REMOTE MINE WIDE COMMUNICATIONS

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ABSTRACT

Mine wide, underground wireless communications are possible with the use of Ultra Low Frequency (ULF) technology. Due to the propagation through rock of ULF radio signals a relatively small antenna can provide communications coverage over a complete mining operation.

Starting as a Personal Emergency Device (PED) for emergency messaging to miners under all circumstances, the ULF communications system has grown to include capabilities of remote control of underground equipment such as pumps and fans and centralised blasting initiation. This technology is now in use on 5 continents having lately made it onto the African mining scene.

The paper and presentation will provide the audience with the benefit from international mining know-how in this technology as well as local African experiences. A recent commissioning exercise for example, is expected to pay for itself in electricity savings within a few months. These and other results from practical demonstrations and usage will be covered.
This novel technology becomes an integral part of the daily operating infrastructure of a mine with immediate safety and business benefits. It is able to reduce capital expenditure and is designed for ease of routine operational use. The paper will conclude with insights into current R&D for further development of this technology.

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1 Ultra Low Frequency (ULF) Communication Technology

Reliable, mine wide communication is fundamental to a productive and safe underground mine. The PED® System is a ULF "through-the-earth" paging, control and blasting system. PED complements two way communication systems such as phones and radios, to give an effective overall communication system.

1.1 Historic Backdrop

Mining disasters rendering existing underground communications infrastructure inoperable led to the development of a true mine-wide communication system not relying on underground cabling. Mine Site Technologies' PED Communication System has been in use underground for more than 15 years, and is currently utilised by some 150 coal and metalliferous mines around the world including Australia, Canada, the USA, China and Sweden.

PED uses ultra-low frequencies to transmit signals through rock strata, allowing it to deliver complete signal coverage to underground mines without the need to install antenna cable throughout the mine – which the more traditional line-of-sight radio systems require. A relatively small antenna on the surface, or underground, provides complete signal coverage, making the system much less expensive than other radio systems. PED is also not as vulnerable as other systems to the hazards of rockfalls, fire and general wear and tear.

1.2 Emergency Communications

PED is an acronym of Personal Emergency Device. The system was originally developed to provide a fast and reliable method of informing underground miners of emergency situations. Due to the system enhancements and the inherent ability to readily contact personnel, wherever they are underground, PED has also come to stand for Productivity Enhancement Device.

PED Communication and Emergency Warning are possible because ULF allows for direct signal propagation through hundred of meters of rock strata. This "though-the-earth" capability ensures all parts of an underground mine are within signal range, thus providing true mine wide coverage. PED is used as an emergency warning system with messages being sent to an individual pager receiver attached to a miner's cap lamp battery.

The use of sophisticated encoding and decoding techniques ensures the absolute integrity of the received message from very weak signals.

1.3 Signal Penetration

The combination of ULF and a high power transmission system enables the PED signal to propagate through several hundreds of metres of rock strata. The signal can therefore be received at any location throughout the mine.

For this reason, PED is an extremely effective emergency communication system. The ability to transmit actual messages is vitally important in allowing, not only a warning to be issued, but specific information regarding the situation to be sent (such as where a fire is, which evacuation route to take, etc).

2 Productivity Enhancement Device (PED)

The transmission system is usually on the surface or there may be minimal infrastructure underground. This means transmission can be maintained when other types of communications are prone to damage, particularly during an emergency, because of their reliance on extensive networks of cabling underground (e.g. telephones & radio systems).

Where extensive mine monitoring is in use the information processed on the surface can be quickly and efficiently relayed back underground to relevant personnel (e.g. fire or high water alarms, low airflow, transfer bins full, etc). Such communication is the basis of improved productivity.

In addition, the use of BlastPED eliminates the need for extensive networks of mains firing lines, hence greatly reducing the chance for any stray currents to enter the firing circuit.

The PED system, as a paging device, has the ability to contact individuals, groups of personnel or provide a general broadcast to all PED receivers. This could be:

- to make contact with another person
- to give an instruction to evacuate
- a request to go to a different location
- an instruction to attend to a breakdown
- a request to bring equipment or supplies to particular location

The PED will enhance the total effectiveness of the underground communications network. Specifically, the ability to immediately contact individuals, regardless of their location, will increase the efficiency and safety of underground operations.

2.1 PEDCall Software

A computer running PEDCALL controls the Transmission System. The PEDCALL software provides the interface from the operator to the system in a simple and efficient manner. It enables messages to be sent to individuals, groups, or broadcasted simultaneously to all receiving units.

