TUNNEL RADIO
Leading the Way in Underground Innovation

ULTRACOMM®
SYSTEM MANUAL

FOR MINING & INFRASTRUCTURE

APPLICATIONS

Revised February 4, 2022

DISCLAIMER

***** WARNING *****

Read entire document before proceeding.

The communications system described herein shall be installed, operated, and maintained under the supervision of a MSHA-certified mine electrical superintendent and follow all State, Federal and MSHA electrical codes and guidelines as applicable.

This equipment will require periodic servicing to maintain correct operability. Such servicing and maintenance is the responsibility of the end user. This includes periodic inspection of power supplies and all connections. Not following said procedures may result in operational failure.

It is the user's responsibility to independently determine the suitability of the equipment and to test and verify the same. The equipment and information provided in this manual by Tunnel Radio of America Inc. (Tunnel Radio) hereunder is provided "as is, where is" and with all faults, and the entire risk associated with the information provided is entirely with the user.

In no event shall Tunnel Radio, its officers, directors, partners, members, agents, employees and assigns be liable for any direct, indirect, punitive, incidental, special, consequential damages, to property or life, interruption of service, accident, injury, death, damages or loss whatsoever arising out of or connected with the use or misuse of the equipment described in this document. User assumes all responsibility for the operation and servicing of the equipment and possible failure of the equipment.

If you have any questions regarding the use, installation, or service of this equipment, contact your local dealer or Tunnel Radio directly at:

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COMPANY HISTORY

Tunnel Radio of America, Inc., was formed in 1988 to meet the demand for better wireless communications in the underground mining environment. They installed the first reliable underground VHF radio system in the United States at Greens Creek mine near Juneau, Alaska, in 1988. This installation continues to operate today, having expanded many miles during the intervening years. Tunnel Radio also continues to expand its product line and reach, installing wireless systems in mines, dams, industrial facilities, and other enclosed spaces worldwide.

In 1993, Tunnel Radio launched their first railroad communication system, and have continued to expand our product line to meet industry needs. Tunnel Radio Link technology for Positive Train Control (PTC), Distributed Power and voice-based communications is being used by all the Class I railroads in America for their tunnels and other low-propagation areas.

Tunnel Radio is committed to providing reliable, high-performance, and cost-effective radio systems worldwide. Our engineering department is continually working to develop and refine our product line, in order to offer quality equipment perfectly suited to our clients' operational requirements. We believe in strong customer support and utilize in-house training of customer employees to provide basic servicing and system expansions.

Ultracomm wireless radio and data system clients include: Rio Tinto, Coeur Mining, Nevada Gold Mines, HECLA, Teck Resources, Morton Salt, Ford Motor Company, Army Corps of Engineers and others. Our innovative radio systems, along with tracking, diagnostics, and control systems have revolutionized underground communication.

SYSTEM SUMMARY

Needs

Two-way radios are used in almost every industrial activity, providing two-way communication for work crews, safety personnel, and administration. Unfortunately, underground mines and other enclosed environments by their nature block radio signals, preventing effective underground communication.

Some have tried to address this problem by placing hard-wired phone systems at strategic locations. The use of these systems has proven to be very cumbersome, and often does little to help in emergency situations. Other systems have been developed that rely on wireless hotspots, but still lack the necessary full radio coverage of an entire site.

Another important consideration is ease of system integration, since many industrial systems often require the use of radio channels for telemetry.

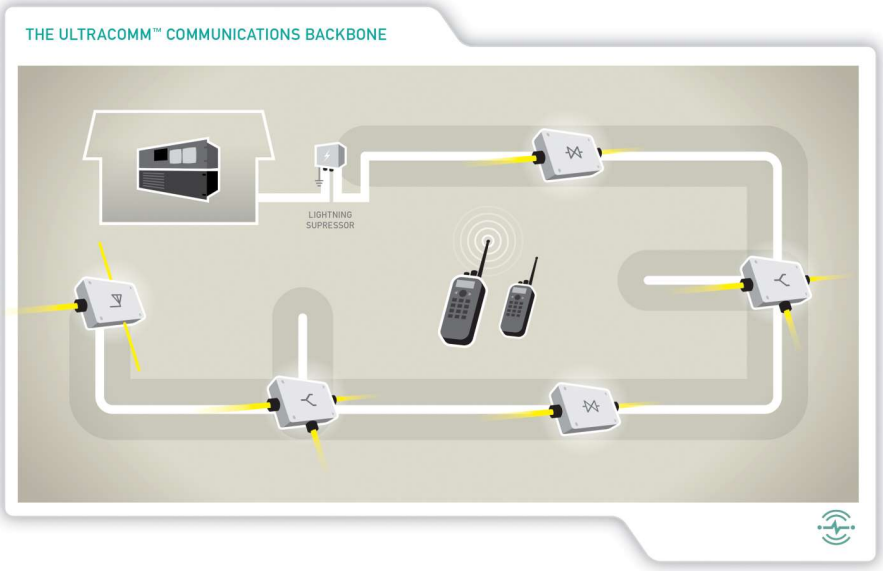
Solutions

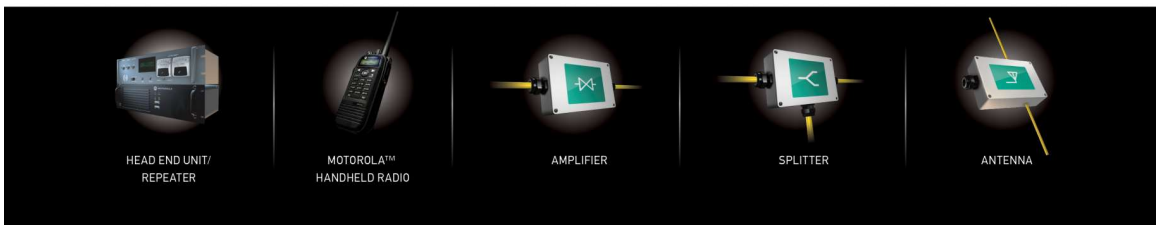
Tunnel Radio has developed the Ultracomm® radio system with these needs in mind. Ultracomm® is a leaky feeder radio system that can be installed in enclosed environments, providing two-way communication. This facilitates seamless radio coverage both above- and underground.

Leaky feeder is a well-established technology that provides continuous coverage by allowing the radio signals to "leak" from the entire length of the cable, much like a sprinkler hose. As radio signal strength diminishes towards the end of the cable, an amplifier is installed, boosting signal strength to support another run of cable. A number of amplifiers and cable runs can be added before requiring more power from the AC line. This makes the system very extensible, cost-effective, and easy to maintain.

Ultracomm is compatible with a wide range of radio systems and devices. It can be seen as the "backbone" system that supports and enables other radio systems. Tunnel Radio continues to develop a whole product ecosystem around the Ultracomm backbone, including personnel and asset tracking, system diagnostics, and more.

Tunnel Radio is committed to providing products with the best performance, quality, and support that meet customers' real-world needs. For more information, visit www.tunnelradio.com.





REASONS FOR ULTRACOMM®

THE BASIC RADIO

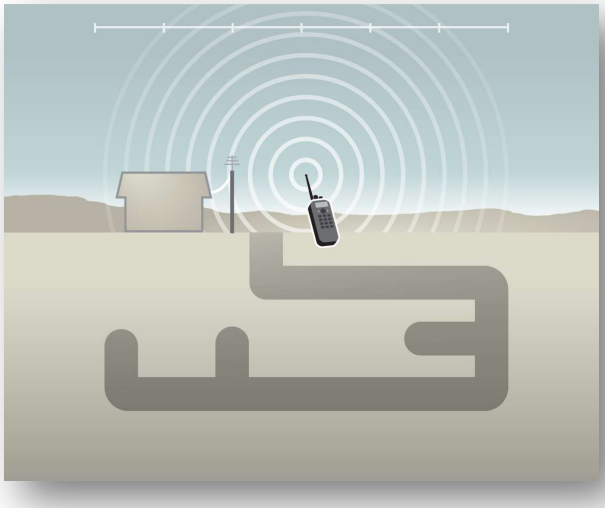
Simple and convenient wireless radio communication in the industrial environment improves both the safety and efficiency of operations.

Two-way radios are used at almost every industrial activity, and are available in mobile, stationary base, and hand-held portable configurations.

Computers can also be equipped with data radios to “talk” to each other.

RADIO RANGE

Typical radios can operate over miles or even tens of miles in surface operations.



A radio that may be able to operate over miles on the surface may operate only several hundred feet underground!

Underground range is affected by the height, width, and number of turns in the enclosed area.

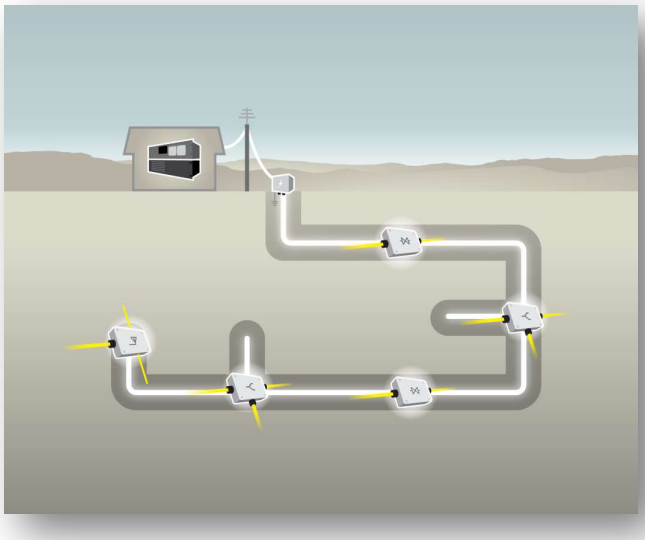
EXTENDING RANGE THROUGHOUT THE MINE

The Ultracomm® system extends radio coverage by emitting and receiving radio signals throughout a Leaky Feeder System (LF).

In radio terms, signals traveling on the LF from the surface down into the mine are called downlink signals.

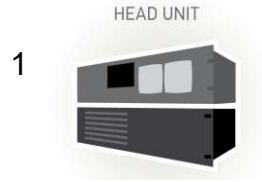
Radio signals coming from inside the mine toward the surface are called uplink signals.

By understanding the system components and knowing some simple terms and rules, you will be able to properly extend and maintain your Ultracomm® LF System.



UNDERSTANDING ULTRACOMM SYSTEM COMPONENTS

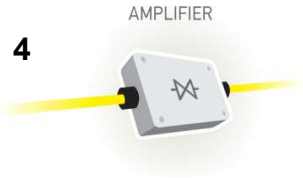
1. **Base Interface Unit (a.k.a. Head Unit)** – Communications bridge between surface and underground radio systems.



2. **Lightning Suppressor** – Protects underground components from lightning strikes.

3. **Leaky Feeder Cable** – Carries radio signals to and from underground areas, providing radio coverage wherever present.

4. **Amplifier** – Boosts weak radio signals back up to proper levels.

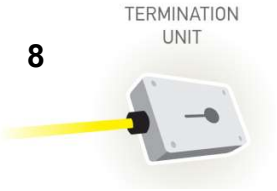


5. **Splice Box** – Joins two pieces of leaky feeder cable together.

6. **Splitter** – Forms a new branch of leaky feeder cable.

7. **Terminal Antenna** – Terminates leaky feeder while extending radio coverage.

8. **Termination Unit** – Properly caps a leaky feeder end point.

