Preface

Wireless communication has emerged as an independent discipline in the past decades. Everything from cellular voice telephony to wireless data transmission using wireless sensor networks has profoundly impacted the safety, production, and productivity of industries and our lifestyle as well. After a decade of exponential growth, the wireless industry is one of the largest industries in the world. Therefore, it would be an injustice if the wireless communication is not explored for mining industry.

Underground mines, which are characterized by their tough working conditions and hazardous environments, require fool-proof mine-wide communication systems for smooth functioning of mine workings and ensuring better safety. Proper and reliable communication systems not only save the machine breakdown time but also help in immediate passing of messages from the vicinity of underground working area to the surface for day-to-day normal mining operations as well as for speedy rescue operations in case of disaster. Therefore, a reliable and effective communication system is an essential requisite for safe working, and maintaining requisite production and productivity of underground mines. Most of the existing systems generally available in underground mines are based on line (wired) communication principle, hence these are unable to withstand in the disaster conditions and difficult to deploy in inaccessible places. Therefore, wireless communication is an indispensable, reliable, and convenient system and essential in case of day-to-day normal duty or disaster situations. However, at present there is no relevant book available in the global market regarding wireless communication technology in underground mines and hazardous areas. Therefore, a comprehensive textbook on wireless communication for underground mines is a vital need for mining and electronics engineers that provides a deeper understanding of the important subject and designing the intrinsic safe systems. Considering these facts, this book is written, incorporating various communication devices designed and developed by the authors for wireless communication in different areas of underground mines and their experiences in the fields.

The wireless communication systems used on surface cannot be applied straight-away in underground mines due to high attenuation of radio waves in underground strata, besides presence of inflammable gases and hazardous environment. Nonsymmetric mine topology, uneven mine structure, complex geological structures, and
extensive labyrinths put further hindrance on the way of communication. Wireless communication in underground mine is a very complex technique that involves multidisciplinary subjects. Therefore, the main focus of the book is on the recent advancement in wireless communication technologies for underground mines and hazardous areas. In this book, a comprehensive treatment has been given that provides a unified foundation of wireless communication systems for transmission of data, voice, and video. The novelty of this book is that it covers up a wide range of the recent practices of wireless communication systems as well as wireless sensor networking, radio frequency identification devices, system-specific embedded software, application software, and designing and developing techniques for intrinsic safe circuits.

The book elaborates the technical aspects for design and development of intrinsically safe trapped miner communication system, shaft communication system, line-of-sight communication system, mine-wide communication system, and web-based information system. The book also describes the latest RFID technology, miner information and safety system, system-specific embedded software, and application software. Further, the book provides the deployment and operation of systems in underground mines. Thus, the book incorporates all the technical details starting from design, fabrication, assembling, intrinsic safety analysis, testing, laboratory and field trials, deployment, and operations of different wireless communication systems. The book is divided into 12 chapters to incorporate different aspects of wireless communication techniques for underground mines and the content of each chapter is briefly enumerated subsequently.

**Chapter 1 – Mine Communication Technique:** The different underground mine communication techniques available worldwide are summarized.

**Chapter 2 – Evaluation of Suitable Frequency:** Experiments carried out in the laboratory and fields are incorporated for characterizing the precise frequencies of the systems for communication in different underground mining zones.

**Chapter 3 – Trapped Miner Communication:** In underground mines, sometimes due to fissured strata, the roof or side walls of a gallery collapse and miners get trapped inside the sealed area. Many miners may also get trapped beneath the big chunk of fallen roof. A communication link between the trapped miner and rescue team is essential to find out the actual location of trapped miner for speedy rescue operation. Therefore, in this chapter, system description, technical description, block diagram, detailed circuit diagram, printed circuit board layout, power supply safety protection, safety analysis, and laboratory and field trials of intrinsic safe trapped miner communication system developed by the authors are discussed.