The operator inputs information, such as the destination and the message content, then the PEDCALL software will encode this information. Encoding of the destination and message utilises advanced encryption methods to eliminate any chance of invalid information being transmitted. These encryption methods also ensure the receivers can decode the information precisely even in adverse signal conditions.

CONTROLPED software enables remote control of underground equipment such as fans, pumps and belts. Each item of equipment is fitted with a CONTROLPED unit

connected into the on/off switching mechanism allowing communication with individual or groups of equipment to suit the mine's layout, ventilation districts etc.

BLASTPED software allows remote blasting via the BlastPED Receiver/Exploder. The software is an enhancement to PEDCALL, which ensures it is user friendly and requires only minimal training. The BlastPED software, like the receiver, is designed to ensure a high level of security is maintained for the blasting operations. For example, it is necessary to utilise a specially coded disk to access the firing menu.

2.2 PED Modulator

The PED Modulator modulates the encoded information and produces a frequency shifted output signal. The output signal is a 0-20 mA Current Loop. The output is usually connected to the Transmitter by a twisted pair, though a radio link can be used if necessary.

2.3 PED ULF Transmitter

The PED Transmitter is connected to the incoming 0-20 mA Current Loop. The main role of the Transmitter is to boost the signal into a high power output capable of driving up to 250 volts at 5 amps into a large loop antenna.

The Transmitter utilises an efficient technique to achieve this role continually, it is also protected from thermal overload and short circuit conditions.

Each Transmitter can drive one loop antenna, therefore if a large mine requires two loop antennas then two transmitters will be connected. The Modulator can effectively drive more than one transmitter enabling very wide coverage areas from one central control point. The Transmitter has a maximum output of 1.2 kVA, hence requires locating in a cool ambient environment, it should also be relatively dust free.