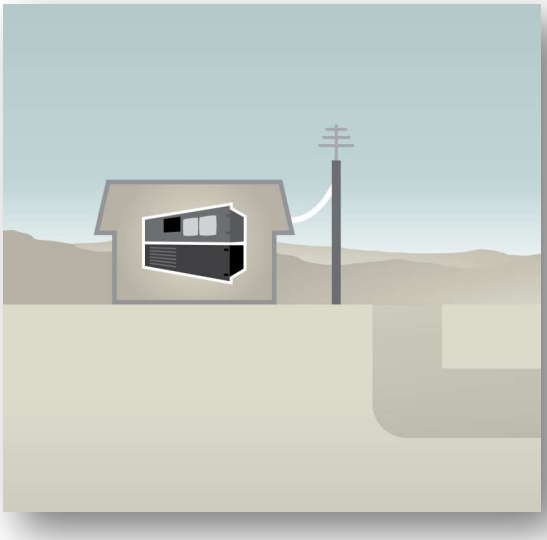


9. **DC Power Supply & Insert** – Provide additional DC power to extend the leaky feeder system.

SYSTEM COMPONENTS

BASE INTERFACE UNIT (a.k.a. Head Unit)

The Base Interface Unit acts as a communications bridge between the surface systems, including the base radio repeater units and ant2ennas, and underground leaky feeder radio systems. The BIU is typically located at the mine entrance where local AC power is available.



In addition to directing radio signals, the Head Unit also provides DC power to the first section of Leaky Feeder communications system. The BIU typically supports 4 radio channel pairs (some models support up to 8), and also includes support for Tunnel Monitoring System (TMS) diagnostics.

Tunnel Monitoring System (TMS) is a 2-way wireless data hardware and software module integrated into TR-160 and TR-560 series amplifiers. It allows the BIU to monitor the radio system amplifier condition and allows for operation of a data channel independent of the voice channels wirelessly within the amplified network. Amplifier and/or power supply conditions are captured to a display on the front panel of the BIU for diagnostic purposes.

Base Interface Unit - Front Panel

Back Panel Overview

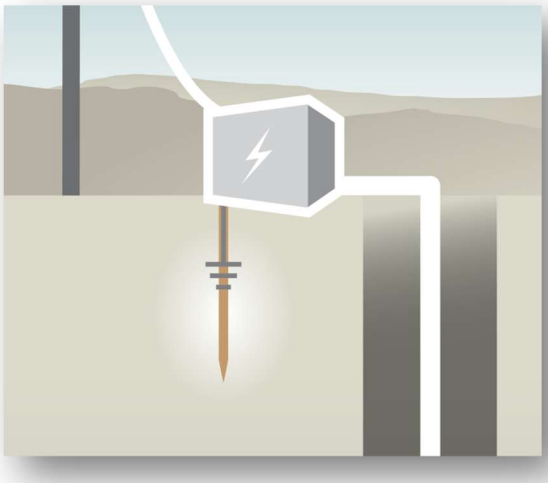
- **RFID Antenna:**
  Receiver for RFID Tags. Receives at 315 MHz
- **System Antenna:**
  Connects to an antenna on the surface for surface communications. All the repeater radios transmit and receive to a surface antenna. Output = +10dBm to surface antenna.
- **Branch 1 and Branch 2:**
  Leaky coaxial feeder connects to the branches. Signal is a combination of transmit and receive of all repeater radios on system. TMS diagnostics talks through here. The pilot (amp leveler) outputs through here. Output = 28V DC. Radio transmit = +5dBm. TMS = 0dBm. Pilot = 3dBm.
- **Ethernet (optional):**
  Allows TR Central, the remote access to TMS data information. Currently there is no Raspberry Pi device in head ends which is required for TR Central.
- **RS-232:**
  Talks to C5 card, the TMS Head card. It allows remote talking to amps and is also the interface to MineAx, TROA's tracking software.
- **Tx and Rx ports:**
  4-port or 8-port optional. The Tx ports connect to the transmit of the radio repeaters, at a maximum of 1W. The Rx ports connect to the Receive port of the radio repeaters.

The amplifiers have 2 transmit/receive ports for downlink and uplink communications.

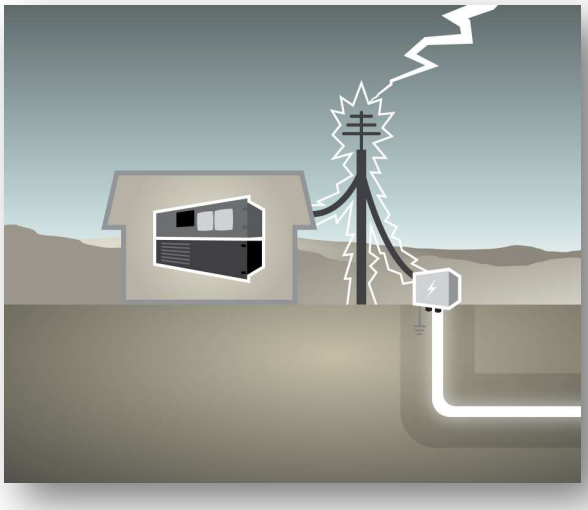
The gain in the amplifiers differs in each system and can be controlled via the Automatic Gain Control (AGC) in the amplifiers' firmware. Gains for the 560 and 160N are typically 28dB.

LIGHTNING SUPPRESSOR

The Lightning Suppressor is used to protect the underground communication system from harmful electrical storms, spikes and/or surges. It is positioned between the above-ground head-end unit and the underground components, at the point where the leaky feeder cable enters the mine.



MSHA requires lightning suppression at every installation, with minimally one suppressor unit per mine entrance cable.

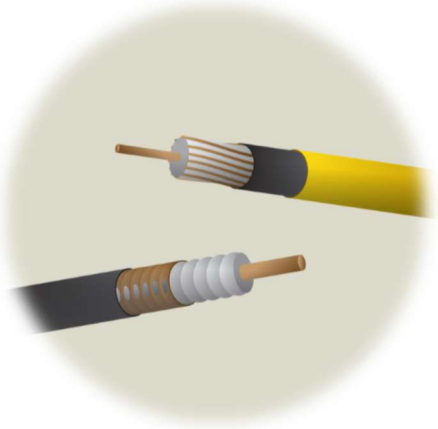


Suppressors provide protection from indirect strikes and should be inspected after any strike that occurs that may have affected the mine area. The devices are multiple-strike capable. Correct operation of the suppressor will depend on a quality ground path.

Proper grounding and maintenance of this ground is an END USER responsibility. Operation of this device is dependent upon such.

LEAKY FEEDER CABLE

Leaky feeder cable runs along the length of the tunnel to emit and absorb radio waves and must be installed wherever communication is desired. The cable is called "Leaky" because it contains openings in its outer shielding to allow signals to leak in and out of the cable for its entire length. In addition to radio waves, the leaky feeder cable also can carry DC voltage used to power attached amplifiers and diagnostic equipment.



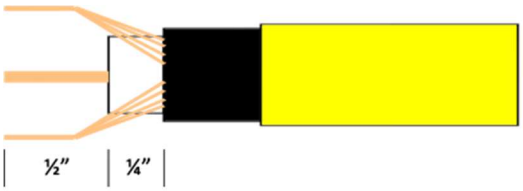
UHF Copper Radiating Coaxial Cable (Black Cable)

1/2" TR-1505-CBL-M Radiating Cable

This cable is an all-copper coaxial radiating cable that offers the lowest DC loss and best range characteristics.

VHF Radiating Cable (Yellow Cable)

The Leaky-Feeder (LF) Copper cable is a 9/16" diameter coaxial cable specially designed to carry RF signal and pass DC voltage. The outer conductor on this cable is an open braided copper which allows the RF energy to radiate off the coaxial cable. It comes in 1120' (350M) or 1650' (500M) spools and interconnects the components of TR-160-PLUS VHF amplifier systems.

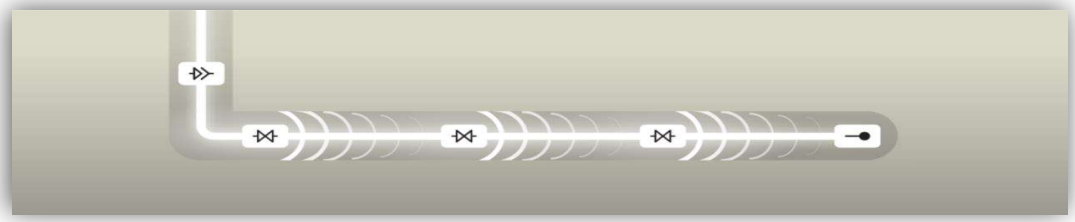


Double Sheath Leaky Feeder Cable TR-1501-CBL

Coaxial Cable Parameters

Cable Type	Signal Loss (Attenuation)	Coupling Loss	Cable Impedance
TR-1501-CBL	1.5dB/100ft @ 150MHz	65dB @ 20ft	75 Ohm
TR-1505-CBL	1.74dB/100ft @ 450MHz	=<60dB@ 20ft	50 Ohm
TR-1505-CBL-M	1.74dB/100ft @ 450MHz	=<60dB@ 20ft	50 Ohm

AMPLIFIERS



As the leaky feeder gets longer and is spliced and split, the radio signals become weaker. To counter this, amplifiers are installed to boost the radio signals to normal operating levels. Without amplifiers, the maximum leaky feeder length would only be in the range of 1000-1500 ft. By using amplifiers, the leaky feeder length can be extended for miles.

Tunnel Radio provides both VHF and UHF system types in the UltraComm line: they have similar components and operate in similar manners. The primary difference between the two system types are the frequency ranges in which they operate.

Tunnel Radio line amplifiers are connected away from the BIU. The amplifiers maintain and amplify signal levels in the outbound and inbound paths. The amplifier is powered by DC voltage applied to the leaky coaxial cable from BIU. Power insertion is required in larger networks.

Each amplifier carries an internal fuse that opens if a short occurs from an internal amplifier component. The amplifier incorporates internal surge regulators to prevent damage by voltage spikes in case of mine power surges or other faults. If the fuse in the amplifier opens, it will not prohibit voltage output to the next amplifier on the line. It will, however, affect the downstream signal gain of the next amplifier.

TR-160 series VHF amps feature a water-resistant enclosure. Tunnel Radio offers an additional “Amp Boot” to further protect TR-560 series UHF amplifiers from water ingress in particularly austere environments.

TR-160 Series VHD Amp

TR-560 Series UHF Amp

External LED indicators on the amplifier's enclosure report proper system operation or fault conditions in the cable network.

- The TMS indicator LED will illuminate when the amplifier's integrated Radio Module transmits a signal toward the BIU.
- The UL indicator LED will light when a signal is detected from a radio being transmitted toward the BIU.
- The DL indicator LED should always be lit. This indicates that a strong pilot signal is detected and AGC is working. (Note: light will be not light up for non-AGC systems.)
- The **"DCU"** indicator monitors the amplifier voltage on the BASE side of the amplifier.
- The **"DCD"** indicator monitors the amplifier voltage on the non-BASE side of the amplifier.

Each amplifier incorporates a switch to control DC current on the amplifier output branch. The switch can be set to the "OFF" position and will supply only Radio Frequency energy past that point. All DC power is stopped from that point in the chain. This can be useful for locating shorts and "powering down" further amplifiers in the network to isolate the cause of excessive noise in the system.

NOTE: The switch should be off on the last amplifier in line to prevent DC shorts in the system while attempting a repair.

SPLITTERS

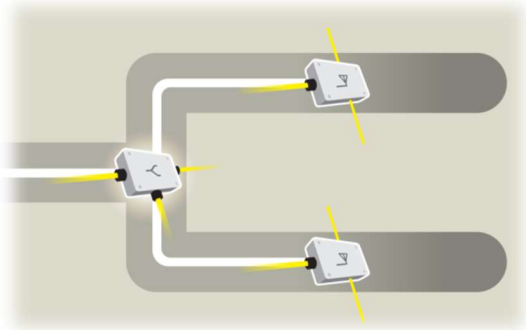
As mine tunnels split and branch, so too should leaky feeder coverage. Splitters are used to fork a cable run into 2 or 3 separate branches.

The **TR-JV3(4)** and **TR-JU3(4)** are passive branch splitters used to expand the Tunnel Radio system. Each branch is designed to support amplifiers down line by passing RF signals and DC current. These units have 3 or 4 ports, one marked BASE for connection to return line to BIU. Features include DC control (On/Off) of each branch, automatically resetting (poly) fuse and LEDs to indicate DC power availability on each switched port. These features provide versatility, system protection, branch isolation, and easy troubleshooting.

