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Centralized wireless remote blasting

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Previous papers have demonstrated minewide, underground wireless communications are possible with the use of the Mine Site Technologies PED 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.

One currently topical use to which this wireless technology can be applied is centralized blasting. Each blast, separately or in combination, can be initiated from a mine's control room via simple, secure software messaging.

The paper and presentation will provide the audience with the benefit of many years of international mining know-how in this technology as well as more recent local African experiences. There will be references to demonstrations, pilot sites and operational systems.

The PED system is no longer a novel technology and is an integral part of the daily operating infrastructure of mines on six continents. It has displayed immediate safety and business benefits.

As functionality is under constant development, new areas of opportunity will be highlighted specifically for centralized blasting. The paper will conclude with insights into current R&D initiatives of particular interest in South Africa and applicable across the global mining industry.

Productivity enhancement devices (PED) using ultra low frequency (ULF) communication technology

Mine Site Technologies' PED communication system has been in use underground for more than 15 years, and is currently utilized by some 150 coal and metalliferous mines around the world, including Australia, Canada, the USA, China and Sweden. The PED suite of products was initially developed to enhance underground safety—but the efficiency benefits that emerged were appreciated almost as much.

PED stands for personal emergency device, and it was reassuring for mine managers to know that in the event of a rockfall or fire they could contact their personnel within seconds, and they could give them evacuation instructions. The operational reliability of the minewide system meant miners found other, everyday uses for the inherent ability to readily contact personnel, wherever they are underground. Hence PED has also come to mean productivity enhancement device.

Signal propagation

The PED system is a ULF 'through-the-earth' paging, control and blasting system. PED communication and emergency warning are possible because ULF allows for direct signal propagation through hundreds of metres of rock strata. The PED system delivers complete signal coverage to underground mines without the need to install antenna cable throughout the mine. 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.

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

Operational benefits

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 a particular location.

The benefits of the PED communication system include:

- minimizing production downtime by immediately directing service crews to the problem
- improving the utilization of underground transport
- enhancing the productivity of all personnel by ensuring they are in the right place at the right time, and are supplied with the tools and materials they require to operate optimally
- being in contact with underground personnel at all times.

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

PED components

The system consists of a number of components:

- a conventional personal computer on the surface running the PEDCall software from which messages are sent

- a PED modulator for encrypted signals
- a PED ULF transmitter to boost the signal
- a PED loop antenna to propagate the signal.

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 and radio systems).

In particular, 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 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.

PEDCall software

A computer running PEDCall controls the transmission system. This software provides the interface from the operator to the system, enabling 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 utilizes 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.

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 utilize a specially coded disk to access the firing menu.

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 or optic fibre link can also be used.

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 utilizes 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, driven by the same modulator.

PED loop antenna

The loop antenna layout is critical to system performance. A conservative propagation distance of 600–700 m is often used for planning purposes. A recent demonstration in the Bushveld Platinum Complex in South Africa achieved 1 400 m with a relatively small 1 600 m surface test loop.

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

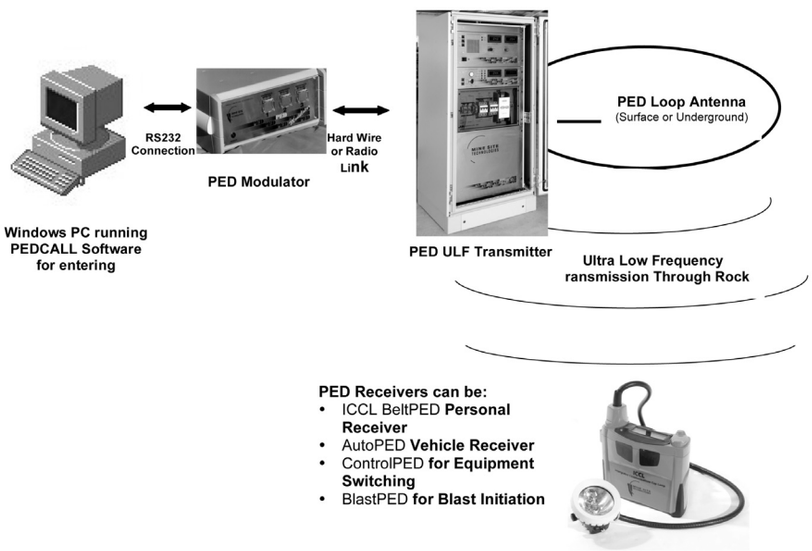

Figure 1. PED® communication system operation schematic

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.

