MineNet

Tracking and Communication

System Troubleshooting

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American Mine Research Inc. P.O. Box 234 Rocky Gap VA 24366 (276) 928-1712

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Section 1 -- Cable Measurements and Troubleshooting

1:1 -- Voltage

The MineNet system operates with a DC line voltage of 14 volts which originates from the *253-0402* repeater card and travels inby on copper to power the Line-powered Readers. This voltage will decrease over distance which causes the need for limitations on cable lengths and devices powered from one repeater. There should be no more than 5,000 ft. of cable and 5 Line-powered Readers on any repeater output or "branch." After this point it would be necessary to add another repeater to boost DC voltage and recondition the data signal.

The DC voltage output from the repeater should measure 13 to14 VDC with nothing inby hooked up. If this voltage drops quickly to below 12 VDC as you add one reader at a time, this suggests a power supply problem or a bad repeater card. Remember that in a bi-directional system, you cannot simply change to a different port on the repeater because each output port behaves differently and they are not interchangeable.

The chart below shows expected voltage measurements at the open end of any given piece of cable connected at the other end to a known good repeater:

Wires	Expected Measurement
Black -- Red	12-13.5 VDC
Black -- White	2.6 VDC
Black -- Green	2.1 VDC
Black -- Shield	0 VDC

If you find discrepancies with the above values, first check your cable lengths and number of devices on the line to ensure they do not exceed the suggested limits. If this is not the case, check the cable in the shortest sections possible to try and identify a bad piece of cable or possibly a splice or connection causing problems.

1:2 -- Current

Current flow through the cable can be inspected in two ways:

1) Placing an ammeter in-line to measure while underground
2) Using the data reported back to MineNet by looking at the current draw for each individual port on the *Repeater Status* screen

One Line-powered Reader will have a current draw of approximately 15mA when communicating. Using this fact, you can calculate roughly what current to expect in a given "branch" or area between two power sources. Simply take the number of readers installed in that section and multiply it by 15. This will give you the approximate current draw expected. For example:

4 line readers **x 15**mA per reader **= 60**mA draw

Note: This 15mA value will vary slightly in different situations but can be used to generally estimate current draw for troubleshooting.

If the measured current in the cable is much greater than the expected current, the cable may have a short or there may be a faulty device installed. This problem can be located by starting at the most outby device in the branch and checking each device and/or section of cable by unhooking everything inby that point and measuring again.

If the measured current is much less than the expected current, the cable may be partially "open" with a bad connection or splice. There could also be a problem with the power supply or repeater output port.

1:3 -- Resistance

Using a 120 ohm terminating resistor, disconnect a section of cable at both ends and connect the resistor across the wires in question on one end of the cable. The resistor will give you a reference value to measure at the other end of the cable. If you only short two wires together and try to measure them on the other end, it could be possible to have another short that would go undetected.

With the terminating resistor in place, measuring the cable accurately will require you to add the resistance of the cable itself to the 120 ohm resistor. As a rule of thumb, for every 1,000 feet of 12 AWG cable (black and red) add 3 ohms of resistance. For example: 120 ohm resistor at the end of 3,000 feet of cable should measure about 129 ohms. If working with data lines (white and green) which are 16 AWG, add 8 ohms for every 1,000 feet.

If the measured resistance is much greater than the expected resistance, the cable may have a “water-ground” or an “open.”

If the measured resistance is much lower than the expected resistance, the cable may be shorted.

Another possible cable problem occurs when the shield wire gets shorted into the other wires. This is not very common, but still possible, and can cause either power or communication problems depending on the wires involved.

While a section of cable is already disconnected at both ends, measure with an ohmmeter between the shield and the other wires. Everything should read completely open in this situation.