The red LED near the entry for each branch is used to indicate voltage to down line units. The LED is lit when DC voltage is present to that individual branch.

If a short occurs down line from the splitter, the fuse will open and stop DC power from passing to the affected branch. Switching off power to branches will assist in isolating problems in the system. Other branch operations will be unaffected. After a short is repaired, the poly-fuse will automatically reset when power is cycled. Loss is 4 dB in the 3-way devices, 7 dB in 4-way types.

Splitters divide the radio signal strength evenly between the branches. This means that the length of the affected cable run is reduced. Please use the table below to calculate the length reduction for your splitter and cable type.



	VHF	UHF	900 MHz
2-way splitter	218 ft	200 ft	140 ft
3-way splitter	344 ft	316 ft	215 ft

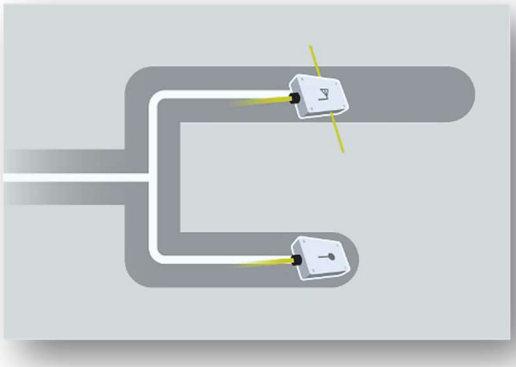
SPLICE BOXES

If the leaky feeder is ever damaged and a segment needs replacing, cut away the bad segment and use splice boxes to join a new segment.

TR-SB1 splice box joins two lengths of coaxial cable that do not require an amplifier or splitter. The VHF units use 3-tab terminal; UHF units use block/clamp termination.

NOTE: Due to the physics of splicing, a splice is never as good as the original undamaged cable. As such, a cable should contain no more than four splice boxes. If additional splices become necessary, the entire cable should be replaced, as excess splice boxes will unacceptably degrade system performance.

TERMINATION UNITS

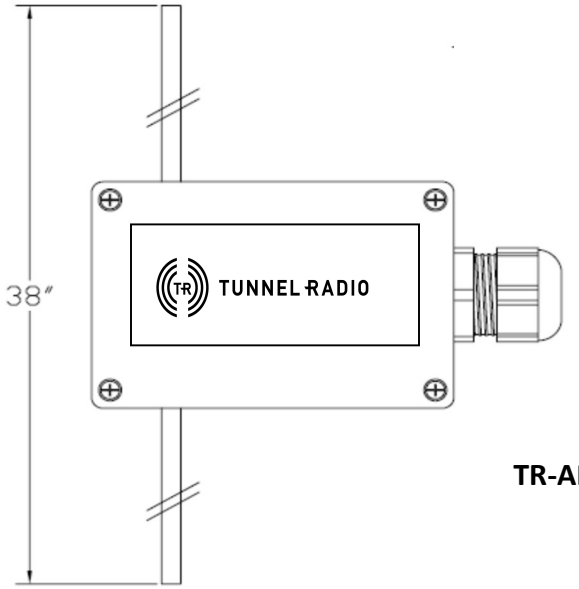


The TR-SBT terminates the end of a coaxial cable to cover the exposed conductors and match the impedance of the transmission line, in order to protect the mine from a possible spark hazard. Entries and housing are moisture resistant and made of plastics and polycarbonate that provides electrical insulation.

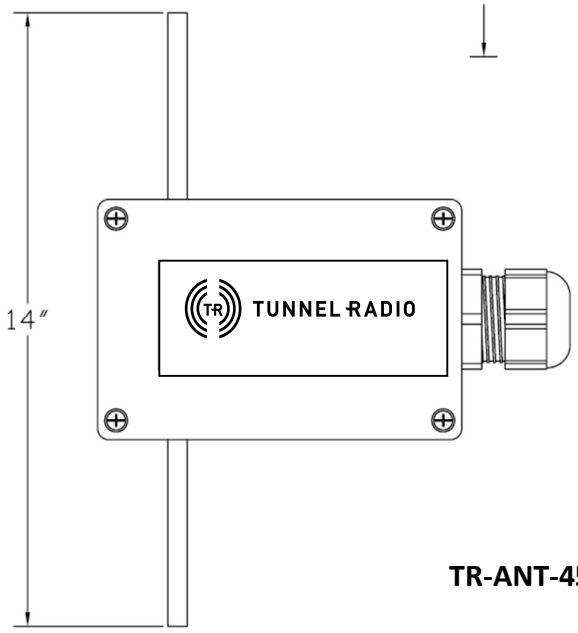
Terminal antennas perform the same safety functions as Termination units, but also provide radio coverage into working sections and stopes.

TERMINAL ANTENNAS

Terminal antennas are designed for use on the end of a cable run to provide maximum radio transmission range. The TR-ANT-1502 is for VHF systems, TR-ANT-4502 is for UHF systems.

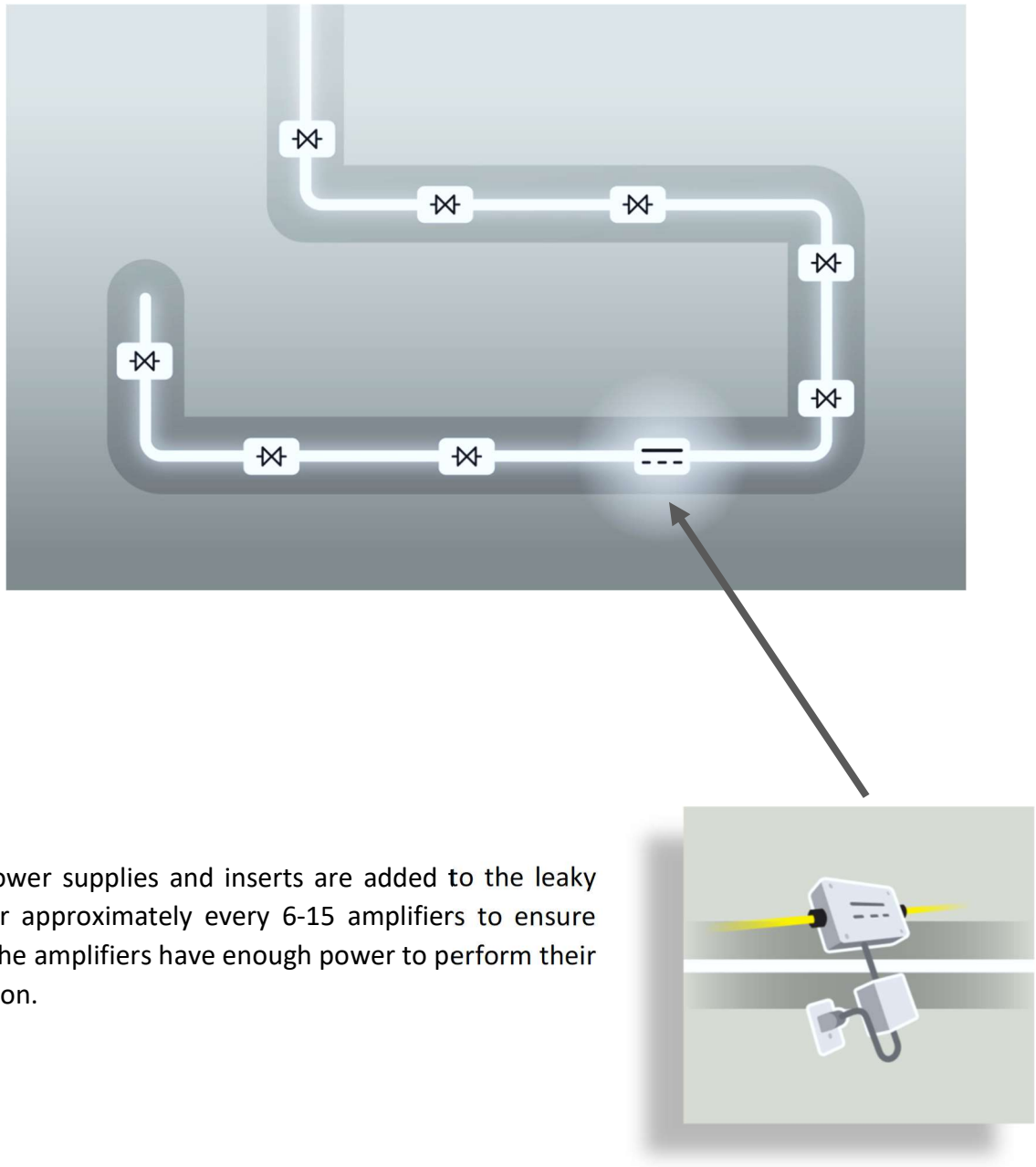


TR-ANT-1502 VHF Antenna



TR-ANT-4502 UHF Antenna

DC POWER SUPPLY & INSERT

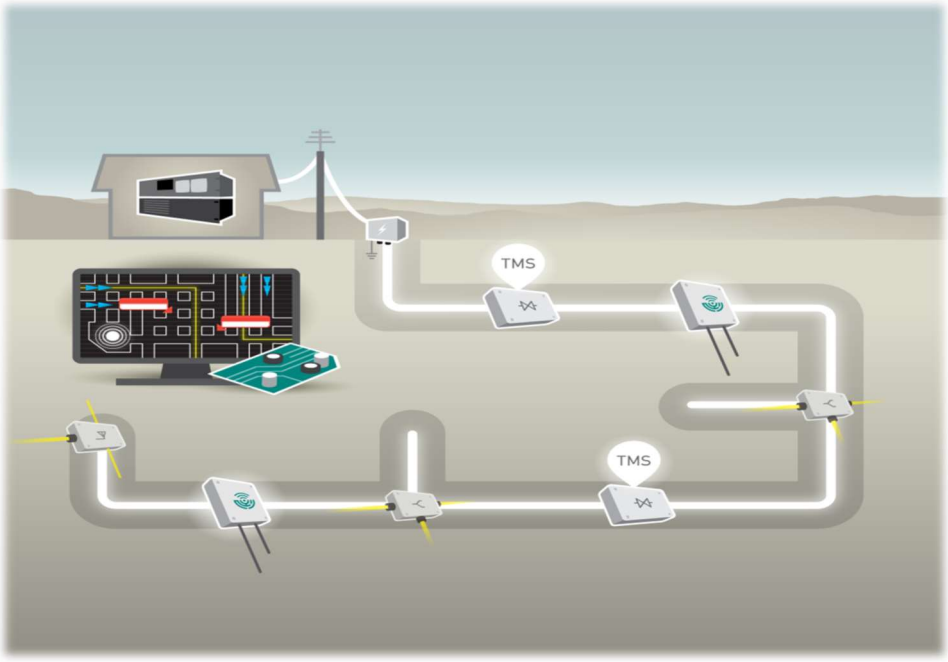


DC power supplies and inserts are added to the leaky feeder approximately every 6-15 amplifiers to ensure that the amplifiers have enough power to perform their function.

INTEGRATED SYSTEMS

TUNNEL RADIO ECOSYSTEM

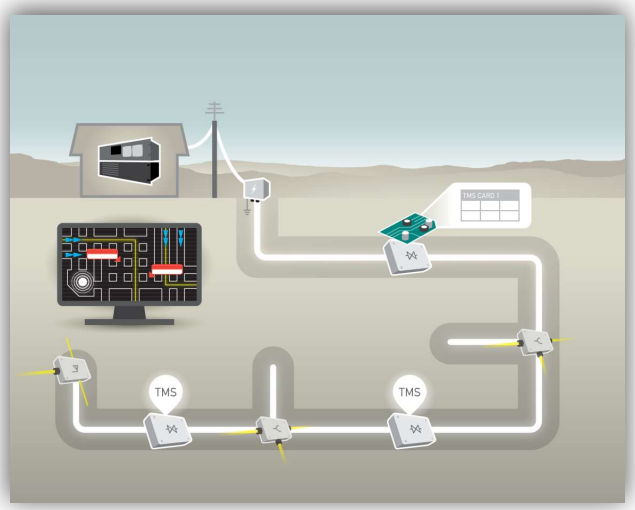
Ultracomm is compatible with a wide range of radio systems and devices. It can be seen as the "backbone" system that supports and enables all other radio systems. Tunnel Radio continues to develop a whole product ecosystem around the Ultracomm backbone, including personnel and asset tracking, and system diagnostics.