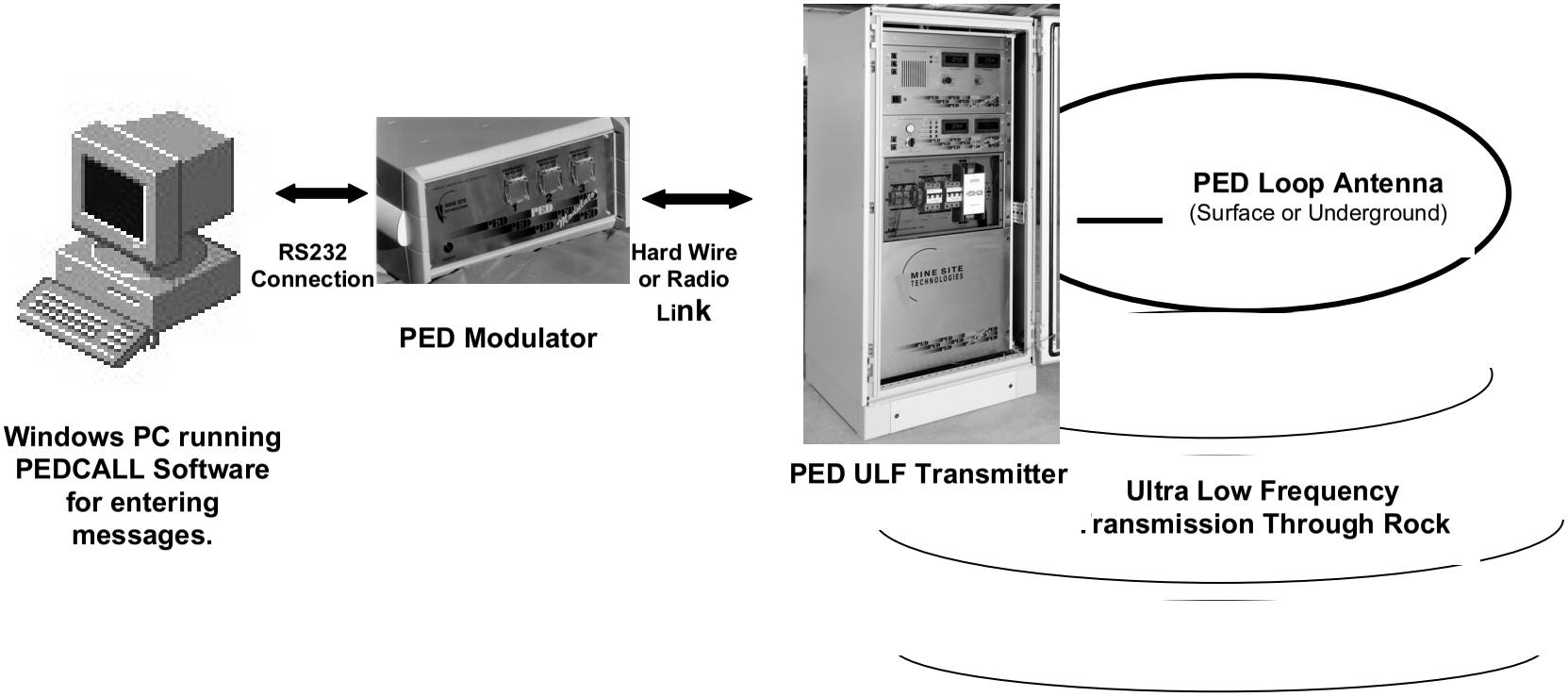
2.4 Personal Messaging

When used in a typical Control Room environment, the PED system in conjunction with phones is an integral part of the Control room's ability to react instantly to communicate and direct personnel, equipment and transport underground as required.

FIGURE 1

PED® Communication System

Operation Schematic



PED Receivers can be:

- ICCL BeltPED **Personal Receiver**
- AutoPED **Vehicle Receiver**
- ControlPED **for Equipment Switching**
- BlastPED **for Blast Initiation**

3 PED Receivers

The PED system can communicate with any, or all, of the following receivers:

- BeltPED®, personal receiver worn by miners.
- AutoPED®, vehicle mounted receiving units.
- ControlPED®, remote control of underground equipment.
- BlastPED®, remote, centralised blasting system.

3.1 BeltPED

PED can send text messages to miners underground, wherever they may be. Their personal receivers are integrated with their cap lamp, which flashes whenever a message is received. The message, which appears on an illuminated liquid crystal display, can either be directed to one or more individuals or broadcast to everyone with a receiver. The system is most often used to notify miners about unscheduled events and emergencies, such as an impending power cut-off, and to pass instructions to individual operators such as service technicians and transport drivers.

BeltPED units interface to the miners caplamp battery. The BeltPED receiver will display any message up to 32 characters in length. On reception of a valid message the cap lamp will flash (full to half brightness) and a buzzer will sound. The message is displayed on a backlit Liquid Crystal Display (LCD). The BeltPED will also store the last two messages for reference.

Environmental Monitoring alarms and information supplied from underground personnel can be quickly relayed to relevant people regardless of where they may be located throughout the mine. Production supervisors and engineering personnel e.g. Mechanics, Fitters & Electricians can be quickly contacted and directed to problem areas or breakdowns. In summary, general dispersal of information to all underground personnel keeps them better informed of relevant matters.

3.2 AutoPED

AutoPED is a vehicle-mounted text message receiver with a large illuminated liquid crystal display that allows everyone in the vehicle to read the broadcast messages.

These units are installed in mine vehicles. Due to The shielding effect of a solid steel cabin, and the electrical noise from the alternator, the AutoPED is separated into an external antenna unit and an internal display/receiver unit. The external antenna removes any limitations imposed by the surrounding cabin. The AutoPED has similar features to the BeltPED. Additionally it can be connected to the horn or lights to indicate message reception.

Using AutoPED receivers, better control over equipment and transport can be achieved.

Operated via the Control Room, a Transport dispatch system can be introduced allowing greater utilisation and significant streamlining of the entire underground transport system.

3.3 ControlPED

These units allow the remote control of devices, such as fans and pumps, underground. The receiver is typically interfaced with the stop/start contacts in the control panel of the device. More precise time management of these devices will reduce energy consumption and hence costs e.g. when fans are not needed due to no personnel being underground or speedy switching during blast times.

3.4 BlastPED

BlastPED is an exploder unit receiving coded signals sent through the PED system. This coding, and several other levels of physical and software security, ensures the safety and the reliability of the system. A similar system (Blast PED ST) is available to suit the surface blasting environment.

The BlastPED units are utilised for remote, centralised Blasting. The units use capacitor discharge into the firing line, thereby initiating electric detonators. The BlastPED system has several levels of security, both hardware and software, to ensure safe operation.

