



RFID Professional Institute Associate Certificate Examination Curriculum

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INTRODUCTION

PURPOSE

The purpose of this document is to provide candidates, tutors and examiners with an outline of the subject areas and content that are within the scope of the RFID Professional Institute's Associate Certificate examination. It is intended to be used as a study guide for those wishing to gain certification, and as a teaching aid for those looking to offer certification training.

SCOPE

This document covers all RFID-related subject areas that could be included as part of the Associate Certificate exam. It spells out the specific subject areas that will be covered.

DOCUMENT MANAGEMENT

All versions of this document are managed and controlled by the RFID Professional Institute's president. That individual is the owner of the processes involved with managing this document, as well as future iterations of it, and is responsible for maintaining this document.

THE ASSOCIATE CERTIFICATE EXAM

The Associate Certificate exam is the first level in the RFID Professional Institute's examinations. It is designed to test the candidate's knowledge and understanding of RFID technology, including core terminology, the different types of RFID and how they work, standards and regulations, system components and the common applications for each type of RFID.

The emphasis of the Associate Certificate exam is not on testing the examinee's knowledge of how to design and deploy an RFID system, but rather on the basic knowledge of all types of RFID, the components of RFID systems, the role each plays and generally how they are applied in various applications. The Professional Level is where candidates are expected to have a good understanding of the more technical aspects of RFID, as well as knowledge of how to deploy such systems.

The RFID Professional Institute certifies that a candidate holding the Associate Certificate has a detailed grasp of the core concepts of the different RFID systems. Candidates that have passed the exam have demonstrated, for instance, that they know which types of RFID systems use inductive coupling and what that means for how the systems operate. It does not mean that they know how to install and configure such a system.

The RFID Professional Institute's certificates are authenticated by VerifyEd, a company that uses blockchain to track each certificate the institute has issued. Thus, potential employers can be sure that an individual's certificate is legitimate.

ABOUT THE EXAM

DELIVERY

The exam is delivered online and is usually taken in two possible settings:

AT AN EVENT

Exams are periodically held at key RFID events, such as the annual RFID Journal LIVE! conference. They are also hosted on behalf of the RFID Professional Institute by other similar organizations, such as the New Zealand Pathfinder Group.

In this setting, there may be a group of candidates taking the exam at the same time in the same room. The exam is still taken online but is proctored by RFID Professional Institute personnel, or by the organization hosting the event.

REMOTELY

Individuals can take RFID Professional Institute exams online via a company offering professional testing services (TestInvite). Once the exam starts, examinees can only open a single window in their browser, and no other applications may be running. The test-taker must complete the exam in a single sitting within 90 minutes.

FORMAT

QUESTIONS

The exam consists of 75 questions divided into 14 sections, each of which tests the candidate's knowledge of one of the subject areas set out in this curriculum. Questions are multiple choice, true/false or matching. For multiple choice questions with more than one correct answer, the test taker will be informed to choose as many responses as apply. Candidates will receive partial credit for selecting one of two or three correct answers, but will be deducted points for a wrong answer. For example, selecting one of two correct answers will result in half credit for that question. But selecting one right answer and one wrong answer will result in no credit, as the wrong answer will cancel out the credit for the right one.

Questions are presented randomly by the system within each section, and the order of the answers is randomized. Candidates may revisit questions they have previously answered or passed over.

TIME

For in-person testing at an event, candidates may start the exam any time after the proctor has told them to start or log in. Whether taking the exam in person or remotely, once candidates start the exam, they will have 90 minutes to answer all 75 questions. At the end of the exam period, no further input or revisions to any question will be possible. Candidates may complete the exam in less than the allotted exam period, but once they have exited the exam, they may not restart it, even if the exam period has not yet expired.

PASSING GRADE

The normal grade needed for passing the RFID Professional Institute's Associate Certificate exam is 70% of the weighted answers. However, this score is provisional and does not mean that candidates who have answered fewer than 70% of the questions correctly have not passed the exam. As with all academic and professional exams, there are occasions when the scores of a group of candidates indicate that a further normalization of the scores and associated pass level is required.

**RFID
PROFESSIONAL
INSTITUTE INC.**

**ASSOCIATE LEVEL
EXAMINATION
CURRICULUM**

Candidates will typically be advised of their formal score and pass or fail grade within 14 days of taking the exam. Communication will be by email from the RFID Professional Institute's president advising candidates of their status. Candidates who have passed the exam will also receive a digital certificate from the RFID Professional Institute signed by the organization's president. This certificate is the only formal confirmation that a candidate has passed the exam. It is authenticated via blockchain and hosted by VerifyEd. Through this e-verify company, candidates can share their certificate on LinkedIn and other social media sites. If you have any exam-related questions, please send an email to contactus@rfidpros.org for assistance.