Section 2 -- MC-4011 Troubleshooting

The MC-4011 provides the interface between computer software and underground equipment in a MineNet system. Follow these steps to confirm correct operation of this device:

1) **Verify that the computer recognizes the MC-4011.** With the MC-4011 turned on, check that the computer can "see" it by moving the mouse to the bottom right of the screen on the taskbar. You should an *Eject Hardware* icon. Left-click this icon once to see a list of things currently hooked to the computer. The MC-4011 should appear in this list. If it does not, unplug the USB cable from the computer and plug it back up into a different USB port. If the computer still does not detect the MC-4011, the device may be bad.
2) **Ensure that the device has power.** If no lights come when the switch is turned on check the fuse inside the device on the power supply board.
3) **Check the DC voltage outputs of the device** Use a meter to check the outputs on the back of the MC-4011 for the following voltages:

27 V	27 VDC
A,B Com +	2.7 VDC
A,B Com -	2.2 VDC

If the measured voltages do not match the expected voltages, check the fuses inside the device located on the *253-0414* board. You can also remove the wires from the connector and measure again with no load to see if the MC-4011 is the problem or the device it is feeding.

Section 3 -- Fiber Optics

AMR's MN-6000 MineNet system uses fiber optics to link the outside equipment to the equipment underground. This technique provides a barrier for lightning as well as gives flexibility with installation because of the added distance capability of fiber.

3:1 -- MN-6012 Fiber Unit

The MN-6012 is installed outside near the MineNet Master Station and is used to take data from the MC-4011 and put it on fiber to be sent underground. It contains a *253-0409* fiber card and has an 110VAC adapter to provide power to the unit. The data input for this device will consist of the white and green data wires hooked to the MC-4011 along with the black DC ground wire.

Section 3:2 will cover troubleshooting of the *253-0409* board but you also need to check the following items when inspecting a MN-6012:

1) **Ensure that the unit has power.** Ensure that the AC adapter plug has not come loose on the side of the unit.
2) **Ensure that the data and fiber connections are secure inside the unit.**
3) **Check that the data wires are securely connected on the back of the MC-4011.**

3:2 -- 253-0409 Fiber Board

The *253-0409* board will be found inside the MN-6012 unit outside and also inside the MN-6020 units installed just inside the mine. This board is the beginning and end of the fiber link between outside and underground devices.

Following are a list of steps to take when checking this device for proper operation:

1) **Check for 6 VDC power input.** Use a meter to measure the DC voltage into the board at connector J2 to ensure that it is approximately 6 VDC. If the measured voltage is lower this could indicate a problem with the board or with the power supply. You can unhook the connector from the board and measure it directly to see if the voltage is low without a load or if the board is pulling it down.

2) **Measure the communication voltages at the board.** Use a meter to measure the DC voltage of the com+ and com- wires with reference to ground. Use the table below for the correct expected values.

Wire	Description	Value
Com+ (White)	In 6012 or 6020 with unbiased repeater	2.7 VDC
Com+(White)	In 6020 with biased repeater	2.6 VDC
Com- (Green)	In 6012 or 6020 with unbiased repeater	2.2 VDC
Com- (Green)	In 6020 with biased repeater	2.3 VDC

Note: These values are approximate and may vary slightly

If the measured communication voltages do not match the above values, this could indicate a problem with the MC-4011 if measuring a MN-6012. It could also indicate blown fuses or a repeater card problem if measuring inside a MN-6020. In order to determine whether the variation in voltage is caused by the fiber board or another device, unhook the communications plug and measure at the plug if working with a MN-6012. If measuring inside a MN-6020, unhook the communications plug and measure the values directly from the board. This will help determine if the fiber board is causing the variation in voltages or if another device is the cause.

3) **Ensure that the fiber optic connectors are securely in place and that they are hooked up properly.** Remember that the strands of fiber must be reversed at the underground *253-0409* board. For example: if the blue strand is hooked to the transmit (Tx) outside, it must be hooked to the receive (Rx) underground.
4) **Look at the lights on the 253-0409 board to confirm operation.** These lights can help you diagnose a problem as well. The two lights closest to the communications connector indicate activity between the board and the MC-4011 if outside, and the board and the repeater if underground. The transmit (Tx) and receive (Rx) lights located next to the fiber connectors indicate activity on that fiber line. If you are outside looking at the board and the Tx light is blinking but the Rx light is not, this indicates that the board is transmitting data underground but is not receiving any data back. Therefore, you should inspect the fiber board at the other end as well as the cable between the two to determine where the data is being lost.