**Chapter 4 – Shaft Communication:** Bell signaling system is being used today in most of the underground mines in India and other countries. But this system is having its own drawbacks. A need exists for improved hoist communication between the persons in the moving skip and the hoist operator. Therefore, design and development of induction-based communication system using hoist/guide rope, as a current carrier is described for the reliable and real-time communication in shaft. The system description, technical description, block diagram, detailed circuit diagram,
printed circuit board layout, power supply safety protection, safety analysis, and laboratory and field trials of the developed system are described.

**Chapter 5 – Line-of-Sight Communication:** Line-of-sight communication using ultra-high-frequency transceivers is discussed, with due emphasis on system description, technical details, detailed circuit diagram, and safety aspects.

**Chapter 6 – Mine-Wide Communication:** Leaky feeder-based communication technique for mine-wide communication is enumerated in detail. Technical details, safety aspects, and installation and commissioning procedures are also discussed.

**Chapter 7 – Web-Based Information and Decision Support System for Mining Industry:** The development of web-based system with different modules is presented for improving production and productivity, shift and personnel management, reduction of production discrepancy, maintenance of equipment, management of inventory, environment monitoring, information of mine, disaster forecasting, mine safety management, statutory requirements, postdisaster management, improvement in working by online record keeping, wireless communication in underground mine, decision making, training, and various other aspects. The chapter summaries the scope of development of web-based system by highlighting the existing problems and solution under different modules.

**Chapter 8 – ZigBee Technology: A Unique Wireless Sensor Networking Solution:** The worldwide advancement of the radio frequency identification (RFID) technology for underground applications is discussed in detail. The feasibility and exploration of the technology in underground mines are also discussed. The ZigBee technology is elaborated in detail.

**Chapter 9 – Miner Information and Safety System for Mines:** In an underground mine, many miners generally enter into underground in a shift for exploitation of coal/mineral from different working faces. As per the current practice, the identification and tracking of a miner is very difficult in case of disaster. Therefore, the identification and coding of the miners is a vital need for underground mine management in case of disaster as well as during normal operating conditions. Therefore, miner information and safety system using RFID technology has been developed by the authors and is discussed in detail. The installation and commissioning procedures both for underground and opencast mines is also highlighted along with its performance in underground mines.

**Chapter 10 – Programming of RFID Devices:** This chapter discusses the compatible system-specific embedded software for underground applications by forming dynamic wireless sensor network, which solves the redundancy problems in a large network. The software is designed to make the RFID devices as coordinator, routers, and end device for different underground use such as tracking of miners and machines, monitoring miners’ unsafe practice and providing warning, monitoring the presence of methane and carbon monoxide gases, vehicle-collision prevention, fatal accident prevention, and messaging. Complete program codes are also provided for different devices, such as coordinator, router, end device, gas-monitoring device, proximity warning device, and message device.

**Chapter 11 – Tracking and Monitoring Software:** The application software for mining applications is discussed in detail. The programming aspects are also
discussed. The software is especially designed for different purposes in mines and has different modules, namely, tracking of miners and vehicles, route tracking in opencast mines, preventing fatal accidents and vehicle collisions, environmental monitoring, observing miners’ unsafe practice, sending alert message, message communication and preparing computerized miners’ duty hours record. Algorithms of different modules of the software are also incorporated in the chapter.

**Chapter 12 – Intrinsic Safety for Hazardous Area**: The concept of intrinsic safe circuit development is the focus of this chapter. The technical aspects of designing and developing the intrinsically safe systems are described in detail. This chapter also enumerates the procedures for designing intrinsic safe circuits for hazardous areas.

All these chapters elaborately describe the different types of wireless communication systems for underground mines. Each chapter is complete in its particular aspects. Detailed technical aspects of various communication devices developed by the authors have been discussed in the respective chapters including implementation, installation, and commission procedures. The book is written for modern telecommunication, electronics and instrumentation, software and system, computer science, electrical, and mining engineers, scientists, and researchers in the field of mining communication and automation. The engineers devoted in the subject would be highly benefited from the book especially for intrinsically safe design aspects of systems. The book is also beneficial for researchers of universities, institutes, and R&D organizations, and business professionals engaged in the field.

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