EXAMINATION SCOPE

The examination for the Associate Certificate will cover 14 areas of RFID knowledge, outlined below. The breadth and depth of knowledge that candidates are expected to demonstrate for each of these subject areas is explained in more detail in the next section.

01 CORE TERMINOLOGY

Including radio frequency identification, air-interface protocols, readers/Interrogators, reader antennas, read zones/read fields, read ranges, transponders and inlays, as well as the general way in which RFID systems work

02 THE DIFFERENT TYPES OF RFID

Passive RFID systems, active RFID systems, battery-assisted passive RFID systems, chipless RFID systems, hybrid RFID systems and alternatives to RFID

03 RADIO WAVES AND THE ELECTROMAGNETIC SPECTRUM

The electromagnetic spectrum, the anatomy of a radio wave, the relationship between frequency and wavelength, wave propagation, and how data is encoded in radio waves

04 COMMUNICATION METHODS AND PERFORMANCE CHARACTERISTICS

Passive systems that use inductive coupling, and the performance characteristics of those that do so; passive systems that use backscatter communication, and performance characteristics of those that do so; battery-assisted passive tags, and the performance characteristics of such tags; active RFID systems, methods of locating active transponders, and the performance of the different types of active systems

05 STANDARDS AND REGULATIONS

The ISM radio bands, regulatory bodies, what is regulated, RFID standards bodies, types of RFID standards and specific standards

06 PASSIVE LF AND HF SYSTEM COMPONENTS

Passive LF and HF transponders, transponder form factors, factors affecting the performance of passive LF and HF RFID transponders, LF and HF RFID readers/interrogators, reader/interrogator form factors, reader antennas and reader cables

07 PASSIVE UHF SYSTEM COMPONENTS

UHF RFID transponders, UHF RFID transponder antenna types, transponder form factors, factors affecting performance of passive UHF transponders, passive UHF RFID readers/interrogators, types of passive UHF RFID reader antennas, antenna polarization, antenna angles and gain, antenna cables

08 ACTIVE RFID SYSTEM COMPONENTS

Active RFID transponders, including conventional active transponders, beacons, and mesh network nodes; active RFID transponder form factors; factors affecting the performance of active RFID transponders; active RFID readers/receivers, antennas and reader cables

09 RFID PERIPHERALS AND OTHER EQUIPMENT

RFID transponder-related peripherals, including RFID label printer-encoders and RFID label applicators; RFID reader-related peripherals and equipment, including bollards, Faraday cages, light stacks, mounting brackets, multiplexers, portals, shielding, tunnels and weatherproof enclosures; reader vehicles, including drones and robots; testing equipment

10 RFID SOFTWARE

RFID firmware, reader software, RFID middleware, real-time location software, RFID application software and industry-specific RFID software applications

11 RFID DATA

RFID transponder data, RFID reader data and RTLS reader data

12 THE DIFFERENT TYPES OF RFID PRODUCT AND SERVICE PROVIDERS

RFID hardware manufacturers, including manufacturers of readers, microchips, inlays, antennas, label printers and peripherals; RFID software providers; and service providers

13 PRIVACY, SECURITY AND SAFETY

Measures companies should take to protect consumer privacy, tactics for ensuring safe use of RFID around workers and in hazardous environments, data vulnerabilities and potential attacks on RFID systems

14 COMMON USE CASES FOR EACH TYPE OF RFID

Common applications of passive low-frequency (LF) RFID (below 135 kHz), passive high-frequency (HF) RFID (13.56 MHz), Near Field Communication (NFC) (13.56 MHz), passive ultrahigh-frequency (UHF) RFID (860 to 960 MHz), battery-assisted passive (BAP) UHF RFID (860 to 960 MHz), active RFID (433 MHz); active RFID (2.45 GHz) applications, and ultrawide-band (UWB) RFID (3 to 5 GHz)

01 CORE TERMINOLOGY

SCOPE

This section will cover the major terms that are used to describe radio frequency identification systems. These terms should be generally familiar to candidates, but it is important to establish a common, accepted definition for each.

KNOWLEDGE TESTED

Candidates are expected to know the definitions of the following terms and understand how they are used in the context of RFID:

- Radio frequency identification
- Air-interface protocol
- Reader/interrogator
- Reader antenna/receiver
- Read zone/read field
- Read range
- Transponder/tag
 - Passive RFID transponder
 - Active RFID transponder
 - Battery-assisted passive RFID transponder
- Inlay
 - Dry inlay
 - Wet inlay
- Smart label

This section will also include a broad explanation of how most RFID systems work.

