Green	= Good, above warning threshold
	Orange	= Fair, between low and normal operation
	Red	= Low, below normal operations threshold
	Blank	= Not Connected or extremely low
Comm LED	Green	= Communications are good, TX/RX Often
	Orange	= Comm is active, address not polled in >30 seconds
	Red	= No Communication Detected

Horizontal LEDs:

Ch 1-4	Green (for 0.5 sec)	= Channel registered at least 1 valid RF TAG input
	Orange (for 0.5 sec)	= Channel registered at least 1 valid Messenger sync.
	Red (Blinking)	= Comm momentarily failed with circuitry
	Red (Continuous)	= No communication with channel circuitry
	Blank	= Channel is responding normally, no valid inputs
	Red (2 Left-2 Right Pattern)	= Peripheral IC not being updated by main controller, it may be locked up or dead, attempts to restart processor will be done

Internal LEDs:

LED # 9	Red, Pulsing	= Illuminates when device is responding to valid address initiated ping from Mine Net System.
LED #10	Red, Blinking:	= RS-485 communication is active on system

Data Format

The Smart Reader follows AMR's standard protocol for data and messaging over RS-485.
RF Tags send the following information in each transmission:

1) Unique ID Number
2) Message Code (1 of 8 fixed messages)
3) Unit Battery Level (abbreviated to 1 of 4 states)
4) Unit Temperature (approximated to best linear range of ~ -10degF to + 145degF)

Messenger Units send the following under periodic "Sync" function

1) Unique ID Number
2) Status Information (Memory, Data Base Update, Op Mode, Time, etc)
3) Battery Level (abbreviated to 1 of 8 states)
4) Message to Send / Last Received
5) System / Update information

Each transmission to the Mine Net System also sends the Smart Reader's internal temperature, battery status, operating status, and other variables. Transmission to the Mine Net System begins with a valid address poll from the Mine Net System software. Response takes precedence over other internal functions. Response contains the number of tags that have been recorded, the number of messengers that have sync'ed. Then the data stream continues with the details of the tag receptions and messenger data packets. A "Master Surface Smart Reader" will typically have extra software in it tied in with the Mine Net System for functions specific to messenger operations like periodic updates of its memory data base, graphics data base, time, and other parameters.

Smart readers also manage data flow. RF Tag inputs are routed into a fixed format to be converted to a RS-485 friendly format for communications to the Mine Net System. Similarly, inputs to the Mine Net System regarding messenger functions have a different format for uploading. Further, the same syntax allows a message generated at the Mine Net System (or other Smart Readers) to be sent to the applicable Messenger Channel for transmission.

Each message has a fixed format allowing communication with Smart Readers (to the Mine Net System software), and other Messengers. A packet consisting of start bytes, data / status bytes, and variable length message body bytes is sent for every message. A Messenger unit will also send a periodic 'Sync' or 'Ping' message to allow for timing synchronization with Smart Readers and other units. This Sync is the same format without a message and serves as a tracking source as well. The Smart Reader will accept these packets and re-transmit them to the Mine Net System base. Similarly, data sent from the Mine Net System will either go to an individual reader or to all of them with messages to be broadcast. During Messenger transmissions, the reception functions of collocated channels are temporarily suspended as part of measures to limit data reflections, similar to functions provided in the Messenger.

Memory Functions

Each Reader will store the last 10 received messages, the last 10 sent messages in non-volatile memory. Additional incoming messages will be saved in higher memory, up to 12 messages or as determined by the version of software inside the unit. Memory use for RF Tag data patterns are much smaller and are stored in RAM areas. There are two memory modes the device will operate in: Standard and Extended. In standard memory mode, data requirement levels are low and most is kept in the main OBC microcontroller module in RAM for fast poll-and-response turnaround. Once a maximum RAM memory section has been exceeded, extended memory operation is initiated and data is shared between non-volatile EEPROM and secondarily stored in the peripheral microcontroller's RAM memory banks. This dual operation allows faster response and system communication and lower power use in the typical case, but provides a wide reserve for times of high usage (such as multiple mantrips passing).

Mine Implementation

The Smart Reader is an intuitive communications portal between the Mine Net System and RF Devices, and should not present any difficulty in understanding its operation. The two largest hurdles to proper operation consist of switch setting and external connection and may be considered it plug-n-play after that. Proper wiring and address selection was discussed earlier and should only be done by qualified personnel. Additionally, the job of the Smart Reader is to interface with RF devices in many areas, hence the redundancy of antennas.