These systems use dedicated radio frequencies to request and send data between devices. Most can be viewed and controlled remotely from a dispatch office many miles away, enabled by our web-based interface software. Some of these systems are described in the following pages.

ULTRACOMM DIAGNOSTICS

Tunnel Monitoring System (TMS)

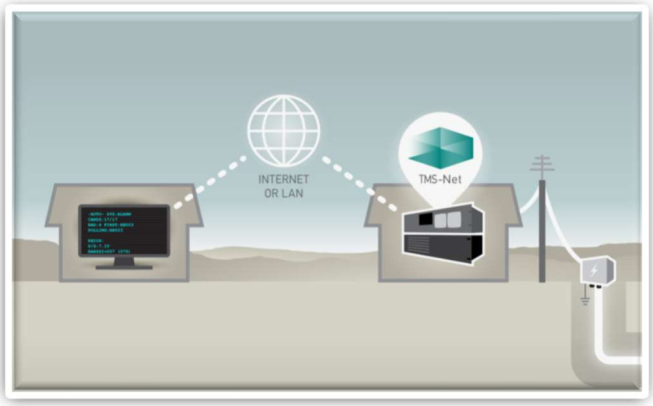


As communication systems continue to expand, their complexity increases as well. Intricate mine systems with Leaky Feeder networks can contain hundreds of amplifiers and other devices. These networks can be complicated to manage, thus the ability to efficiently troubleshoot dense systems is critical.

In response to these needs, Tunnel Radio has developed the Tunnel Monitoring System (TMS), a two--way wireless data hardware and software module. TMS is integrated into all TR-160 (VHF) and TR-560 (UHF) series amplifiers. It allows the BIU to monitor the radio system amplifier condition and allows for operation of a data channel independent of the voice channels wirelessly within the amplified network. Amplifier and/or power supply conditions are captured to a display on the front panel of the BIU for diagnostic purposes.

Designed for integration in our amplifier products, TMS sends Ultracomm system health data to the server in a user-friendly format. With TMS, you can remotely monitor your system's performance anytime and anywhere through either the MineAx software or a TRC-Net device.

TRC-Net

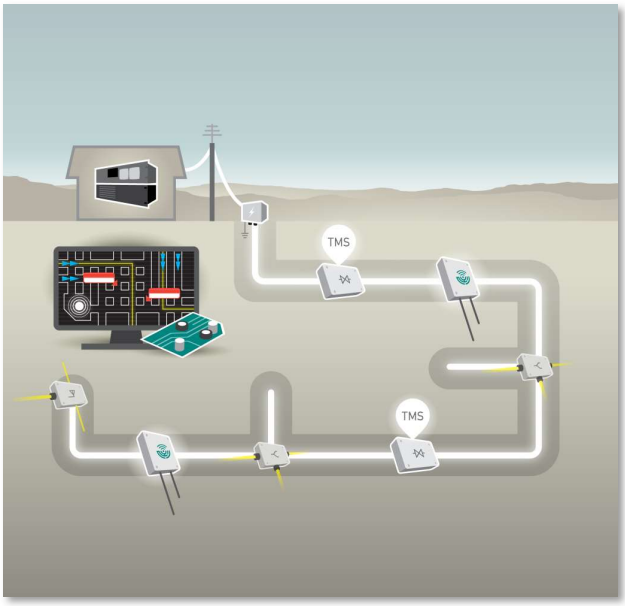


TRC-Net is an option on all Ultracomm systems and provides the ability to remotely access your TMS system anytime and anywhere. It contains an embedded network server, providing a basic level of web-based administrative functions to be used in conjunction with a TMS system. A system administrator may monitor the current operating state, control the TMS system via the command console, or update firmware from hundreds of miles away.

WIRELESS TRACKING

MineAx® RFID Personnel and Asset Tracking System

The MineAx® RFID tracking system provides you with the critical ability to locate people and equipment onsite, both on the surface and underground.

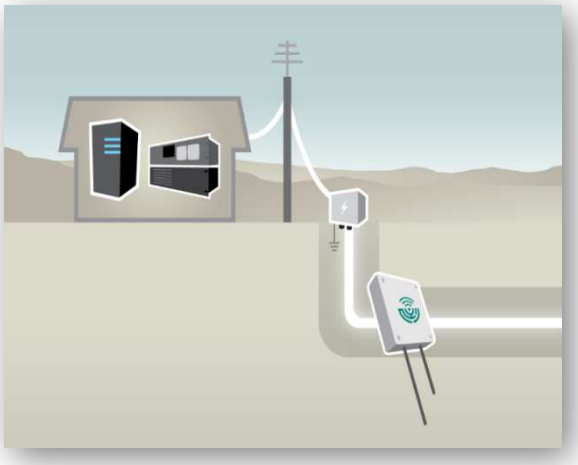


Our intrinsically-safe MineAx system offers flexibility in system design and installation, supporting configurations that include wireless readers via leaky feeder, wireless MultiHop readers, and Ethernet-connected readers.

MineAx tag readers can be located anywhere within the LF coverage area or Ethernet-connected areas.

Our MultiHop units can be placed beyond the leaky feeder coverage, as they use a node-based system to relay the data to the nearest leaky feeder. This can be an ideal option for working areas where leaky feeder is not present.

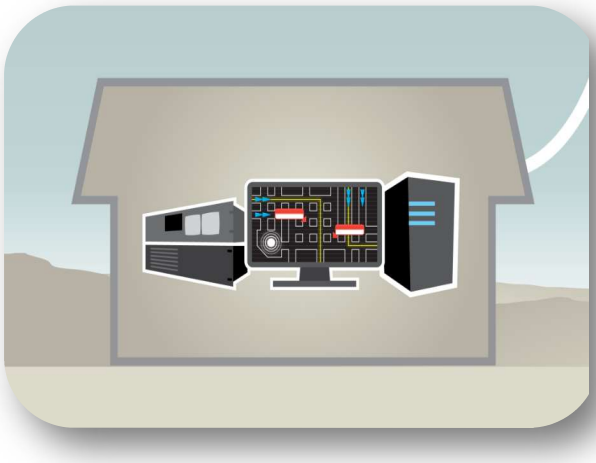
MineAx HEAD UNIT (VHF or UHF)



The MineAx® tracking system has a master unit known as the “head unit,” which controls the polling of all the MineAx readers on the leaky feeder system. The MineAx head unit is connected to the BIU of the leaky feeder system, alongside the radio repeaters. In some Ultracomm systems, the two head units may be sold as one combination unit.

The head unit operates on the MineAx-dedicated radio channel, sending data requests to the wireless readers. When the tag data arrives, it is forwarded to the MineAx server for processing.

MineAx SERVER AND SOFTWARE



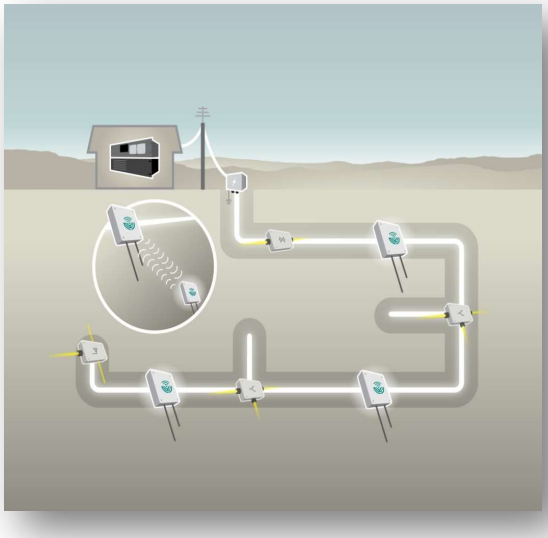
The MineAx® tracking system requires a server to process data and provide a web-based user interface. Tag reader data flows from the readers to the head unit and up to the MineAx server, where the MineAx software stores the information for 30 days. The MineAx user interface can be accessed from any computer on the local network or remotely by using a web browser.

MineAx software can simultaneously retrieve data from multiple head units and Ethernet readers. Tracking information is displayed in a tabular view or overlaid on a site map. Other features include detailed tracking history, search, and a variety of reports.

MineAx also displays the current TMS state and history graphs for all recorded measurements, as well as supporting other optional subsystems, such as industrial controls and gas monitoring.

MineAx RFID READER (VHF or UHF)

Wireless MineAx® tag readers receive radio transmissions from RFID tags in the area.

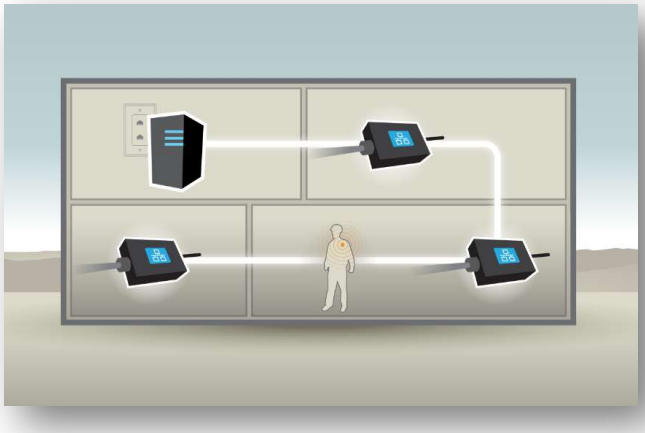


- Read range extends up to 400 feet, depending on conditions.
- When the tag data arrives, the reader stores the tag with a precise time-stamp in memory and relays the data to the MineAx server when polled.
- For standard wireless readers, the data is relayed to the server via the leaky feeder system.
- MineAx MultiHop readers utilize a node-to-node structure to pass the data back to the leaky feeder system.

MineAx RFID READER (ETHERNET)

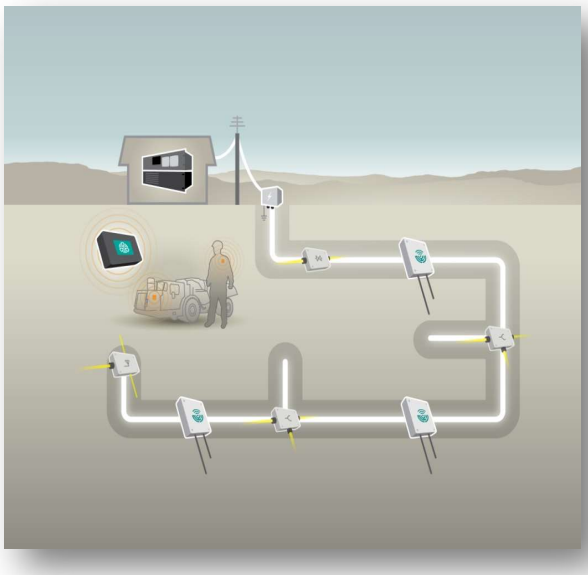
MineAx® Ethernet tag readers receive radio transmissions from RFID tags in the area.

- Read range extends up to 400 feet, depending on conditions.
- When the tag data arrives, the reader immediately sends the tag data to the MineAx server via a TCP/IP network.
- The tag data is then time stamped and processed at the MineAx server.