4 PED Loop Antenna

The Loop Antenna layout is critical to system performance. The layout will determine the range of signal transmission. Generally, the larger the loop the better the coverage will be. For example, a conservative propagation distance of 600-700m is often used for planning purposes. A recent demonstration in the Bushveld Platinum Complex in South Africa achieved 1400m with a 1600m surface test loop and signal propagation from a Canadian example of a large loop (12Km) has been measured 4Km away.

The Loop Antenna carries 5 amps of current (nominally) and due to this current flow an electromagnetic field is created around the Loop Antenna. This field appears as concentric bands radiating off the cable. The concentric pattern ensures signal is

present inside, above, below and off the edge of the loop. Due to the signal radiation pattern, one centrally located loop can cover an average size mine.

Surface loops are most desirable, due to the infrastructure being on the surface rather than underground. Underground loops are used where surface access is difficult. Underground loops work as effectively as a surface loop and are usually smaller, as the signal does not have to travel as far.

The Antenna Safety Unit (ASU) provides protection to personnel from the potentially lethal voltages present in the PED Antenna Loop.

5 Benefits

The benefits achieved through the use of a PED system relate to safety and productivity.

5.1 Safety

The PED system was first deployed as a communications medium enabling messaging to miners under all emergency circumstances. In the event of an emergency, personnel can be contacted underground immediately and specific messages sent to them (e.g. type of emergency, evacuation routes to be taken). Such knowledge has proved to be a life saver. With PED implemented on a mine it gets used not just used in emergencies. With this ability to send messages to personnel wherever they are underground, means it is often installed as a day-to-day management tool for general communications.

5.2 Productivity

Communication impacts in every area of a mining operation. Therefore the cost benefits of installing a PED system can be obtained from every facet of operations throughout the mine.

Whether it is an underground Shaft access mine using Shaft haulage or an Open Pit / Underground Decline access operation, they both depend on effective communications to maximise their production potential.

Streamlining all aspects of production through more effective communications will create a more efficient mining operation thereby lowering cost per tonne of ore produced.

The PED Communication system will improve productivity and increase the utilisation of personnel, transport and machinery. Examples of how this is achieved with PED are:

- Minimising Production downtime by directing service crews to the problem immediately.
- Greater efficiency in deployment of engineers to all major breakdowns including Jumbos, LHDs and Haulage and Transport vehicles.
- Greater utilisation and streamlining of the underground transport & supply vehicles getting personnel, spare parts, equipment and production consumables to where they are required in the most efficient time and method.
- All personnel underground can be in contact from the surface at all times.

On top of the benefits received by through the earth communication providing mine wide coverage, the lack of, or minimal underground infrastructure means maintenance of the system is minimal.

From installation of the PED system, signal coverage can be provided throughout the mine for typically 3 to 5 years operations of the mine, without ongoing additional transmission equipment required to be continually added on as the mine's production area advances.

By utilising the ControlPED feature, significant cost savings can be obtained from power savings in KW hours of electricity saved. A recent African implementation requiring the control of some 96 underground fans was justified on the ability to pay for itself within 5 months. This is to be achieved by reducing the time and manpower to turn fans on and off at blasting time and to turn fans off when not required.

BlastPED offers further significant safety and cost benefits by providing a highly secure means of remote blast initiation thus separating people from the blasting operation.

6 R&D

Mine Site Technologies has an active, continuous R&D programme for all its offerings in underground communications and tracking, including the PED system.

One such effort is aligned with Australia's Commonwealth Scientific & Industrial Research Organization (CSIRO) and aims to develop a return signal for the PED through-the-earth system. It will allow miner's underground to respond to PED messages through-the-earth to repeater stations, which then transmit back through-the-earth to the surface. This is expected to be available within two years time.

From a BlastPED perspective, further R&D efforts are well advanced and aimed at the initiation of electronic detonator systems, in conjunction with the suppliers of such systems.

7 Conclusion

The Mine Site Technologies PED system has proved it works no matter how hostile the conditions in a wide variety of mining environments. PED's unique ability to transmit a radio signal through rock strata allows it to provide genuine mine wide communication coverage. This ability means PED forms the basis of a very effective emergency warning system and a cost effective management tool for reliable, daily operational use also allowing for remote switching of equipment and remote blast initiation.

The current evolution of the PED system comes from a record of continuous development over the last 15 years. The PED system has been continuously enhanced in areas such as miniaturisation of the receiver and refinement of the BlastPED functionality and this improvement process is ongoing.

Together with complementary cap lamp technology the PED system is a unique and successful addition to the miner's communications tool set.

8 References

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