The four antenna ports at the bottom of the unit allow direct antenna attachment or attachment through a variable length coaxial cable. Several antennas are available for the units by AMR. It is important to match the correct color tip/marker with the correct frequency application:

BLUE = 418MHz = Messenger GREEN = 315MHz = RF Tag Receiver

A ZONE is where a Smart Reader is located. SUB-ZONES are established at the center of the applicable antenna (its effective radius). Each Zone (Reader) has up to 4 Sub-Zones (antennas). Depending on antenna Placement, sub-zones may overlap each other. This is fine for operation but may create inconsistency in tracking visualization.

Also important is the role of extension cable attenuation to zone establishment. An antenna will receive and radiate RF signals as expected, but poor connections and longer lengths of extension cables will reduce the ability to transmit and receive, effectively reducing the range and sub-zone radius. Extension cables provided by AMR are RG-58 and Low-Loss RG-58. Normal RG-58 co-axial cable is more flexible and easier to install, splice, and route in odd places, but does have a slightly more lossy rating. This RF signal strength is only noticeable when running more than 100ft. The range will be reduced proportionately to length, but is not always predictable due to other mine conditions and connectors. Low Loss RG-58 is recommended in extension cables of 150ft or longer. Lengths of up to 350 ft have been tested with decreased antenna range, longer lengths are possible.

Blinking green lower level (horizontal) LEDs for Ch 1-4 are useful locally to test extension cable effective range at t he antenna. Limit the number of active RF Tags to 2-5. Place them on a person that walks away from the antenna and away from the cable. When the consistent blinking of that channel ceases, you may roughly establish the effective radius. This distance is also dependant on ceiling height, local metal objects, orientation, and other factors. Establishing Sub-Zones for proper coverage is not fully covered in this manual. Please refer to AMR Sales for proper installation and implementation planning.

Mine Operators and Safety Personnel may want to schedule or present some of the emergency functions of the device as part of safety briefings especially in areas of emergency beacon activation, Fast Keys use, and the many advantages of utilizing Extended Memory (if installed).

Contact AMR with any questions on installation or operation.

Appendix A

Auxiliary System Components

Auxiliary System Components Description:

1) Model XXX 315MHz “Rubber Duck” Local Sub-Zone Antenna with 10ft extension
2) Model XXX, 100Ft Extension RG-58 Cable (w/ M/F end Connectors)
3) Model XXX, 315MHz AMR “T” Type 315MHz Dipole Antenna
4) Model XXX, 400Ft Extension Low-Loss RG-58 Cable (w/ M/F end Connectors)

Appendix B

Detailed Performance Specification Sheet

Physical:	
Weight (without Antennas, Cable, Battery)	XXX 23 oz
Size	XXX
Enclosure	Fibrglass NEMA-4 Rated
Front Panel	Polycarbonate w/ SilkScreen
RF Transceiver:	
Linx Technologies RF Product #	TRM-418-LT
Frequency (OOK Modulated)	418MHz +/- 50KHz
Peak Radiated Output Power (During TX / High)	+9dBm / 8mW
Average Radiated Output Power (During Active Period)	+6dBm / 4mW
Radiated Output Power (During Sleep/Low)	<60dBm / <1nW
Harmonic Emissions	> -36dBm
Sensitivity	<-118dBm
RF Receiver	
Linx Technologies RF Product #	RXM-315-LR
Frequency (OOK Modulated)	315MHz +/- 50KHz
Sensitivity	<-118dBm
Battery Power:	
Battery Pack Mounting	Soldered
(Consists of 8x AA NiMH Rechargeable Cells and output power limiting stage)	
Sanyo NiMH (8 Cells - sealed with power limiting stage)	HHR-210AA/B2B
Primary Current Limiting	15 Ohm, 10W Resistor
Open Circuit Voltage	~10.2V nom
Short Circuit Current	~ 680mA
Maximum Inst. Output Power (@ 15 Ohms)	~1.74W
Active Transmission (in transceiver):	
Period	6 sec (+/- 0.5sec) typical
System Synchronization Duration	~10 msec
Maximum Message Transmission Duration	~58 msec
Typical Active Duty Cycle	1 / 100 (1%)

Battery Life:

Capacity (each 1.2V Cell)	2000mAH
Sleep Mode (Used in low power situations)	<10mA *
Normal Mode	~25mA *
Active Mode	~15mA-20mA *
Expectancy**	>48-60 Hours on Low Power Mode

A Total Time of over 100 hours is provided by a combination of IS Smart Reader and Smart Repeater battery capacity

Recharging:

Full Charge during trickle at 15mA from discharged	100 hours
Quick Charge (OK for Pulsed jump start, <10% capacity to start)	10 hours
Peak Charge Current	100 mA
Maintenance Charge Current	15 mA

* = Battery Drain Current (Prior to internal power converting electronics)

Installation Manual

The following will instruct users on the proper installation of the Smart Reader as part of the AMR Mine Net System based on 4 conductor copper (dual twisted pair) cable. Only properly trained individuals should attempt installation of the device. Although AMR Mine Net System power and communications lines are protected, it is recommended that power and communications be temporarily turned off at the nearest repeater/splitter or removed during installation. "Hot" installation is possible with great care not to short wires together or to metal objects in any combination.

A) Equipment:

1) Smart Reader, (Battery optional)
2) 315MHz antennas (and associated extension cables, if necessary)
3) 418MHz antennas (configuration dependant)
4) 2-5 RF Tags (for testing)

B) Tools Needed:

1) Digital / analog multimeter
2) Hand wiring tools, strippers, screwdriver, flathead micro-screwdriver
3) Associated wire termination hardware (spaded lugs, etc)
4) Extra wire, tie wraps, or similar hanging mounting method

C) Identification

1) Identify location of reader mounting, should be away from high traffic areas, facing a travelway, ceiling or eye-level mounting is helpful for installation, troubleshooting, and routing of antennas/extension cables. The location of the reader establishes its Zone. The location of antennas establishes one of four Sub-Zones.
2) Identify distances to Sub-Zones and applicable extension antenna cables.
3) Identify the cable to use, by splice or as an end point, allow 2-5 feet for flexibility.
4) Identify applicable system cable individual connections. It may be helpful to cut, separate and measure individual wires' voltage to verify the function and assignment of cables while "Hot" prior to intricate wiring procedures, then cut off exposed wire before inserting into enclosure.
5) Typical wire assignments are below. In some cables there is a bare shield line.

TB Position	Wire Assignment	Wire Type (Typical)
1	POS/A Data	16 AWG Black
2	NEG/B Data	16 AWG White
3	Power +	12 AWG Red
4	Power-Ground	12 AWG White
5	Shield (bare)	16-22 AWG bare.

D) Wiring:

1) Temporarily mount enclosure by hanging by wire / tie wrap from higher attachment point in a dry well lit place (if possible), open enclosure front panel, disconnect primary orange 5-pin connector.
2) Insert the source/system side of the cable into top access port, watch for exposed wire contacts if "Hot", pull through ~1 ft.
3) Strip and attach +V / Power wire to center position (3) on right terminal block, use terminal lugs or insert wire into terminal clamp, tightened to firm not over tight.
4) Strip and attach GND / Power wire to position (4) on right terminal block
5) Strip and attach +Comm/A wire to the top position (1) on right terminal block
6) Strip and attach -Comm/B wire to position (2) on right terminal block
7) Attach the shield conductor.
8) When attaching cable to the lower access hole, follow the wiring procedure for 1-7, be careful that there is no danger of overloads or shorts if the end of the cable being connected is in an uncertain state.
9) "Neaten" stripped wire cable within enclosure, pull out spare length
10) Re-attach twist on cable/housing connectors.
11) Attach antennas / extension cables as needed. Do not stretch or put force on the antenna cables. Loop though a tie wrap at the base or similar nearby attachment point as a strain relief.
12) Hang enclosure, cables, and antenna cables out of travelway as much as possible. Hang antennas in useful areas where they cover the most area (test with 2-5 tags) while not prone to being damages.
13) Terminate communications lines as required if at a comm. end point with 120 Ohm resistors, these can be wired into the first two positions of the orange 5-Pin connector inside the farthest Smart Reader.