Section 4 -- MN-6020

4:1 -- 253-0402 Repeater Board

The *253-0402* Repeater Board is located inside the MN-6020 and is used to recondition and re-transmit data as well as supply a new 14 VDC to the line running inby from its output. It can be configured for a "tracking only" or "tracking and communications" system. Use the following steps when troubleshooting this board:

1) **Ensure the board has the proper firmware for your system type.** The small red board sitting on top of the repeater board can be thought of as the "brain" of the board. It should have a label on the processor chip indicating the firmware version installed. In a *tracking only* system, this module should have "Rev. H" firmware. With a *tracking and communications* system, it should have "BD Rev B" firmware.
2) **Ensure the address is correct and the repeater is communicating.** The *253-0402* board can be addressed from 1-99. Ensure that the address set on the board matches what has been enabled in MineNet. Observe the *TX IN* and *RX IN* lights on the right side of the board. They should be flashing rapidly if the board is communicating with MineNet.
3) **Check that the outputs have been properly allocated.** With "Rev. H" firmware installed, each output port of the repeater can be used independently to split the system three different directions if needed. In a bi-directional system with "BD Rev. B" firmware, Output 1 is always used to continue the system inby. Outputs 2 and 3 must have the data wires tied together between the two as follows: Output 2 com+ tied to Output 3 com+, Output 2 com- tied to Output 3 com-.
4) **Check the 6 VDC input.** Use a meter to measure the 6 VDC input. It should measure approximately 5.8-6 VDC. If the measured voltage is low, unhook the connector and measure without a load to see if the power supply board is functioning properly.
5) **Check the 14 VDC input.** Disconnect the three output plugs from the bottom of the board. Use a meter to measure the 14 VDC input on connector J6. It should measure approximately 14 VDC. Reconnect the outputs one at a time and ensure that the voltage does not drop drastically when any one output is connected. This would indicate a problem on that line.

6) **Check the 14 VDC output for each port.** Use a meter to measure each output for the correct DC voltages. Pins 1 and 2 are the 14 VDC output. Unhook the connector and carefully measure the pins directly to ensure that there is no significant loss from the input on J6 to the output. They should read the same value on the output as measured at J6. The voltage will drop slightly when the connector is hooked back up because of the load the devices place on the supply voltage.

7) **Check the data wires for the correct DC voltage on each output.** With the connector still unhooked, measure the data output on pins 3 and 4. They should read 2.6 VDC on pin 3 and 2.1 VDC on pin 4 with the negative meter lead on ground and the positive lead on the pin. These values will also change slightly when the connector is hooked back up. Pin 3 should always read 0.3 to 0.5 volts higher than pin 4.

Note: By taking measurements on the *253-0402* board with the connectors unhooked, you are trying to identify a problem with this board instead of a problem being caused by another device in the system.

4:2 -- Power Supply Boards

When testing the *253-0400* 6V and *253-0401* 18V power supply boards, it is important to remember that they rely on 110 VAC as well as the presence of a battery pack to operate properly. Use the following steps to confirm proper operation of these boards. The steps are the same for the 6V and 18V board. Some values will differ for each however.

1) **Check the AC voltage input on connecter J1.** With a meter, check that the AC voltage input measures 8-10 VAC for the 6V board, and 20-23 VAC for the 18V board.
2) **Check for a battery charge voltage on J3.** With a meter, check the DC charge voltage being supplied to the battery by placing the negative meter lead on pin 3 (Bat -) and the positive lead on pin 1 (Bat/CG) of connecter J3. You should measure a value of 7-7.5 VDC on the 6V board, and 20-22 VDC on the 18V board.
3) **Measure the actual battery voltage.** Disconnect J3 from the board and measure the actual voltage level of the batteries by placing the negative meter lead on the black wire of the plug and the positive lead on the blue wire. This voltage should be approximately 6 VDC for the 6V board and 14 VDC for the 18V board if the batteries are fully charged. If these measurements are low, do not be concerned. As long as a charge voltage is being supplied which we measured from step 2 above, the batteries should charge back to their full capacity. If there is no voltage on either connector, the *kill relay* may be tripped. Press and hold switch *S2* for 5 to 10 seconds and see if the relay kicks back in. If there is no voltage present on these wires and the relay is not tripped, this indicates a blown fuse or other problem inside the battery pack. At this point you would need to change the battery pack and send it to AMR for repairs.
4) **Measure the voltage being supplied to the repeater.** Use a meter to measure the DC voltage being supplied to the repeater on connector J4. For the 6V board, you should measure approximately 6 VDC. For the 18V board, this measurement should be approximately 14 VDC. If either of these measured voltages is low, unhook the connector and measure again directly from the pins of the power supply board. If the voltage is correct at the pins and then drops sharply when the connector is hooked up, this indicates a problem with the repeater board or possibly the *253-0409* fiber board if one is present.