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Precise definitions of the terms above
- Specific products from specific vendors

SAMPLE QUESTIONS

1. The air-interface protocol defines which of the following in an RFID system?

- A** The security measures protecting data transferred via radio waves
- B** The means by which tags and readers process RF signals from one another
- C** The means by which tags and readers process RFID data
- D** None of the above

2. A passive RFID reader is sometimes called which of the following?

- A** An interrogator
- B** An interlocutor
- C** An interviewer
- D** None of the above

3. An active RFID transponder has which of the following elements that are not found on passive RFID transponders?

- A** An onboard capacitor
- B** An onboard digital signal processor
- C** An onboard power source
- D** None of the above

ANSWERS: 1-B, 2-A, 3-C

02 THE DIFFERENT TYPES OF RFID

SCOPE

This section will cover the different types of RFID systems, which are generally categorized by the way in which the tag or transponder is powered for receiving data or instructions from the RFID reader (interrogator) and then transmitting back a reply. The three main types of systems are:

- Passive RFID—the responding tag has no power source of its own but derives its power from the reader’s transmission
- Battery-assisted RFID—the responding tag relies upon the reader transmission to initiate action but has an onboard battery to assist with transmitting data back to the reader
- Active RFID—the responding tag is completely power self-sufficient and does not rely at all on the reader’s transmission for any power needs

This section will also cover subcategories of the main systems:

- Passive RFID
 - Low-frequency (LF) passive RFID
 - High-frequency (HF) passive RFID
 - Near Field Communication (NFC)
 - Ultrahigh-frequency (UHF) passive RFID
 - Chipless RFID systems

For each of the different types of passive RFID systems, candidates are expected to know:

- Relative costs of the main the main components
- Active RFID systems
 - Conventional active RFID systems
 - Real-time location systems (RTLS)
 - Ultra-wideband (UWB) systems
 - Bluetooth mesh networks

The exam will also cover hybrid systems that combine RFID transponders with other technologies. It’s important for candidates to understand why certain technologies are combined with RFID transponders and how they can be used for various applications. The hybrid systems covered will include:

- RFID and infrared
- RFID and cellular systems
- RFID and GPS

Finally, this section will touch on several alternatives to RFID, as such technologies are similar to RFID in their capabilities but might be more or less appropriate for certain applications. It is important for candidates to understand the technology options available in the marketplace.

- Infrared
- Ultrasound
- Two-dimensional barcodes

KNOWLEDGE TESTED

Candidates are expected to know the broad categorizations of RFID systems, as well as the characteristics of each and their relative costs. Candidates are expected to know the following about each of the major types of RFID systems:

- Relative costs
- Relative read range
- Major features or characteristics that distinguish one type of system from another

For each of the different subcategories of each major type of RFID system, candidates are expected to know:

- Distinguishing characteristics (e.g. looped antenna, onboard battery)
- Frequencies or frequency bands of operation
- Modes of operation (e.g. induction or backscatter)
- Broad applications (e.g. real-time location monitoring, supply chain tracking)

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- How passive transponder power is harvested or used
- Various minimum transponder power requirements
- Battery types and lifespans
- Specific products
- Specific costs of individual types of RFID

SAMPLE QUESTIONS

1. Which of the following types of RFID tags have their own onboard power source?

Choose the two best answers.

- A** Passive
- B** Battery-assisted passive
- C** Active
- D** None of the other answers are correct

2. Which are the three major types of passive RFID?

- A** Low-frequency, high-frequency and ultra-wideband
- B** Low-frequency, high-frequency and ultrahigh-frequency
- C** Microwave, far-field and ultrahigh-frequency
- D** Near-field, far-field and ultra-far-field

3. Which of the following types of RFID transponders have a looped antenna?

Choose as many as apply.

- A** Low-frequency RFID transponders
- B** High-frequency RFID transponders
- C** Ultrahigh-frequency RFID transponders
- D** Active RFID transponders

ANSWERS: 1-C, 2-B, 3-A AND B

03 RADIO WAVES AND THE ELECTROMAGNETIC SPECTRUM

SCOPE

To understand RFID systems and how they operate, it's important to have some basic knowledge about radio waves—what they are, how they are generated and how they are used to communicate information. While candidates are not expected to know highly technical information about radio waves, they should understand the following concepts broadly.

- The electromagnetic (EM) spectrum—what it is, what types of EM energy exist in nature and how different types of electromagnetic waves are used in radios, microwave ovens and other devices
- The anatomy of a radio wave—the means by which we characterize different types of EM waves, including the following:
 - Amplitude
 - Cycle
 - Frequency, including how we measure frequency
 - Phase
 - Wavelength
- The relationship between frequency and wavelength
- Wave propagation—how radio waves are created by electrical systems
- Modulation—how data is encoded in radio waves
 - Analogue modulation techniques, including:
 - Amplitude modulation
 - Frequency modulation
 - Digital modulation techniques, including:
 - On-off keying (OOK)
 - Amplitude shift keying (ASK)
 - Frequency shift keying (FSK)
 - Phase shift keying (PSK)

KNOWLEDGE TESTED

Candidates are expected to know:

- What the electromagnetic system is and some characteristics of the different types of electromagnetic waves, including
 - Relative frequency of radio waves versus x-rays and gamma rays
 - Relative amounts of energy carried by radio waves versus other types of waves
 - Key characteristics of radio waves versus other types of waves (e.g. penetration of materials)
- The definition of terms used to describe radio waves, including:
 - Amplitude
 - Frequency
 - Cycle
 - Phase
 - Wavelength
- Measures of the frequency of radio waves, including:
 - Kilohertz
 - Megahertz
 - Gigahertz
- The relationship between frequency and wavelength

- How waves are propagated by electrical systems
- Modulation— techniques for encoding data in radio waves
 - Analogue modulation techniques
 - Digital modulation techniques, including
 - On-off keying (OOK)
 - Amplitude shift keying (ASK)
 - Frequency shift keying (FSK)
 - Phase shift keying (PSK)
 - Why digital modulation is superior to analogue modulation

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Highly technical information about the electromagnetic spectrum
- Specific frequency bands within the EM spectrum (e.g. the frequency range of gamma rays or microwaves)
- The technical means of modulating waves
- Modulation techniques used in specific RFID air-interface protocols

SAMPLE QUESTIONS

1. The amplitude of a wave refers to which of the following?

- A** The distance from the crest of a wave to its trough
- B** The size of the wave
- C** The distance from any point on a wave to the same point on an adjacent wave
- D** The distance from the crest or trough of the wave to the rest position, or midpoint between the crest and the trough

2. The cycle of a wave refers to which of the following?

- A** The period of changes to a wave during the process of modulation
- B** The completion of one trip by a signal from a reader to a transponder and back to the reader
- C** The completion of a single wave
- D** The period of time required to send a command from a reader to a transponder

3. True or false? All radio waves are sine waves.

- A** True
- B** False

ANSWERS: 1-D, 2-C, 3-A

04 COMMUNICATION METHODS AND PERFORMANCE CHARACTERISTICS

SCOPE

The different types of RFID systems covered in Section 2 perform differently based on whether they have a power source, as well as the frequency used and the manner in which tags and readers communicate. This section will cover the different methods RFID systems employ to power transponders, send commands to the transponders from RFID readers and transmit data back from the transponders. It will also cover the different frequencies used and how all of these factors affect system performance—that is, how reliably tags and readers can send and receive information to and from one another.

- Passive LF and HF RFID systems—inductive coupling
 - Performance characteristics of inductively coupled systems
 - Low-frequency RFID
 - High-frequency RFID
- Passive UHF RFID systems—backscatter communication
 - Performance characteristics of backscatter systems
 - Multipath
 - Null spots
 - Absorption
 - Cable loss
 - Orientation mismatch
 - Path loss
- Battery-assisted passive tags
 - Performance characteristics of battery-assisted passive UHF tags
- Active RFID systems
 - Methods of calculating the locations of RTLS transponders
 - Triangulation
 - Trilateration
 - Performance characteristics of different active RFID systems
 - Active 433 MHz
 - Active 900 MHz
 - Active 2.45 GHz
 - Active 131 kHz (RuBee)
 - Active 3 GHz to 10 GHz (ultra-wideband)

KNOWLEDGE TESTED

Candidates are expected to know:

- How inductively coupled passive RFID systems differ from passive RFID systems that use backscatter
- The frequencies of passive RFID systems that use inductive coupling and the frequency of those that use backscatter
- How the method of powering the transponder (e.g. inductive coupling or backscatter) affects the read range and performance of passive RFID systems
- The specific issues that can negatively impact the performance of passive LF, HF and UHF RFID systems
- How battery-assisted passive RFID transponders are powered, how they are commonly used in RFID systems, and their advantages over pure passive or pure active systems for certain applications

- How active RFID transponders are powered and how their locations can be determined
- The performance characteristics of active RFID systems using different frequencies

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Power requirements of the different types of RFID transponders
- Specific data-transfer rates of different RFID systems
- Types of batteries used in active RFID transponders
- How to address the performance issues of various RFID systems

SAMPLE QUESTIONS

1. Which of the following technologies uses backscatter to enable transponders to communicate with readers?

- A** Passive LF RFID
- B** Passive HF RFID
- C** Passive UHF RFID
- D** Active RFID

2. In the context of RFID systems, which of the following is the best definition of “inductive coupling”?

- A** The process by which two patch antennas communicate with each other
- B** The process by which two coiled antennas form a single electromagnetic field
- C** The process by which two transponders form a single electromagnetic field
- D** None of the above

3. In the context of RFID systems, the term “multipath” refers to which of the following?

- A** Radio signals from the same transponder arriving at the antennas of more than one reader
- B** Data from RFID transponders traveling to backend systems via more than one reader
- C** Radio signals from the same transponder arriving at a reader antenna from more than one direction, due to reflections
- D** None of the above