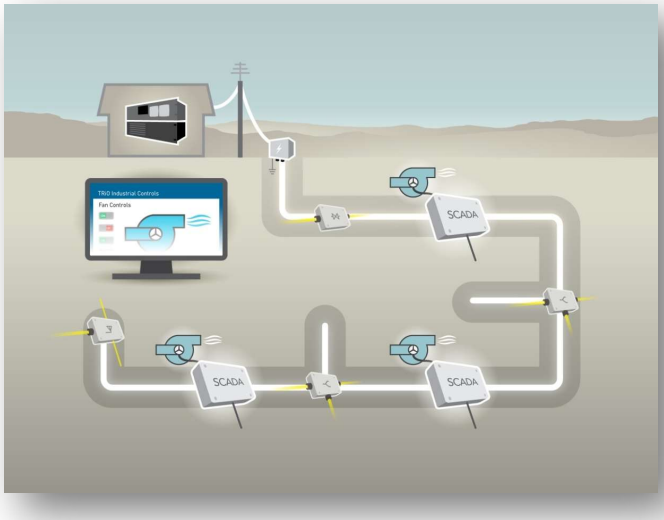
MineAx RFID TAGS

MineAx® RFID tags are designed to be carried by personnel or attached to vehicles.



- The unique RFID serial number is transmitted every few seconds, allowing nearby readers to identify personnel and assets within that read zone.
- The tag battery is replaceable and should last at least 2 years under normal daily use.
- When the battery is nearing end of life, the tag will transmit a low battery warning, allowing about 30 days for the battery or tag to be replaced.

TRiO INDUSTRIAL CONTROLS

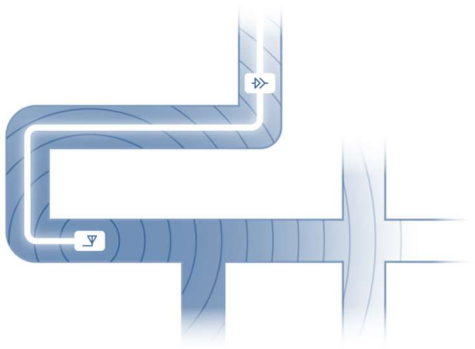


TRiO is a simple SCADA system, utilizing the MineAx software for the user interface, leaky feeder or Ethernet for communication, and robust electrical hardware to perform the work.

TRiO is useful for remotely controlling fans, pumps, stench release, and many other applications.

PLANNING A SYSTEM EXTENSION

THE NEED FOR GROWTH



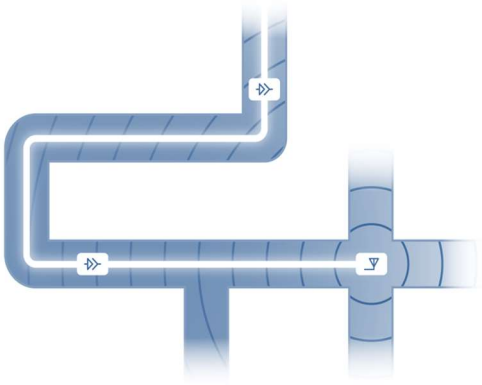
As a mine expands, it will be necessary to provide radio coverage by extending the LF system into the newly formed areas.

Careful planning is the first step in every successful system extension.

Prior to installing a Tunnel Radio system, a mine plan shall be submitted for proper layout and design by the Tunnel Radio Engineering Department or its designated nominee.

USE EXTRA CAPACITY FIRST

The extra capacity of a branch will tell you how much further leaky feeder can be extended before installing an additional amplifier. Examine the mine map and identify nearest upstream amplifier to support the area into which you want to expand.



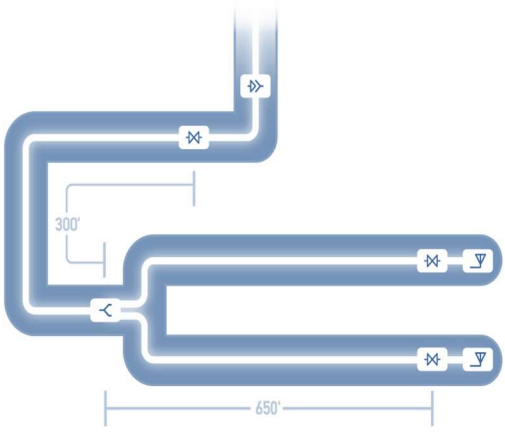
Refer to amplifier manual to determine proper length of cable between amplifiers. Remember, splitters will reduce the length of cable between amps. Refer to splitter component overview on page 13 for details.

If necessary, use a splice box to add to existing leaky feeder.

HOW TO ADD AN AMPLIFIER

Attach an amplifier to the end of the leaky feeder, taking care to use the extra capacity first. (*See* page 23) On a scale drawing of the area to be covered, draw in the paths that you expect the leaky feeder to follow. Draw in splitters, if necessary.

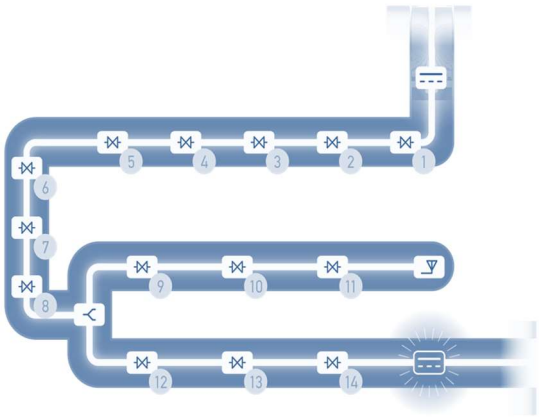
Refer to amplifier manual to determine the proper length of cable between amplifiers. Remember, splitters will reduce the length of cable between amps. Refer to the splitter component overview on page 13 for details.



Sample VHF installation

HOW TO ADD A DC POWER SUPPLY & INSERT

As the mine expands, it may be necessary to provide additional DC power to the system, so that the amplifiers can perform their function.



Sample VHF installation

Examine the mine map and identify the nearest DC power supply. In smaller installations, the head unit may be the only power supply.

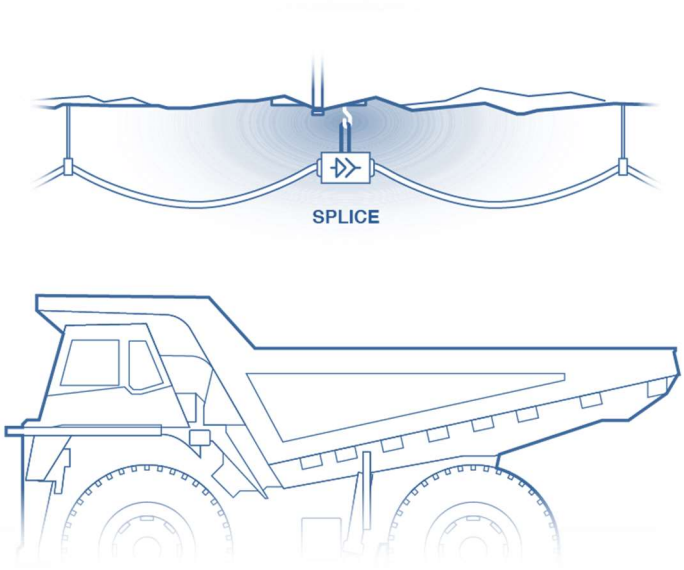
Count the number of downstream amplifiers. If the number of amplifiers is more than the limit described in the amplifier manual, you will need to add a DC power.

The new insert should be located no closer than 10’ to an amplifier.

INSTALLING LEAKY FEEDER

MAKE YOUR MARKS

In accordance with your planning, survey the routing area and mark the splice, splitter, amplifier, and power insert locations.



Consider vehicle clearances when selecting component placement to minimize the possibility of damage due to snagging or collision.

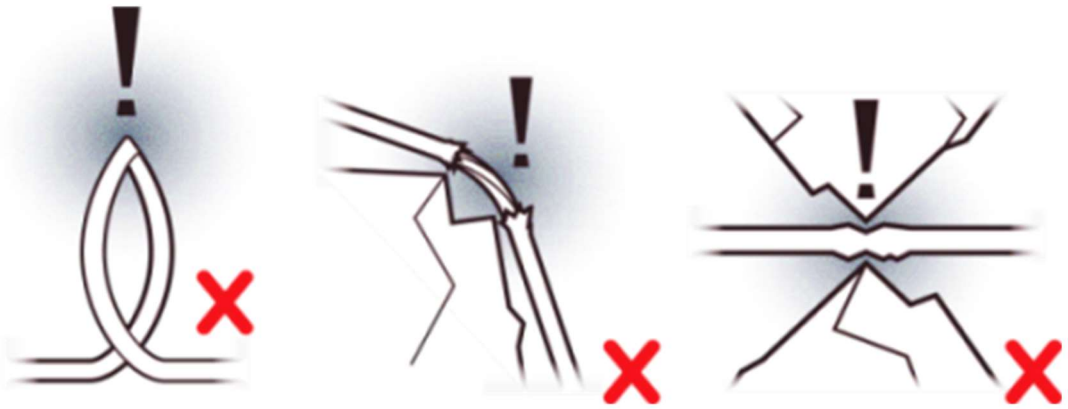
LEAKY FEEDER CABLE: IMPORTANT CONSIDERATIONS

The leaky coax cable must be handled following certain precautions to avoid internal or external damage. If not handled properly, reduced quality or even failure of the cable's radiating characteristics may occur.

The primary function of the leaky feeder cable is to act as an antenna which transmits and receives signals throughout the mine. The secondary functions are to carry DC voltage to networked amplifiers and transfer RF from amp to amp.

Inspect each spool for shipping damage. Spools should be stored inside a covered area and kept dry to prevent water ingress. Review the mine's system plans and start layout of cable from base radio/interface location.

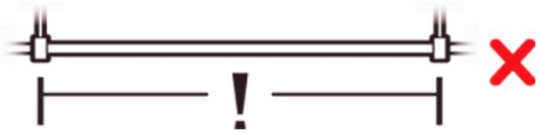
DOs and DON'Ts for Leaky Feeder:

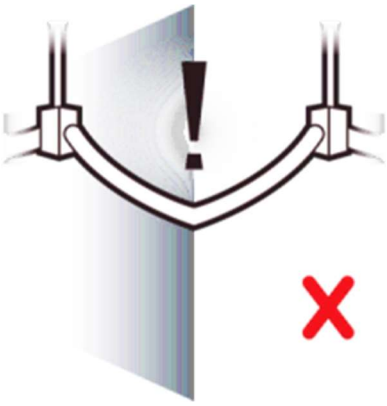


The leaky feeder cable must not be kinked, chafed or pinched.

Place as little tension on the cable as possible.

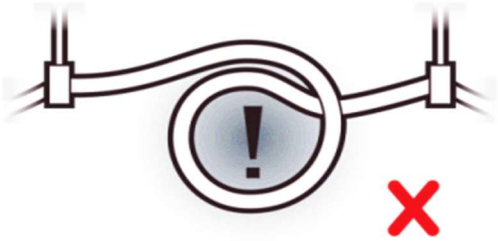
Pulling or stretching cable long distances will damage the cable internally.

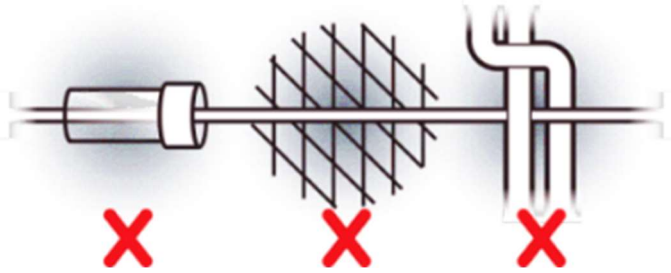




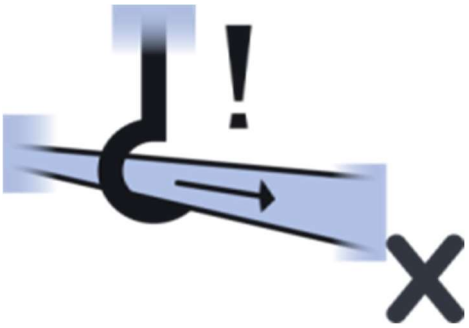
Pulling or stretching cable around corners will damage the cable internally.