4:3 -- MN-6020/ Troubleshooting Unit as a Whole

The MN-6020 can only operate properly when all of the individual components are working correctly and have the correct connections with each other. The following checks will ensure that the unit is working as a whole.

1) **Check that the 110 VAC supply and transformers are working correctly.** Use a meter to check the AC input on each power supply board. The 6V board should have an 8-10 VAC input and the 18V board should read 20-23 VAC. If these voltages are correct, there should not be any problems with the AC Power section of the MN-6020. If these voltages are not correct check switch *S1* as well as fuses *F1-F4*.
2) **Check the 6V and 14V DC supplies to the repeater board.** Use a meter to check that the outputs of the power supply boards are correct and are reaching the repeater board. If no voltage is present at the repeater board, hold in switch *S2* for 5 to 10 seconds or until the relay latches. If voltage is present but not correct, unhook connectors J1 and J6 from the repeater and measure the connectors without a load. If the voltage is correct at this point, hook the connectors back onto the repeater board and unhook the outputs of the repeater board. Measure the voltages again to see if a board is the problem or if the problem is on an output line.
3) **Check the data input to the repeater.** Use a meter to measure the DC voltage on the data lines at connector J5 of the repeater board. Place the negative meter lead to pin 3 of this connector, which is the isolated ground. Use the positive lead to measure pins 1 and 2. Pin 1 should measure approximately 2.6 VDC. Pin 2 should measure 2.1-2.3 VDC. If these voltages are not correct, check the fuses 5 and 6 located at the bottom of the enclosure under switch *S2*.
4) **Check the data and DC voltage outputs of the repeater.** Use a meter to measure the outputs of the repeater on the connectors J2-J4 across the bottom of the board. Measure again at the top of the corresponding fuse holders located at the bottom of the enclosure. By measuring at the top of the holder you are confirming that the fuses are good since the signal comes from the repeater board to the bottom of the fuse holder.

Section 5 -- Line-powered Reader

5:1 -- General Information

The Line-powered Reader consists of two main components: the OBC board and the antenna board. It is powered by 14 VDC supplied by a MN-6020 unit. Each reader is addressable from 1-199. No two readers can have the same address in a system. A reader and repeater can however have the same address because the MineNet software distinguishes between the two.

The reader has visible lights on the front of the enclosure to give the user a quick summary of information about the device. Below is a description of each of these lights:

Power -- if 14 VDC is present and the device is on, this light will be green

Ext. Voltage -- this light gives the user a general description of the DC voltage level present. A green light indicates a voltage range of 12-14 VDC. An orange light indicates 10-12 VDC. Red means that the DC voltage is less than 10 VDC. A reader can operate below 12 VDC but may begin working intermittently.

Battery -- the battery light will not be used.

Comm -- this light shows the status of the data communications with MineNet. A red light means no data is present. An orange light indicates the presence of data but the reader is not communicating. One cause of this could be that the reader is not enabled in MineNet. A green light indicates that the reader is communicating with MineNet.

Zone A through D -- these lights indicate activity on the antenna board channels. In a bi-directional system zones A and B are tracking ports. These lights will flash green when a tag is being detected on the port. Zones C and D are the messenger channels. These lights will flash orange when a message is sent through the port. A red light flashing on any zone indicates an error with the communications on that port.