ANSWERS: 1-C, 2-B, 3-C

05 STANDARDS AND REGULATIONS

SCOPE

Global standards provide a way to ensure the interoperability of RFID equipment from different manufacturers and for global use. They also provide a means to define, use and interpret data in the same way, regardless of who is using the data or where that information is being used. The main standards-developing organizations for RFID are:

- ISO/IEC
- IEEE
- GS1

Regulations for the use of radio devices, including RFID, exist in all countries, each of which is responsible for defining its own regulations. Some nations are part of a regional group, while others decide to model their own regulations on those of another country or group. The regulations most commonly used as a model for other countries are those of:

- The U.S. Federal Communication Commission (FCC)
- The European Conference of Postal and Telecommunications Administrations (CEPT) through its European Telecommunications Standards Institute (ETSI)

This section of the exam will cover:

- ISM radio bands
- RF regulatory bodies
 - FCC
 - CEPT
 - Canadian National Organization for the International Telecommunication Union
- What is regulated
 - Frequencies used
 - Power output
 - Interference avoidance techniques
 - Duty cycle
- RFID standards bodies
 - International Organization for Standardization/International Electrotechnical Commission (ISO/IEC):
 - Institute of Electrical and Electronics Engineers (IEEE)
 - GS1
 - AIM Global
 - NFC Forum
 - RAIN RFID Alliance
- Major RFID standards
 - Air-interface protocol standards
 - ISO 14223
 - ISO 18000-2
 - ISO 18000-3
 - ISO 14443
 - ISO 15693
 - NFC
 - ISO 18000-63
 - ISO 18000-7
 - ISO/IEC 24730

- Data standards:
 - ISO 11784
 - ISO 28560-1
 - ISO 15961 and ISO 15962
 - ISO 17360
 - EPC Tag Data Standard
 - EMVCo Specifications
 - NFC Data Exchange Format (NDEF)
- Conformance standards
 - ISO/IEC 10373
 - ISO/IEC 18047
 - ISO/IEC 18046

KNOWLEDGE TESTED

Candidates are expected to know:

- The major organizations that establish regulations governing the use of RF-emitting devices
- Which aspects of RF-emitting devices are regulated
- The major organizations that create RFID standards
- The different aspects of RFID systems that are standardized (e.g. air-interface protocols, data)
- The major air-interface protocol standards
- The major data standards
- The major conformance standards

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Specific regulations in any region or country
- Specific limits on RF power output
- Specific details of air-interface protocol, data and conformance standards

SAMPLE QUESTIONS

1. The ISM radio bands were set up for which of the following reasons?

- A** So low-powered RF devices could legally operate without a license
- B** So low-powered RF devices could operate without any regulation
- C** So low-powered RF devices could operate without interfering with other low-powered RF devices
- D** So low-powered RF devices could operate internationally on the same frequency

2. Regulatory agencies in each country, such as the Federal Communications Commission in the United States, typically place restrictions on which of the following aspects of RFID systems? Choose as many as apply.

- A** Frequencies used
- B** Power output
- C** Number of transponders used
- D** These bodies do not regulate RFID systems

3. Regulatory agencies typically require RFID reader manufacturers to limit the amount of RF energy their reader systems (readers with cables and antennas) can emit. Which of the following are measures of power output of RFID readers? Choose as many as apply.

- A** Gain
- B** Amperage
- C** Effective radiated power (ERP)
- D** Effective isotropic radiated power (EIRP)

ANSWERS: 1-D, 2-A AND B, 3-C AND D

06 PASSIVE LF AND HF SYSTEM COMPONENTS

SCOPE

All RFID systems are composed of a set of key system components—readers, reader antennas, cables to connect readers to their antennas (unless the antennas are integrated into the readers), tags that are placed on or in objects, and software to transfer data from a reader to the system that will process the collected data.

This section will cover passive low-frequency (LF) and high-frequency (HF) RFID hardware components. As both LF and HF use inductive coupling to capture energy from a reader antenna and send back RF signals, they behave and perform similarly and thus will be covered in the same section. This section will cover:

- Components of passive LF and HF transponders
- Passive LF and HF transponder form factors, including:
 - Barcode labels
 - Clear laminates
 - Glass ampules
 - Key fobs
 - Metal-mount tags
 - Plastic buttons
 - Plastic cards
 - Plastic cylinders
 - Plastic ear tags
 - Screws or nail tags
 - Wristbands
- Factors affecting the performance of passive LF and HF RFID transponders
- LF and HF RFID readers/interrogators
 - Passive fixed readers with internal antennas
 - Passive fixed readers with external antennas
 - Mobile readers with integrated antennas
 - Handheld readers
 - Handheld computers with an integrated RFID reader
 - Pen readers
 - Smartphones with integrated RFID readers
 - Passive LF and HF reader antennas
 - Passive LF and HF antenna reader cables

KNOWLEDGE TESTED

Candidates are expected to know:

- The type of antenna passive HF and LF transponders use
- How to identify an HF transponder versus an LF or UHF transponder in a photo
- The most common form factors for LF and HF tags
- Factors affecting the performance of LF and HF systems, including the ability to identify specific form factors in photos
- Types of passive LF and HF readers
- Types of handheld passive LF and HF readers
- Passive LF and HF reader antenna characteristics

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Manufacturers of LF and HF hardware
- Specifications for LF and HF hardware on the market
- The cost of LF and HF components

SAMPLE QUESTIONS

1. Which of the following is a form factor most common to LF RFID systems?

- A Key fobs
- B Metal-mount tags
- C Plastic cards
- D Glass ampules

2. True or false? Passive low-frequency RFID readers are often embedded in smartphones.

- A True
- B False

3. The read range of a passive LF RFID system is typically how far?

- A Within 3 feet (1 meter)
- B Within 10 feet (3 meters)
- C Within 30 feet (10 meters)
- D Within 2 inches (5 centimeters)

ANSWERS: 1-D, 2-B, 3-A

07 PASSIVE UHF SYSTEM COMPONENTS

SCOPE

Passive UHF RFID systems have components similar to those of passive LF and HF RFID systems: readers, reader antennas, cables to connect readers to their antennas (unless the antennas are integrated into the readers), tags that are placed on or in objects, and software to transfer data from a reader to the system that will process the collected data. But UHF systems employ different energy-harvesting and communication methods. Thus, transponders and readers have different types of antennas, and there are different reader and transponder form factors. This section of the exam will cover:

- Components of passive UHF RFID transponders
 - UHF transponder antenna types
 - Dipole antennas
 - Double dipole antennas
 - Dual-frequency antennas
 - Near-field antennas
 - Near-field and far-field antennas
 - Slot antennas
 - Passive UHF RFID transponder form factors
 - Barcode labels
 - Ceramic tags
 - Hard tags
 - Metal-mount tags
 - Plastic cards
 - Plastic ear tags
 - Tamper-evident labels and tags
 - Wet and dry inlays
 - Wristbands
 - Other specialized tags
 - Factors affecting performance of passive UHF transponders
 - Antenna size
 - Antenna shape
 - Antenna material
 - Microchip sensitivity
- Passive UHF RFID readers/interrogators
 - Passive fixed readers with internal antennas
 - Passive fixed readers with external antennas
 - Mobile readers with integrated antennas
 - Handheld readers
 - Handheld computers with an integrated RFID reader
 - Sled readers
 - Wearable readers
 - Overhead readers
 - Robot readers
 - Desktop readers
- UHF RFID reader antennas
 - Types of passive UHF RFID reader antennas
 - Patch antennas
 - Phased-array antennas
 - Omnidirectional antennas
 - Bidirectional antennas
 - Near-field antennas

- Mat antennas
- Passive UHF RFID reader antenna polarization
 - Linear-polarized antennas
 - Circular-polarized antennas
- UHF RFID reader characteristics
 - Antenna angles
 - Gain
- dB (decibels)
- dBi (decibels relative to isotropic)
- Antenna reader cables

KNOWLEDGE TESTED

Candidates are expected to know:

- The types of antennas used in passive UHF RFID transponders
- How to identify a passive UHF transponder in a photo
- The common form factors of passive UHF RFID transponders
- Factors affecting the performance of passive UHF systems
- Types of fixed passive UHF RFID readers
- Types of handheld passive UHF readers
- The different types of passive UHF reader antenna characteristics
- The different types of antenna polarization
- Antenna characteristics
- The types of cables used to connect external passive UHF antennas to readers

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Manufacturers of UHF RFID hardware
- Specifications for passive UHF RFID hardware on the market
- The cost of passive UHF RFID components

SAMPLE QUESTIONS

1. True or false? Some passive UHF RFID transponders have antennas enabling them to be read either in the near or far field.
 - A True
 - B False
2. In which scenario does it make sense to use a circular-polarized antenna?
 - A When there are few tags in the read field
 - B When tags can only be read from far away
 - C When the orientation of tags is unknown or random
 - D All of the above
3. Which of the following is the most common type of antenna used in passive UHF transponders?
 - A Dual-frequency
 - B Slot
 - C Coiled
 - D Dipole

08 ACTIVE RFID SYSTEM COMPONENTS

SCOPE

Active RFID systems also have a set of components, including readers, reader antennas (sometimes called receivers or sensors), cables to network readers to one another (reader antennas are usually built into the reader unit itself), transponders that are placed on or in objects, and software to locate tagged objects in two- or three-dimensional space. Active transponders have an energy source that enables them to transmit a signal, so their performance and form factors differ from those of passive transponders.