Various 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, centralized blasting system.

BeltPED

BeltPED is a personal receiver built into the miner's integrated communications cap lamp (ICCL). The lamp flashes and a buzzer sounds when a text message is received and displayed on an illuminated LCD screen. The same cap lamp can also house a wi-fi tag for use in tracking personnel throughout the mine. This is done in conjunction with the ImPact WLAN system, another of MST's offerings taking the digital network underground.

The BeltPED receiver will display any message up to 32 characters in length. The BeltPED will also store the last two messages for reference. In common practice 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. (Figure 2.)

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 and 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.

AutoPED

AutoPED is a text message receiver mounted inside a vehicle, and has a large display allowing all passengers as well as the driver to read the messages. In addition to safety alerts, the AutoPED is used as part of a dispatch system to improve vehicle utilization and overall operational productivity

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. (Figure 3.)

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 utilization and significant streamlining of the entire underground transport system.

ControlPED

ControlPED is a receiver connected to the stop/start contacts of a wide variety of devices such as pumps, fans, spray chambers, underground lighting and the like, allowing them to be switched on and off from the surface. These devices are typically left running much longer than required, because of the cost and inconvenience of sending someone to switch them on and off.

Remote control reduces energy consumption and equipment wear and tear, and ensures that operations such as blasting are not delayed by someone having to attend to the fans. 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. (Figure 4.)

BlastPED

The BlastPED exploder unit receives a secure, coded signal from the surface or underground control room. It emits a capacitor discharge into the firing line, which initiates the electric detonators or incendiary equivalents.

With the PED signal range from the antenna in excess of 1 000 metres, it eliminates the need for anyone to remain in the vicinity of a blast. Signal coding, and several other

Figure 2. BeltPED receiver

Figure 3. AutoPED text message receiver

Figure 4. ControlPED receiver

Figure 5. BlastPED exploder unit

levels of physical and software security, ensures the safety and the reliability of the system. (Figure 5.)

A similar system (BlastPED ST) is available to suit the surface blasting environment. This is a two-way communication system between a control unit and a receiver used to initiate shock tube.

Global PED users

The PED system in its various forms is in use in well over 100 mines on 6 continents. This has directly affected the safety and productivity of over 12 000 miners.

African experience

Tanzania

A recent implementation of ControlPED in Tanzania requiring the control of some 96 underground fans was justified on the ability to pay for itself within 5 months. This is achieved primarily by reducing the time and manpower to turn fans on and off at blasting time.

Daily routines used to involve a period of one-and-a-half hours for the task of turning off underground fans prior to blasting. This was followed by a similar period devoted to restarting the fans in a sequence to avoid undesirable vent flows and minimizing workings under smoke. Further savings also became possible by the simple expedient of turning off unnecessary fans when no one is underground. All this is coordinated from a surface control point.

Further use of the PED system involves a number of ICCL cap lamps, currently primarily used in testing for signal propagation. The PED loop antenna is placed underground in a central location relative to the spread of workings and if necessary can easily be extended to accommodate future extensions to mining areas.

Mali

A mine in Mali has commenced its PED initiative by choosing BlastPED to begin with and installing a system capable of expanding as the mine grows.

As this is a relatively new mine, only recently gone underground, it is still in its main development phase. The PED loop antenna is soon to be installed during the course of mine infrastructure establishment. It will be partly above ground and partly buried around the perimeter of the orebody.

DRC

A mine in the DRC is focusing on the use of PED for messaging with ICCL cap lamps to maintenance and supervisory staff.

This is a case of a previously operating mine with several kilometres of haulages and widespread stoping operations. It is currently being refurbished and re-equipped to bring it back to full production. Given the mining depth and current layout, a surface PED loop antenna is most effective. In the future there is excellent potential for an underground loop catering for decades of mining to come.

South African experience

Discussions and proposals for South African mines have covered all these aspects but in particular centralized blasting is a major consideration, not least because of changing emphasis of legislation.

This is designed to bring South African legislation in line with what is common practice elsewhere in the mining world. The emphasis is on standards of design and production coupled with formal risk assessment, enabling the mine manager and equipment supplier to comply with the requirements of 'duty of care'.