The antennas connected to the readers are color coded with green and blue markings. These antennas are tuned for different frequencies and should not be interchanged. Green antennas are for tracking and should be connected to Zones A and B. Blue antennas are messenger antennas and should be connected to Zones C and D.

5:2 -- 253-0403 OBC Board

Before changing out a *253-0403* board, there are a few checks that can be made to ensure that the problem you are seeing is actually on the board.

1) **Measure the DC and Comm voltages.** Use a meter to measure the voltages on the back panel board. The chart below shows approximate expected values for these measurements.

Measurement	Wire	Expected Value
Com +	White	2.6 VDC
Com -	Green	2.1-2.3 VDC
+ VDC	Red	12-13.5 VDC

Note: These values are approximate and may vary slightly. All measurements are with reference to ground (black wire).

2) **Measure the voltages at the connector on the OBC board.** After you have taken measurements on the back panel board and determined that they are correct, measure on the connector (J1) and see if the values are the same. If the values are not the same check the fuses F1-F3 on the back panel board to see if they are blown.
3) **Check that the address of the reader matches what is set in MineNet.** Ensure that dip switch 1 (*plus 100 switch*) is set in the proper position for the address you are using. If you are using an address in the 100s range, the switch should be in the down position. Otherwise the switch should be up.
4) **Check that the address reported by the reader is correct.** This is done by making sure that the rotary switch settings for addressing are being read correctly by the OBC board. Near the center of the board you will see a six-pin connector (J6). Pin 3 of this connector is a test pin for the output of the 10's digit switch and pin 6 shows the output of the 1's digit switch. The pins are numbered as follows:

   1 2
   3 4
   5 6

   Place the negative lead of your meter on DC ground and use the positive lead to measure voltages on pins 3 and 6. The voltage range for each address number is given in the chart on the following page.

Address Setting	Low Voltage	High Voltage
0	0.0	0.06
1	0.32	0.42
2	0.6	0.7
3	0.85	0.95
4	1.05	1.16
5	1.22	1.32
6	1.36	1.47
7	1.48	1.58
8	1.6	1.7
9	1.71	1.79

If the measured voltage for a given number does not fall within the allowed range, the reader is reporting a different address than the one set. If you find this discrepancy you will need to send the board in to AMR for repairs.

5:3 -- Antenna Board

The antenna board must have continuous communications with the OBC board for proper operations. If this communication is broken there will be an “Antenna” alarm in MineNet that corresponds to the reader.

When looking at an antenna board, if all zones have flashing red lights, this usually indicates a problem with the communications between it and the OBC board. The first thing to check in this situation is the ribbon cable connecting the two as it can sometimes get pulled loose when opening and closing the door. If the cable is securely connected and all lights are still flashing red, change the antenna board.

If an antenna board does not seem to be detecting tags, first check the antennas and make sure that they are not connected to the wrong zone. Ensure a green antenna is connected to zones A and B. Physically inspect the antenna and connector for damage or loose connections. Next make sure that MineNet has the correct zone of that reader labeled with the correct location.

If an antenna board is not sending or receiving messages, first check that blue antennas are connected to zones C and D. Next check the antenna and connector for damage or loose connections. Finally, check the reader’s configuration in MineNet to be sure that is has the correct antenna board type set. In a system not using AMR text messengers, you will have type 4:0 antenna boards. This means that there are 4 tracking channels and 0 messenger channels. If you have AMR messaging, the antenna boards must be type 2:2. This indicates 2 tracking and 2 messenger channels. If a 2:2 antenna board is configured wrong in MineNet, it will ignore messages completely.

Section 6 -- MN-6215 P.A.D.