This section of the exam will cover:

- Active RFID transponders
 - Conventional active transponders
 - Beacons
 - Sensors
 - Mesh network nodes
- Active RFID transponder form factors
 - Bricks
 - ID badges
 - Key fobs
 - Wrist or ankle bands
- Factors affecting performance of active RFID transponders
 - Reflections by metal objects
 - Absorption by water at certain frequencies
- Active RFID readers/receivers
- Active RFID reader antennas
- Antenna reader cables

KNOWLEDGE TESTED

Candidates are expected to know:

- The types of active RFID transponders—differences in the operation of the various types of active RFID transponders
- How to identify an active RFID transponder in a photo
- The common form factors of active RFID transponders
- Factors affecting the performance of active RFID transponders
- How active RFID readers differ from passive RFID readers
- The types of cables used to connect active RFID readers to one another

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Manufacturers of active RFID hardware
- Specifications for active RFID hardware on the market
- The cost of active RFID components

SAMPLE QUESTIONS

1. Which are among the common form factors of active RFID transponders?

Choose as many as apply.

- A Brick tags
- B Key fobs
- C Smart labels
- D Wristbands

2. True or false? Active RFID readers typically have an integrated antenna, rather than several external antennas.

- A True
- B False

3. Active RFID systems typically are less susceptible to interference or environmental factors for which of the following reasons?

- A Because they use frequencies in the gigahertz range, which are less susceptible to interference
- B Because their reader antennas are designed to overcome environmental interference
- C Because the transponders have an onboard power source enabling them to broadcast a strong signal
- D Active RFID systems are just as susceptible to interference as passive systems

ANSWERS: 1-A AND D, 2-A, 3-C

09 RFID PERIPHERALS AND OTHER EQUIPMENT

SCOPE

Transponders, readers, antennas and software for transferring RFID data to backend systems make up the core components of each type of RFID system. But these components are often supplemented by peripherals and add-ons to create a complete solution.

This section of the exam will cover:

- RFID transponder-related peripherals
 - RFID label printer-encoders
 - RFID label applicators
- RFID reader-related peripherals and equipment
 - Bollards
 - Faraday cages
 - Light stacks
 - Mounting brackets
 - Multiplexers
 - Portals
 - Shielding
 - Tunnels
 - Weatherproof enclosures
- Reader vehicles
 - Drones
 - Robots
- Testing equipment
 - Anechoic chambers
 - Signal detectors
 - Spectrum analyzers

KNOWLEDGE TESTED

Candidates are expected to know:

- What label printers and applicators are used for
- The roles of bollards, light stacks, multiplexors, mounting brackets and other peripherals
- How to identify various peripherals in photos
- The roles of different types of test equipment

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Manufacturers of RFID peripherals and other equipment
- Specifications for various peripherals on the market
- The cost of RFID peripherals and other equipment

SAMPLE QUESTIONS

- 1. Shielding around an RFID reader is sometimes required for which of the following reasons? Choose as many as apply.**
 - A** To prevent cell phones from capturing RFID data illegally
 - B** To avoid reading transponders that are not intended to be read
 - C** To prevent RFID readers from interfering with other equipment
 - D** Shielding is not used in RFID deployments

- 2. Tunnels are sometimes used in RFID deployments for which of the following reasons? Choose as many as apply.**
 - A** To read tags on items, cases or containers traveling along a conveyor
 - B** To read both passive HF and passive UHF tags at the same time
 - C** To read tags on a large number of items in a container
 - D** Tunnels are not used in RFID deployments

- 3. Which of the following are uses of an RFID label printer at a facility where goods are already tagged, such as a warehouse or retail store? Choose as many answers as apply.**
 - A** To improve the ability to identify an item with an RFID reader that is far away
 - B** To change the barcode on an item
 - C** To replace an RFID label that has fallen off
 - D** To replace an RFID label in which the transponder is no longer functioning

ANSWERS: 1-B AND C, 2-A AND C, 3-C AND D

10 RFID SOFTWARE

SCOPE

Software is a critical component of any RFID solution, as it is software that processes the data provided by RFID transponders and readers. This section will cover the different types of software that can be part of an RFID solution and the roles of each.

This section of the exam will cover:

- RFID reader firmware
- RFID reader software
 - RFID software tasks
 - Handling the duty cycle
 - Filtering data
 - Controlling input/output functions
- RFID middleware
 - RFID middleware tasks
 - Filtering data
 - Formatting data
 - Passing data to backend systems
- Real-time location software
 - RTLS software tasks
 - Locating tagged items
 - Displaying tagged items on a facility map
- RFID application software
 - Industry-specific RFID software applications
 - Retail
 - Manufacturing
 - Healthcare
 - Energy and mining
 - Telecommunications and technology
- Beyond tracking

KNOWLEDGE TESTED

Candidates are expected to know:

- The different types of software that might be used in an RFID solution
- The specific tasks that different types of RFID software handle

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- The companies offering different types of RFID software
- Specifications for various RFID software products on the market
- The costs of the different types of RFID software

SAMPLE QUESTIONS

1. Which best describes RFID middleware?

- A Software that resides between RFID firmware and the reader's operating system
- B Software that resides between two backend enterprise applications
- C Software that resides on a reader in the middle of many other RFID readers
- D Software that resides on a server that sits between the RFID reader and backend computers, running enterprise applications

2. Real-time location systems have specialized software that typically does which of the following tasks? Choose as many as apply.