E) Testing:

1) Set internal switches according to specific installation requirements including operating mode and unique address; same addresses will create comm. failures.
2) When all wires are tested as assigned, and all ends accounted for, apply power to system **THEN** re-attach 5-Pin Orange connector to main board.
3) Observe unit function, Start-up sequence, LED response to configuration and power levels, use 2-5 RF Tags to determine Sub-Zone range.
4) When testing is complete, close panel door, and hang securely.
5) Observe / record local tag interaction at the base station, record typical ranges and other applicable performance specs.
6) Adjust extension cable / antenna locations for optimal coverage, in some high speed traffic areas, double coverage by placing sub-zones in near proximity (~150ft) along the direction of expected travel may insure reads.

F) Helpful Hints:

1) It is best to wire from the very end of a string or a chain of Smart Readers to its primary power point, especially when "Hot".
2) Check voltage at the farthest point away from the primary power source to maintain proper voltage. Lower voltages indicate that a Repeater/Splitter may be required to boost comm./power levels.
3) A few feet (or more) of spare cable length / coils will help in expansion and repositioning that may be required.

G) LED Operations and Indicator Description:

Vertical LEDs:

Power LED	Green	= Primary Power is 'ON'
	Blank	= Off
Line Power LED	Green	= Good, above warning threshold
	Orange	= Fair, between low and normal operation
	Red	= Low, below normal operations threshold
	Blank	= Off
Battery LED	Green	= Good, above warning threshold
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	Blank	= Not Connected or extremely low
Comm LED	Green	= Communications are good, TX/RX Often
	Orange	= Comm is active, address not polled in >30 seconds
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Horizontal LEDs:

Ch 1-4	Green (for 0.5 sec)	= Channel registered at least 1 valid RF TAG input
	Orange (for 0.5 sec)	= Channel registered at least 1 valid Messenger sync.
	Red (Blinking)	= Comm momentarily failed with circuitry
	Red (Continuous)	= No communication with channel circuitry
	Blank	= Channel is responding normally, no valid inputs
	Red (2 Left-2 Right Pattern)	= Peripheral IC not being updated by main controller, it may be locked up or dead, attempts to restart processor will be done

Internal LEDs:

LED # 9	Red, Pulsing	= Illuminates when device is responding to valid address initiated ping from Mine Net System.
LED #10	Red, Blinking:	= RS-485 communication is active on system

Troubleshooting Guide

Applicability

This Troubleshooting Guide in intended for AMR's IS Smart Reader as installed on its 4 conductor copper dual twisted pair Mine Net System and is not applicable to other units or applications. This guide can be used with both line powered Reader enclosures and AC powered data repeater enclosure with on-board Readers.

Introduction

The Smart Reader is a self-contained communications portal between a Mine Net System base station and its software and AMR RF devices intended for underground mining operations. The Smart Reader consists of three circuit boards and an optional battery pack. This guide then serves to narrow down possibilities of error causing conditions and possibly solve the issue without removing the device from service. The goal of this guide is to determine possible sources of failure to the level where it becomes operational or the most likely culprit requires a board or battery change. No field repairs of the electronics with the exception of changing PC boards or fuses is supported or recommended. Such failures require the enclosure or suspect boards to be sent to AMR for diagnostics and repair if needed.

Generally, upon new installations, check wiring assignment, switch settings, and connection as required by the "Installation Manual". Then 'beep-out' the three green fuses on the back panel board to see if they are blown, replace as necessary. Upon failure after successful operation, test line levels, fuses first then feel for any warm areas or components. In the case that the unit is running a test mode, or the antenna board is unplugged, responses are covered in the main Operation Manual.

When diagnosing this device, the general approach is to review what it should be set to, what it's doing, and what it's not doing. There is no need for board level diagnostics. Further, if there is evidence or the suspicion of heat in any of the components, verify with safe and precise means. In this device, no components should be hot or even warm. If such a condition exists, it should be removed from service and sent for repair.

Problem/Symptom:	**Course of Action**
No Unit operation and no external LED indication and no internal LED	1) Verify system power upstream is active, observe state of downstream units. 2) Open the enclosure, verify that the main 5-pin orange power connector is inserted into the matching socket correctly and that the wires are inserted in the correct slot and are firm. 3) Use a digital multi-meter (DMM) to test for source voltage between terminal ground and terminal power. It should be from 9 to 19 volts. If there is voltage, "beep out" the fuses, replace as necessary. 4) Check battery voltage, it should be 7.8-10V, if below 7 volts, it needs a charge and it may have been powering the enclosure in lieu of external line power. 5) Beep out (check for continuity) between all connector wires at the orange connector and the terminal blocks, repair any "opens".