The MN-6215 P.A.D. or *Portable Acquisition Device* is used to provide tracking and communications in areas where cable is undesirable. These devices relay information to other P.A.D.s and also communicate with Line-powered Readers in order to get data onto the cable backbone and to the computer outside. If one or more P.A.D.s on a section are not functioning properly, use the following guidelines when troubleshooting:

1) **Ensure that the Section Reader is operating properly.** Check to see that the last reader on the line, also known as the *Section Reader,* is operating properly without counting multiple errors. If this reader is not functioning the P.A.D.s will not have a path to get data to and from the MineNet computer. In this situation you will most likely have several, if not all, P.A.D.s on a particular section in a "no reply" status.
2) **Check the antennas on the Section Readers.** The Section Reader could appear to be operating properly but could have one or more of its local antennas damaged or missing. This could cause P.A.D.s to be "no reply" or to not receive messages. Again this would have an effect on many or all of the P.A.D.s on a section.
3) **Check that the P.A.D.s configuration matches the configuration in MineNet.** There will be a guide for switch settings inside the device. Use this to ensure the configurations match. For example: if the P.A.D. is configured in MineNet as a *Mesh Pad*, the device should have dip switch 4 *on* and 5 *off*. Check the address, including switch 1 (plus 100 switch), to ensure it is correct. Also make sure that switch 3 is off if you are using the P.A.D.s for tracking and communications.
4) **Check the lights on the P.A.D.** As you approach a P.A.D. underground, notice whether or not the light on the front is flashing. If it does not flash until you are directly under the device, check the green antenna as it might be broken or loose. If the light continuously flashes red, this indicates the batteries are getting low. If no lights come on at all, this usually indicates the batteries are dead.
5) **Ensure "Line of Sight".** RF signals cannot turn corners very well. If you have a P.A.D. that goes "no reply" occasionally, look at the location of the device and see if it has a clear path to another P.A.D. Make sure it is not hanging around a corner or with most of its path obstructed. Also try to maintain a 2 foot distance between the device and any high voltage source.

Section 7 -- Using MineNet Software to Troubleshoot

7:1 -- Repeater Status Screen

The repeater status screen shows all data reported back to MineNet from any repeater in the system. If you have identified a particular area of the mine where equipment is not operating properly, first identify the repeater/repeaters that are feeding power and data to that area. Next click the repeater status button in MineNet and select the address of the repeater in question. From this screen you can see several important pieces of information.

- AC power status and DC supply voltages are displayed on the right side of the screen. An "AC Power Off" error will be displayed if the unit has lost its 110 VAC power supply. Also take note of the 6 volt and 18 volt DC supply voltages. If the 6 VDC value is too low, the repeater might begin to work intermittently or not at all. The 18 VDC value will actually be 14VDC if working properly. If this value becomes too low, the devices inby will not have enough DC power to operate.
- The remainder of the status screen is divided into three sections, one for each port on the repeater. These sections will tell you what the current draw is for each port, whether or not a line is open at the end or terminated, and also if the line is shorted. You can also turn power and data off and on independently for each port.

7:2 -- Polling Diagnostics

In a bi-directional system, use the following steps to help locate a problem underground such as a cable break or a faulty device.

1) **Poll the system in one direction**. In the MineNet software click the "*Configure*" button to open the configuration screen. Under "*Data Line Detect*" select "*Port A*" and then close the configure screen. This will poll the entire system in only one direction.
2) **Observe repeaters for problems.** Open the "*All Repeaters*" screen and reset the error count. Watch this screen for 3 to 5 minutes and observe the error counts as well the status of the repeaters.
3) **Note location of repeater problems**. Take note of any repeaters that are counting errors or that their status went to "no reply". Use the repeater description to determine the actual location of the repeaters in question.

4) **Observe readers for problems.** Open the "*All Readers*" screen and reset the error count. Watch this screen for 3 to 5 minutes and observe the error counts as well as the status of the readers.
5) **Note location of reader problems.** Take note of the physical location underground where devices worked up to but not beyond. Consider that the signal might have looped around the section and began its trip back out the other entry before a device goes "no reply."
6) **Poll the system in other direction.** Open the "*Configure*" screen again. Under "*Data Line Detect*" select "*Port B*."
7) **Repeat steps 2 through 5.**
8) **Compare locations of failures to determine cause**. Take the notes you made of the physical locations of where the problem begins and compare them with each other. You should be able to locate a point underground where devices worked up to but not beyond from both directions. This should be where you focus your attention underground first. Likely locations would be a working section where the redundant loop was not properly connected, or a section of cable between two readers with a bad splice or damage. Another possible location would be a repeater with an output not functioning properly.