Do not install the cable looped onto itself.

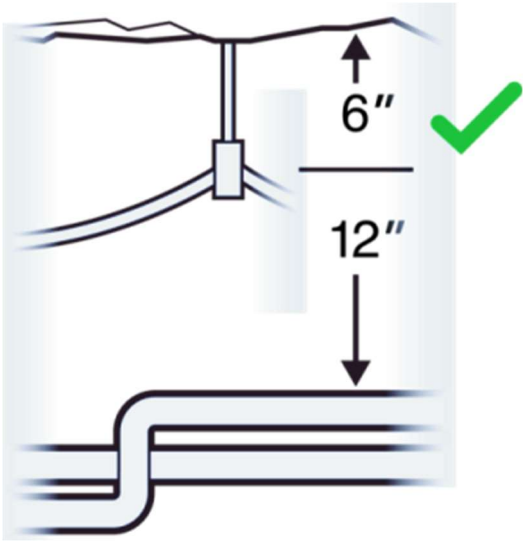




To the greatest extent possible, keep away from metallic conductors, conduit, pipes, metal mesh, etc.



The cable cannot be pulled through hooks or hangers due to its delicate internal design.



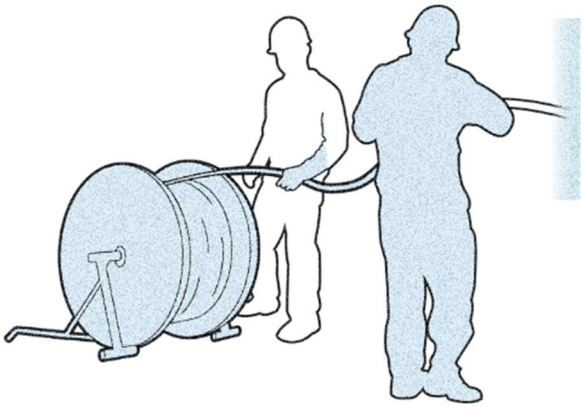
Try to keep cable around 6” away from roof and wall.

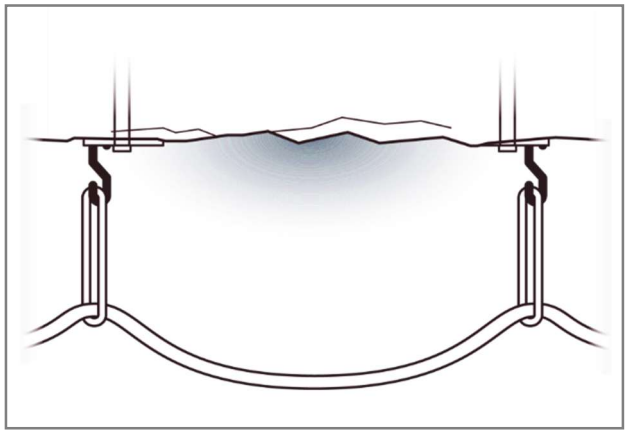
Use standoffs as necessary to maintain 12” gap between cable and such objects.

LEAKY FEEDER CABLE - DRIFT INSTALLATION METHODS

Using a spool winder or reel buck, carefully unreel no more than 20’ of leaky feeder cable at a time along the routing area.

Never roll cable on mine floor.





Attach the cable to roof bolts as you go, using cable ties or tie wrap. Tie to the outside of metal hooks with cable ties.

The recommended distance between hangers is eight (8) feet.

Allow the cable to sag at least 6 inches from the roof.

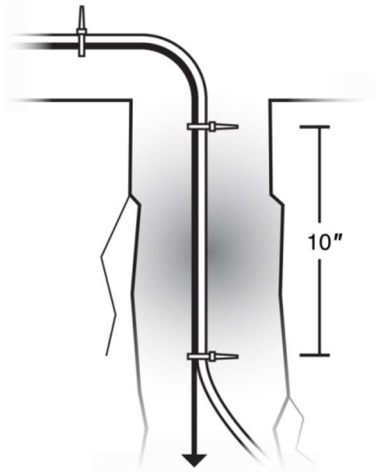
At every splice, splitter, amplifier, and power insert location be sure to leave 3’ of slack. Do not install the cable in a loop on itself.

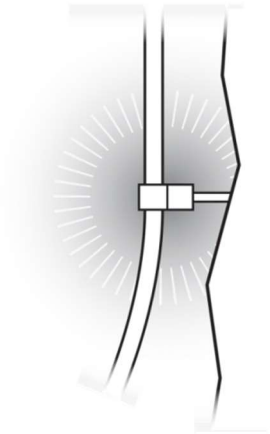
A reversed, poorly connected or improperly spaced amplifier or other component can create noise in the system. Always verify proper orientation of component to base and recheck terminations and power switch prior to closing component housing.

LEAKY FEEDER - SHAFT INSTALLATION METHODS

Shaft installations require special attention to cable location and attachment. If not properly installed, debris and moving parts can damage cable and/or amplifiers.

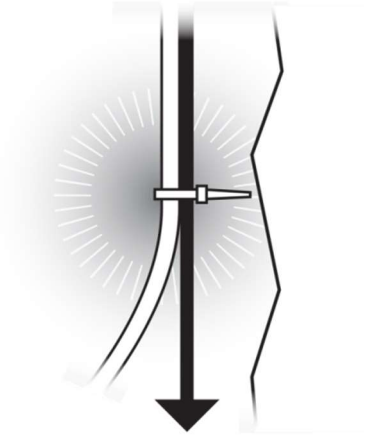
If you are clamping to an existing messenger cable, clamp leaky feeder to messenger every 10'. Mount a spool winder or reel buck on the elevator and pay out cable as cage is slowly lowered.





If LF cable must be dropped down through the shaft, tie-wrap LF to a messenger cable every 10' and slowly lower joined cables together. When fully extended, attach messenger cable to shaft wall, as necessary, for support.

If installing directly onto shaft wall, use cable clamps (Tunnel Radio part# TR-CL15x3). Place clamps every 6' to 10' in wall and simply snap in cable as cage is lowered.



No matter what installation method you use, leave 12' of slack at each end of shaft for future repairs.

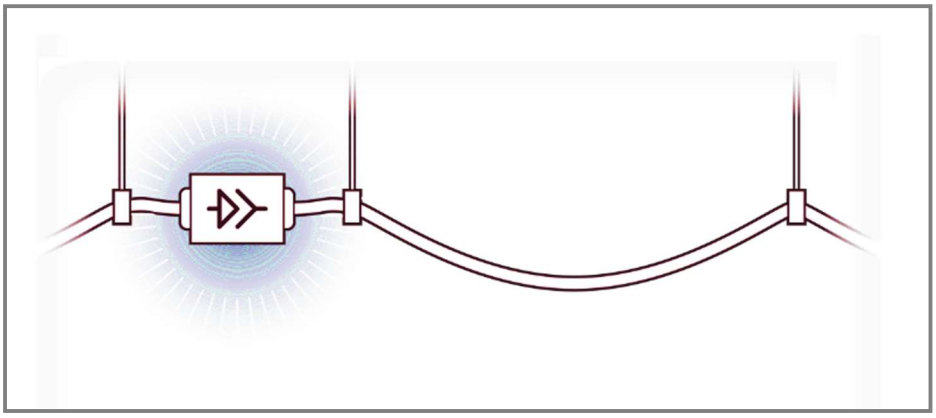
LEAKY FEEDER INSPECTION

Inspection of the leaky feeder cable should be done on a regular basis.

- If cuts in the outer jacket are found, inspect for damage to the internal metallic shield.
- If no internal damage is found, use seal tape on areas with jacket damage to prevent moisture ingress.

Replace any areas of pinched or kinked cable.

If internal damage is found, cut out the damaged segment and use a splice box to reconnect. Leave 3’ of slack for future repairs.



PREPARING LEAKY FEEDER FOR CONNECTIONS

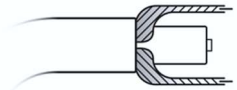
Before you install splice boxes, splitters, amplifiers, and power inserts into the system, you will need to prepare the leaky feeder connections for attachment.

In order to work with clean conductors, use cable shears to cut off end of cable. Verify that there is no moisture in the end of cable. If moisture is discovered, then cable may be unusable.

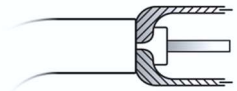
For VHF cable

1. Use cable shears to remove about ¾" (19mm) of outer jacket without nicking or damaging ANY of the outer wires. Any wire broken off here will dramatically reduce quality of your system.

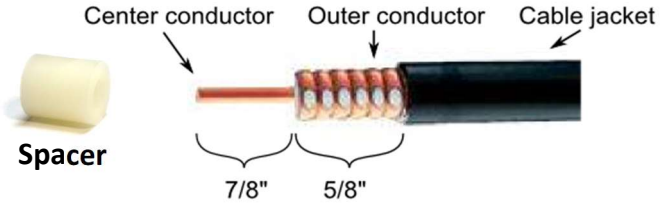
2. Separate the outer small copper wires into two equal groups and use pliers to twist each group together. Include all of the wires. If any wires break off, use the cable shears to cut off the entire end of the cable and start again.



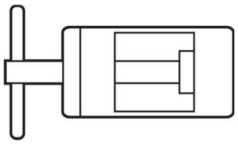
3. Cut back inner insulation ½" (13mm) to bare center conductor. To eliminate the possibility of stress damage later, be sure not to cut into this wire when removing the insulation.



For UHF cable



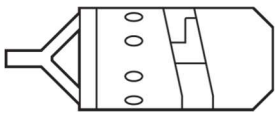
1. Using Tunnel Radio cable preparation tool (TR-RFS-TOOL-DRILL), strip 1½ " of cable jacket from cable.



2. Cut the exposed outer conductor to reveal 7/8" of center conductor.

3. Carefully scrape center conductor to remove plastic coating, if present.

4. Using cable coring tool (TR-RFS-TOOL), core out enough of the insulator between inner and outer conductors to allow for insertion of supplied plastic spacer.



5. Install the supplied plastic spacer.

INSTALLING SYSTEM COMPONENTS

COMPONENT INSTALLATION: IMPORTANT CONSIDERATIONS

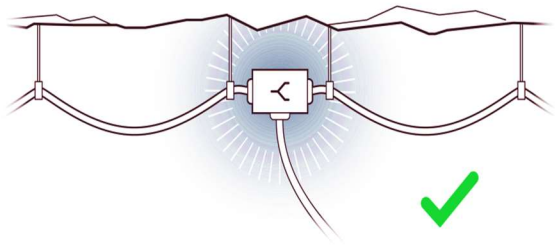
Leaky feeder components such as amplifiers, power inserts, splitters and splices must be located no closer than 10’ from each other.

Warning!

Ensure that power is not being supplied to this branch of leaky feeder system while component installation is in progress! Turn off power at base unit, power insert, or splitter, as applicable to your installation.

- Keep away from metallic conductors, conduit, pipes, metal mesh, etc., where possible.
- Keep components at least 6” from roof and wall.

- Use the 3’-6’ of slack leaky feeder to create drip loops that extend below the component.
- Take up additional slack using a figure-S pattern, being sure not to pinch or kink cable.
- Separate cable runs by at least 6’ immediately after entering or exiting components. Do not loop the cable on itself.



SPLICE BOX INSTALL

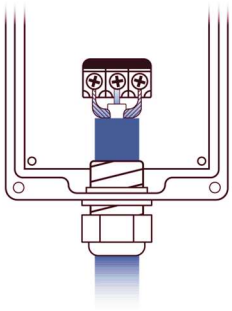
Warning!

Ensure that power is not being supplied to this branch of the LF system while component installation is in progress! Turn off power at base unit, power insert, or splitter, as applicable. Use a voltmeter to verify that power is not supplied.