6) If at this point, proper voltage appears between a ground point and the "+24V" slot on the orange connector and it is firmly and correctly in place, there seems to be an internal error on the board. Attach the black / negative lead to the DMM at the pin marked G in the upper right corner and carefully test voltage at the pins of J7 and J4. If their voltage does not match the expected result, the board itself is suspect.

No Unit Operation but LEDs are illuminated

1) Use DMM to "Beep Out" test both communication fuses.
2) Observe LED 10, it should be blinking in sync with the communication protocol, if it is, the data is at least getting onto the board.
3) Check the address of the device and that the switches are 'locked in' to the desired settings to insure the settings match its assignment at the Mine Net System base station. Remember, switch position 4 is the 'hundreds' value.
4) Change U9 if primary communications IC is suspect -- insert into socket correctly or send OBC board to AMR repair department.
5) If there is no LED10 illuminated (even dimly) check for connections and proper bias voltage across the comm. lines.
6) If bias voltage is between 0.5 and 1.5V (typical) at the orange connector and at pins 7 and 6 of U9, the problem is on the OBC board and needs to be sent in for diagnostics / repair.

No Antenna response to nearby RF devices, LEDs are blank (not red)

1) Test that antennas are present and that the cables (if any) are properly installed. If testing with a cabled channel, remove cable, insert a correct "Rubber-Duck" and observe, if works, test / replace cable.
2) If there is a response to the Rubber Duck" Antenna, reattach extension cable.
   A) IF a Tag channel, hold 2-3 RF Tags on antenna cable to see if its channel blinks green, the problem is most likely along or at the other end of the extension antenna, possibly at the far connector --replace if suspect.
   B) IF a Messenger channel, hold device close to antenna to see if it received a sync pulse (blinking orange) for 20+ seconds, the problem is most likely along or at the other end of the extension antenna, possibly at the far connector -- replace if suspect
3) Travel down extension cable with device next to cable, observe when signal is lost. Normal reads are 1.3 seconds for tags and 5-10 seconds for messengers. Replace antennas / extension cable.

Unit works for a while and quits

1) Suspect no line voltage and decaying battery life, test with a DMM for line power, and battery pack voltage. Applying line power will recharge the battery over time.
2) If battery is over-discharged (a level below 5 volts), it needs to be replaced

Bottom LEDs blinking alternately in pairs	1) The " train crossing " signal of the bottom row of LEDs indicates the main processor is not responding. It will try to reset it occasionally. No operation or communication is possible in this state. Unplug the primary orange connector for 5-10 seconds, reattach, observe start up sequence. If no sequence, repeat then replace the board. 2) The antenna board (the board normally assigned to these LEDs) is not necessarily broken in this state.
No LEDs, Faint Top Green	1) The unit is in low power operation due to loss of line power or request by the Mine Net System to enter that state. If the device is operational, observe the internal LEDs and updating presence from the base station to verify.
Single Channel LED is Red blinking continuously or Single channel not responding	1) A single channel indicator (the bottom row of the LEDs), shows the status of each channel's RF/microprocessor. If it is Red, then the system has a 'no response' from that channel. In some cases, the channel is turned off on purpose and should be marked as such. 2) If the channel is expected to work or did previously by blinking green, or orange or being clear, then the channel has failed. Failed channels are not an antenna issue. If the channel failed, it is not useful and the antenna board needs to be replaced.

Diagnostics Details:

J7:	Pin 1	~3.3V	J4:	Pin 1	GND
	Pin 2	~5.1V		Pin 2	~Source Voltage
	Pin 3	~4.3V		Pin 3	Recharge Ref
				Pin 4	Recharge Voltage across 1 Ohm

J1	Pin 1	+Line / Vin, ~12-19V (marked as +24), maximum normal voltage is 36V.
	Pin 2	GND
	Pin 3	+Battery Pack Voltage, ~ 7.8V- 11V, 10.8 nom
	Pin 4	-Comm / B (RS-485)
	Pin 5	+Comm / A (RS-485)

Additional conditions may exist in normal operation or during non-documented failures. We strive to provide the latest findings of field issues. A list of the current IS Smart Reader "**Troubleshooting Guide**" is downloadable on our website: ***www.AmericanMineResearch.com/SmartReader.***

Items for repair can be shipped to:

American Mine Research
12187 N. Scenic Highway
Rocky Gap, VA 24366
Attention: Repair Department