Typical South African miner experience

Experience during a local South African pilot BlastPED project, clearly showed the miners were able to maintain integrity of their series blasting circuit. With a minimal amount of training and having become familiar with the system, the miners were well pleased with its simplicity. They demonstrated an ability to detect and repair damaged cables within 4 to 6 minutes and expressed enthusiasm to use the system. While some formal training in maintaining a series circuit is required, training personnel believe a miner can be trained to use BlastPED 'in less than an hour'. This is consistent with MST's experience.

BlastPED in use

The BlastPED system allows remote, centralized blasting and has been developed to reduce the high cost of maintaining underground blasting cables and other time-consuming procedures.

The main components of the blasting are:

- miner setting up the remote receiver/exploder unit at blasting point
- following clearance procedures established for remote blasting

- initiation of the blast from a central control point, via the PED operating system, by an authorized person.

Remote receiver setup

The BlastPED receiver is set up in a safe area where it will not be hit by fly-rock or receive excessive concussion. This would be out of line-of-sight of the face and in a position where a miner would be prepared to hand fire the blast. In South African gold and platinum mining this means placing a BlastPED unit in a cross-cut from where it initiates the blasts associated with any one raise line.

Having turned on the BlastPED receiver, the unit completes its self-diagnosis and indicates it is receiving PED signal. When the miner's blasting circuit is ready it is connected to the BlastPED unit, circuit checked and the miner can then leave the workplace.

The mine is cleared for blasting

When all the miners are out of the mine and shift clearance procedures have been completed, the blast control officer is clear to initiate the blast from the surface control room.

The blast cannot be fired without the security disc, which is locked up at all times to ensure only authorized personnel initiate the blast.

Blast is initiated

The BlastPED receiver circuitry includes an independent supervisory circuit to monitor all actions and the signals the BlastPED receives are uniquely coded. Using the PEDCall software, the 'ARM' command is selected. The security disc is inserted and the ARM command is sent to the BlastPED remote unit(s). The 'BLAST' command must be sent within 10 minutes of the arm command and a successful blast is initiated.

These simple procedures are common practice in many mines successfully using BlastPED for centralized wireless remote blasting. More recently, in various countries, there is strong debate on the various merits of electric versus electronic detonation systems. This means there is a growing need to accommodate both systems and MST continues to keep pace.

R&D for electronic detonator initiation

MST's PED system is a mature technology in use for the past 15 years by mines in Australia, Canada, the USA, China and Sweden. Development has been continuous, especially in the areas of miniaturization, functionality, and the ability to operate within the most hostile of environments.

There is an active, continuous R&D programme for all the MST offerings in underground communications and tracking, including the PED system. Among the more prominent R&D efforts, future enhancements will enable the BlastPED to interface with an electronic detonator system.

Some local South African mining companies have in common with their global counterparts, chosen the electronic detonator route on the basis of safety, to rule out the potential for a miner to initiate his own blast. This requires the development of a specific initiation device located in the cross-cut or vicinity of the blast.

Joint R&D is currently aimed at having the PED signal sent through the rock and picked up by a PED receiver built into the Blast Web instrumentation of Detnet. The features of the secure communications to BlastPED receivers are being included in a switching module for the electronic detonator initiation system. This will then enable the initiation of Net Shock (for shock tube), Net Start (for ignitor cord) or Quick Shot (for development ends).

While several 'hard wired' methods of sending signals to such a device are possible, PED is the only one to be able to do it wirelessly.

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 minewide communication coverage.

This ability means that PED, besides being an effective emergency warning system, also becomes a cost-effective management tool for reliable, daily operational use. One of those uses is centralized wireless remote blasting, simultaneously enhancing safety and productivity.

Ongoing R&D efforts continue to provide enriched functionality and features appropriate to the mining industry's needs, and South Africa is a part of that ongoing development.

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Graduated from Sydney University in 1973 and after a year of working around Australia, came to South Africa in April 1975 for two years to take a look.
In the last 33 years he has worked extensively in SA gold and platinum mining for Gold Fields, JCI and AngloGoldAshanti before joining GMSI in 1998
Since then he has worked on introducing various IT technologies into the local mining scene and more recently on introducing communications and tracking technologies from Australia onto Africa. He is happily married to Waveney and due to be a grandfather in a few months' time.