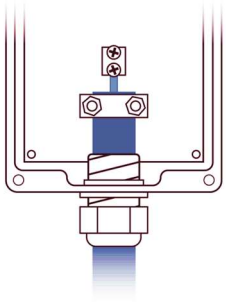
Note: DO NOT use more than FOUR splice boxes per cable between amplifiers. If additional splices become necessary, the entire cable should be replaced as excess splice boxes will degrade system performance.

For VHF Systems:

1. Remove the top cover and loosen a strain relief grip nut.
2. With all the wires facing forward, push the leaky feeder cable into the box through the strain relief.
3. Connect the center conductor to the center terminal and each twisted set to a corresponding outer terminal.
4. Tighten the center terminal and then the outers.
5. Tighten the upstream and downstream strain relief grip nuts by hand and replace the cover.

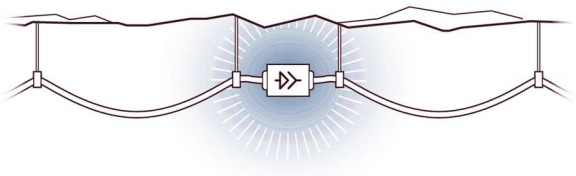


For UHF systems:



1. Remove top cover and loosen a strain relief grip nut.
2. Push the leaky feeder cable into the box through strain relief.
3. Push cable through center of clamp and into hole in block. The center conductor must be inserted far enough for both block screws to contact it. Take care not to allow outer conductor to touch block.
4. Fasten center conductor to block terminal using screws provided. Be sure to tighten them well.
5. Tighten nuts on clamp to firmly contact the cable's outer conductor without pinching cable jacket.
6. Tighten upstream and downstream strain relief grip nuts by hand and replace the cover.

Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component.



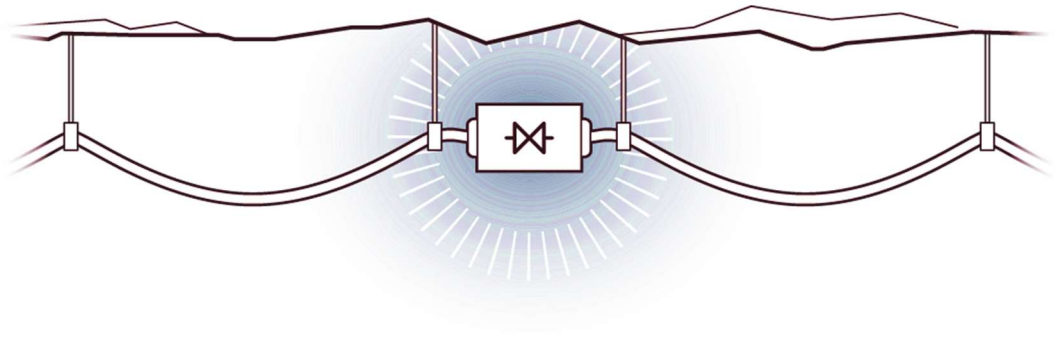
AMPLIFIER INSTALL

*** Warning ***

Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Do not install amplifiers within 10 feet of power inserts, splitters or other major system components.

Remove the top cover and examine the amplifier orientation. The arrow on the component PC board and/or the label on the outside of the box will indicate where to connect the cable that goes toward the base radio. This is the upstream direction. Make cable connections in the same manner as a splice box.

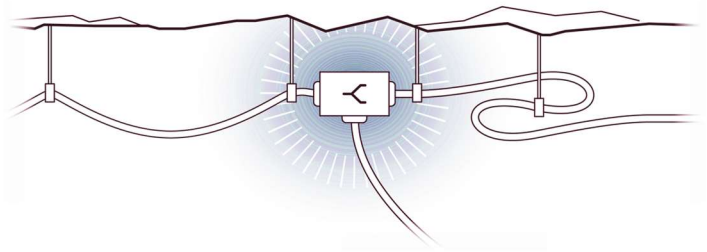


Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component. Take up additional slack using a figure-S pattern, being sure not to pinch or kink.

SPLITTER INSTALL

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Remove the top cover and examine the splitter orientation. The arrow on the component PC board and/or the label on the outside of the box will indicate where to connect the cable that goes toward the base radio (outside the mine). This is the upstream direction. Make cable connections in the same manner as a splice box.



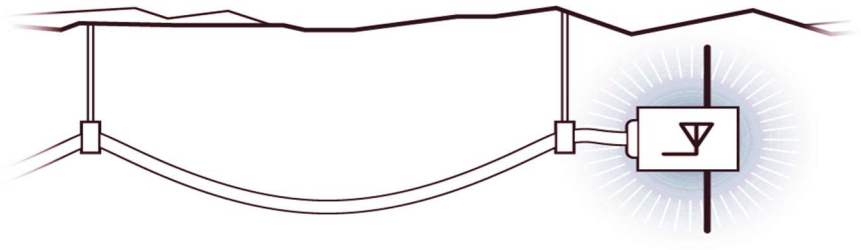
Take up additional slack using a figure-S pattern, being sure not to pinch or kink the cable.

Use the 3'-6' of slack leaky feeder to create drip loops that extend below the component. Ensure that downstream cables are separated immediately for at least 6' upon exiting the splitter.

TERMINATION UNITS & TERMINAL ANTENNA INSTALL

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Make cable connection in the same manner as a splice box installation. (See page 33.)

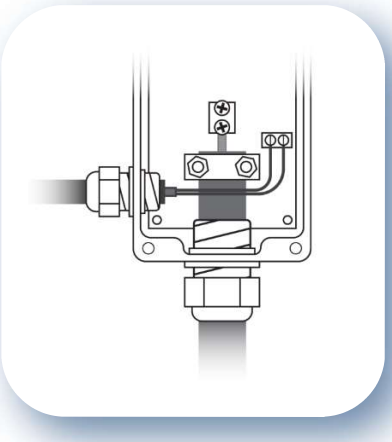


Use the 3'-6' of slack leaky feeder to create drip loop that extends below the component. Take up additional slack using a figure-S pattern, being sure not to pinch or kink.

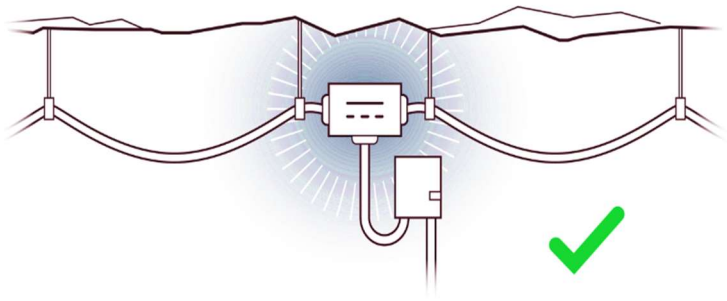
DC POWER INSERT INSTALL

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while component installation is in progress!

Note! Maximum distance from power supply to cable insert is 400’ when using 18 AWG wire.



- Remove the top cover and examine the insert orientation. The arrow on the component PC board and/or the label on the outside of the box will indicate where to connect the cable that goes toward the base radio. This is the upstream direction.
- Make LF cable connections in the same manner as a splice box.
- Remove 2” of outer sheath from the DC cable to expose the internal wires.
- Loosen the DC cable entry strain relief grip nut. Push the DC cable into the box.
- Strip off 3/8” and crimp a ferrule onto each wire.
- Connect the red (+) wire to the positive terminal. Connect the black (-) wire to the negative terminal. Tighten terminals with hand tools only.
- Tighten the DC strain relief nut by hand and replace the cover.



Take up additional slack using a figure-S pattern, being sure not to pinch or kink the cable.

Use 3’-6’ of slack leaky feeder to create drip loops that extend below component.

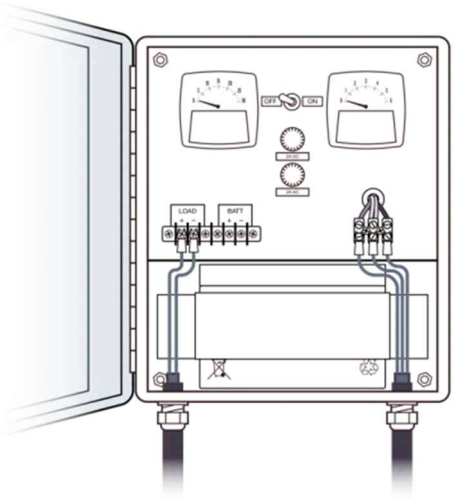
Create drip loop with DC cable and route cable to power supply in accordance with expansion plan.

DC POWER SUPPLY INSTALL

Warning! This installation shall be made under the supervision of the certified mine electrical superintendent and follow all State, Federal and MSHA electrical codes and guidelines. Read entire section before proceeding.

Warning! Ensure that applicable AC mains power is disconnected while component installation is in progress!

- Mount the power supply to a secure location in accordance with the expansion plan. Open the power supply front panel.
- Remove 2” of the black outer sheath from the DC cable to expose the internal wires.
- Loosen the DC cable entry strain relief grip nut. Push the DC cable into the box.
- Strip off 3/8” and crimp a ring or slip terminal to each wire.
- Connect red (+) wire to the LOAD+ lug. Connect the black (-) wire to the LOAD- lug. Tighten lugs with hand tools only.



- Tighten the DC strain relief nut by hand and close the cover.
- Secure DC cable, as necessary, to ensure a drip loop.
- Connect the AC plug to 112VAC to complete the installation.

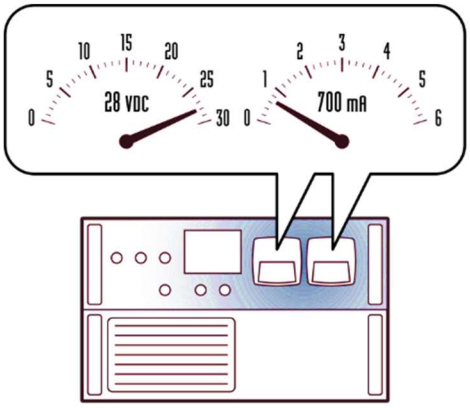
Note! The maximum distance from AC mains to power supply is 100’ with AWG 16/3 wire.

PREVENTIVE INSPECTION

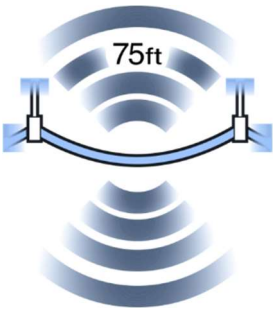
WEEKLY OPERATIONS INSPECTION

Simple procedures, when performed on a regular basis, are the first line in assuring service quality. Regular verification of communications clarity is the best way to assure consistent and reliable coverage throughout the system.

Every week -



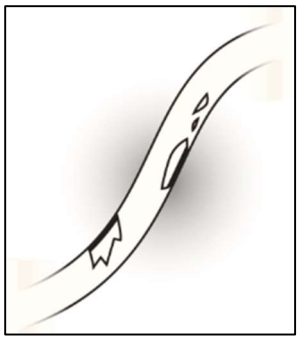
- Dust head-end cabinet and keep free of clutter that may interfere with ventilation.
- Verify that head indicates proper supply voltage.
- Verify that head ammeter indicates less than 1A.
- Verify a minimum 75' clear voice communication range from VHF leaky feeder cable throughout mine. (UHF systems can expect over 200' communication range.)



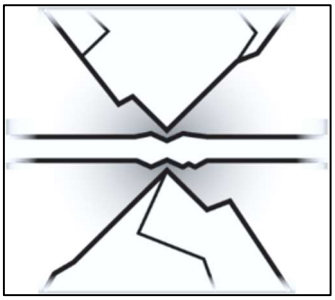
A record of the examination should be kept on file for future

WEEKLY DAMAGE INSPECTION

Over 75% of all failures are due to cable, connection, and water intrusion damage. Establishing a regular routine of system inspection is vital. Carefully examine the system every week for indications of physical damage such as:

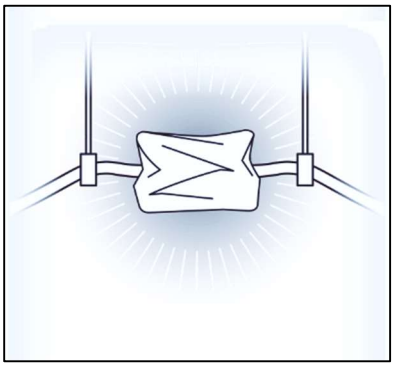


Cut or abraded cable sheathing



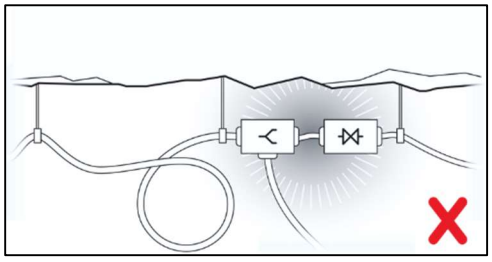
Pinched cables

Visible signs of corrosion which may suggest pinhole breaks in sheathing

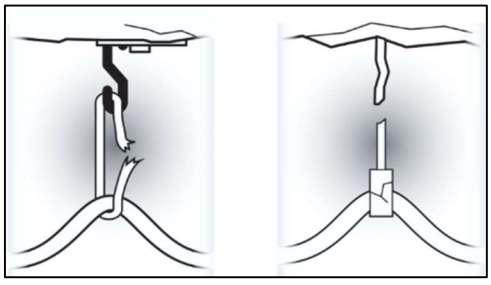


Damaged or compromised enclosures

If cable sheathing is damaged but no internal damage is found, use seal tape on areas with damage to prevent moisture ingress.



Improperly routed cables which may suggest an unauthorized repair



Damaged nylon clamps or cable ties

PERIODIC INTERNAL INSPECTION OF COMPONENTS

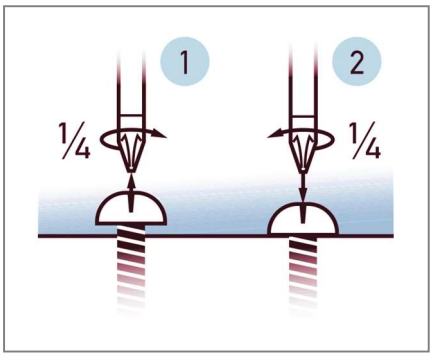
WARNING! These instructions do not apply to power supplies!
For instructions on how to inspect power supplies, see page 42.

Warning! Ensure that power is not being supplied to this branch of the LF system while retightening connections!

Every month:

For each system component, remove the top cover and check for:

- Condensation or standing water
- Corrosion at or near the cable connections
- Corrosion anywhere else, including circuit boards, interconnects, and mounting screws



Additionally, ensure good electrical contact with the terminals by loosening each connection by ¼ turn and retightening using hand tools.

PERIODIC INTERNAL INSPECTION OF POWER SUPPLY

Warning! Ensure that power is not being supplied to this branch of the leaky feeder system while retightening connections!

Every month:

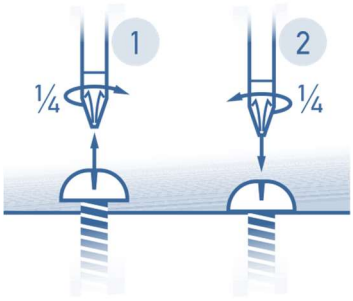
Check for:

- Condensation or standing water
- Corrosion at or near the cable connections
- Corrosion anywhere else including circuit boards, interconnects, and mounting screws

Every three months:

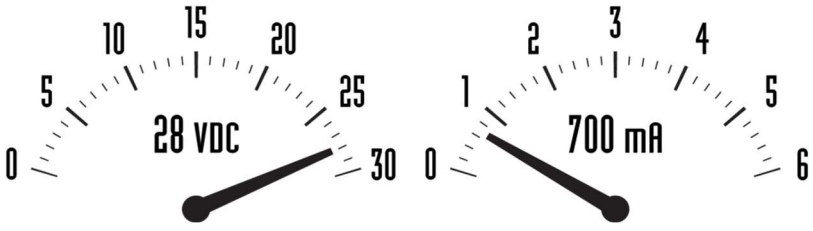
Ensure good electrical contact and operation:

- Turn off power and see that the volt and current gauges read zero.



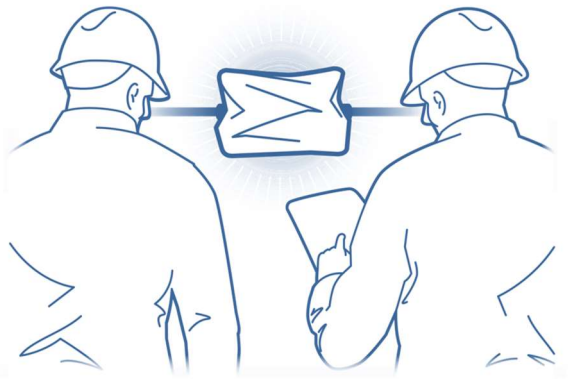
- Ensure good electrical contact with the LOAD terminals by loosening each lug by ¼ turn and retightening using hand tools.

- Turn power back on and see that voltmeter indicates the proper voltage and ammeter indicates no more than 1A.



BASIC TROUBLESHOOTING

Warning! Always disconnect power when removing and/or replacing system components or tightening connections.



A good understanding of system operation and specific mine system layout are all that is required to properly repair the most common problems. Always keep a system map handy when troubleshooting.

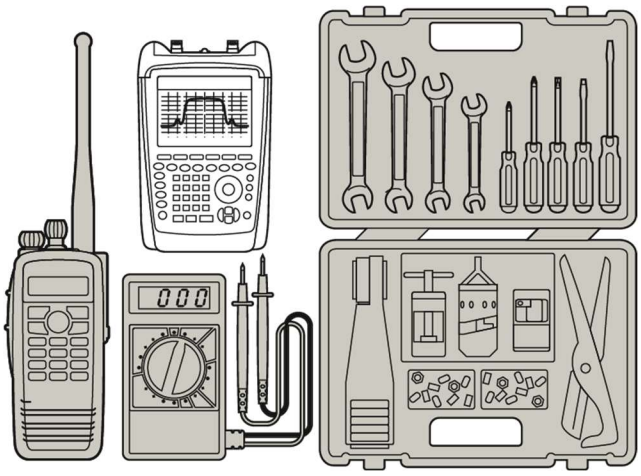
Most faults in a mine radio system center around damaged cable, water intrusion or low DC power. Any of these faults can result in degraded or disabled operation.

When troubleshooting, always start at the head unit and work your way downstream to the end of the suspect branch.

RECOMMENDED TOOLS

The recommended equipment needed to properly service and troubleshoot a system includes:

- Two-way radio
- Spectrum Analyzer
- Digital Multimeter
- Standard tool set, including cable splice tools



CHECK FOR SHORTS

Proceed to the head unit. Verify operation of repeaters by use of portable radios.

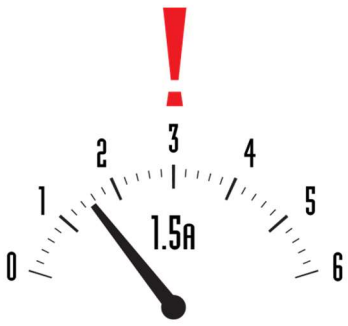
Check status of LEDs on the head unit to verify DC power is “on” and that the voltmeter shows proper voltage is being supplied.

- Use the branch power switches to check the amperes supplied to each individual branch. If a single branch is consuming more than 1 ampere of current, then there is likely an electrical short on that branch.
- If the branch is consuming less than 1 ampere of current and there are no additional power inserts downstream, then the possibility of a short on this branch has been eliminated. Otherwise, proceed to the next downstream power insert.

Check status of LEDs on the insert to verify DC power is “on” and that the voltmeter shows proper voltage is being supplied.

Check the amperes supplied. If this segment is consuming more than 1 ampere of current, then there is likely an electrical short on that segment.

Repeat this test for every power insert. If all segments are drawing less than 1 ampere of current, then the possibility of a short has been eliminated.



IF A SHORT IS SUSPECTED

Starting at the head or power insert, proceed in the downstream direction and inspect the leaky feeder as you go. When you reach the nearest downstream amplifier or splitter, open its case and use the switch to turn off downstream power.

Use a voltmeter to probe the DC voltage across the upstream leaky feeder center conductor and shield. If the DC voltage is greater than 8, turn on downstream power, close the case, and proceed to next component. If the DC voltage is less than 8, remove the component from the system.

Measure the voltage across the upstream leaky feeder center conductor and shield again. If the DC voltage is less than 8, then the short is in the upstream leaky feeder segment itself and requires inspection.

If the DC voltage > 8, then the removed component is faulty and should be replaced.

CHECK FOR OPENS

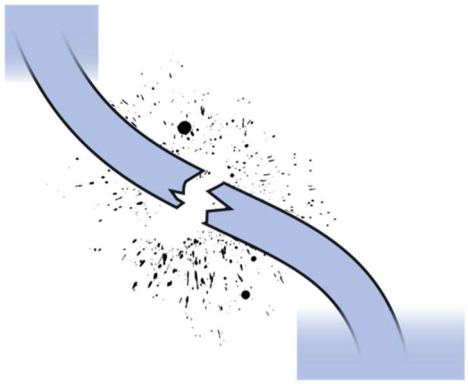
Proceed to the head unit. Verify operation of repeaters by use of portable radios.

Proceed to the first downstream amplifier or splitter. Verify that the “DC OUT” indicator is lit.

If the indicator is not lit, then a probable electrical open has been discovered.

Repeat this process for every component up to the last amplifier in the suspect branch.

Beyond the last amplifier, simply perform a routine component and damage inspection.



IF AN OPEN IS DISCOVERED

Open the component case and use a voltmeter to probe the DC voltage across the upstream leaky feeder center conductor and shield.

- If the DC voltage is near zero, then the open is likely within the upstream leaky feeder itself or where connection is made to the nearest upstream component.
- If the DC voltage is greater than 8V, then the open is possibly within this component.

Disconnect the downstream leaky feeder.

Turn on downstream power and observe the “DC OUT” indicator.

- If the “DC OUT” indicator is lit, move to the next component downstream.
- If the “DC OUT” indicator is not lit, then the component or internal fuses should be replaced.

TECHNICAL SUPPORT

CONTACT US

Tunnel Radio is dedicated to helping you maintain the quality of your communications systems.

For more information about the Ultracomm System, please do not hesitate to contact your local dealer or Tunnel Radio directly at **techshop@tunnelradio.com.**

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ELECTRICAL BLASTING CONSIDERATIONS AND RADIO IN MINES

Safety Library Publication #20[(1)] provides an overview of using blasting caps with radio transmitters. This document was developed by the Institute of Makers of Explosives relative to this issue. In summary, tests have shown that the probability of inadvertent detonation of electric caps is "almost nil," but concerns persist about the use of radio underground near electric blasting caps.

Publication #20[(1)] limits radio use to 5 watts maximum RF power no closer than 20 feet from electric caps. In 1979, the U.S. Bureau of Mines[(2)] conducted a study in which three mobile-radio-equipped vehicles and three portable radios were located within a few yards of a mine face that was loaded with live un-terminated electric caps. The radios were set to transmit simultaneously at full power for one minute. No detonation occurred as a result. This controlled test was conducted by scientists and engineers from Motorola, the Pittsburg Research Center (PRC), and the U.S. government. See the note below to obtain a copy of the #20 report.

Notes:

1. Institute of Makers of Explosives, 1120 19th Street NW, Washington DC 20023. www.ime.org Publication Safety Library Publication #20

2. USBM Report Implementation of UHF Radio Communications in a Room and Pillar Mine, March 1981, Isburg, Allen