- A Calculates the distance between active RFID readers
- B Calculates the location of a transponder in two or three dimensions
- C Displays the location of a tagged item on a facility map
- D Displays the weight of tagged objects

3. RFID software applications differ from many conventional backend enterprise applications in which ways? Choose as many as apply.

- A They are only used in retail
- B They can guarantee inventory accuracy of 99 percent or better
- C They are always cloud-based, rather than running on-premises
- D They are often updated in real time versus in batch mode

ANSWERS: 1-D, 2-B AND C, 3-D

II RFID DATA

SCOPE

RFID systems are usually deployed to collect large amounts of real-time or near-real-time data and provide it to systems that process the information in ways that companies can act on. It is important for candidates to demonstrate an understanding of the types of data that RFID systems can provide.

This section of the exam will cover:

- RFID transponder data
 - Tag identifier
 - User serial number
 - User memory
- RFID reader data
 - The ID of the reader that captured the transponder data
 - The antenna that captured the transponder data
 - The date and time on which the transponder data was captured
 - The strength of the signal that was returned by the item
- RTLS reader data
 - Time of arrival (ToA)
 - Time of flight (ToF)
 - Angle of arrival (AoA)
 - Received signal strength indicator (RSSI)

KNOWLEDGE TESTED

Candidates are expected to know:

- The different types of transponder data that can be captured by RFID readers
- The different types of reader data that can be transmitted to backend systems
- The different types of data that RTLS readers capture, enabling software to calculate a transponder's location within 2D or 3D space

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Specific formats for RFID transponder data
- Specific formats for RFID reader data
- Specific formats for RTLS reader data

SAMPLE QUESTIONS

I. Which of the following best describes the tag identifier (TID)?

- A** It is a serial number written to the transponder chip by the chip manufacturer
- B** It is a serial number written to the tag by the system's user
- C** It is a serial number that identifies the transponder on a wireless network
- D** It is a serial number that identifies different tags put on the same object

2. RFID readers typically report which of the following along with the tag ID?

Choose all that apply.

- A** Their own Media Access Control (MAC) address or unique identifier
- B** The antenna that captured the tag data
- C** The data and time at which the tag was read
- D** None of the above

3. True or false? All types of RFID systems, including RTLS solutions, use Electronic Product Codes.

- A** True
- B** False

ANSWERS: 1-A, 2-A, B AND C, 3-B

12 THE DIFFERENT TYPES OF RFID PRODUCT AND SERVICE PROVIDERS

SCOPE

RFID systems are made up of many components and often require systems integration, installation and other services. It is rare to find all of the different components provided by a single organization, so it is important for candidates to know who provides each of them within a deployment.

This section of the exam will cover:

- RFID hardware manufacturers
 - Reader manufacturers
 - RFID microchip manufacturers
 - RFID inlay, tag and label manufacturers
 - RFID label equipment manufacturers
 - RFID reader antenna manufacturers
 - RFID label printer manufacturers
 - RFID cable manufacturers
 - RFID peripheral manufacturers:
 - Portals
 - Label applicators
 - Bollards, light stacks and weatherproof enclosures
 - Tunnels
 - Multiplexors
- RFID software providers
 - Middleware providers
 - Software applications providers
- Service providers
 - RFID systems integrators
 - RFID consultants

KNOWLEDGE TESTED

Candidates are expected to know:

- Which types of companies typically provide the hardware components used in an RFID deployment
- Which types of companies typically provide the software elements used in an RFID deployment
- What services are typically used in a RFID deployment and which types of companies provide them

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Specifications of any hardware or software components
- Names of specific component or service providers
- Names of specific software or middleware providers
- Details of integration into any specific backend system, such as ERP software
- Costs for any hardware, software or services

SAMPLE QUESTIONS

- 1. RFID microchip manufacturers typically do which of the following?**
 - A** Design chips, attach them to antennas and sell inlays to label makers
 - B** Design chips, create inlays and convert them into labels
 - C** Design chips and sell them to companies that attach them to antennas to create inlays
 - D** None of the above

- 2. Systems integrators will typically help companies with which of the following?**
Choose as many as apply.
 - A** Conducting a site survey
 - B** Choosing the best hardware for an application
 - C** Integrating RFID data with backend systems
 - D** All of the above

- 3. Barcode labels with an embedded RFID label can be printed and encoded with RFID data corresponding to the information printed by RFID label printers. These printers are typically manufactured by which of the following?**
 - A** RFID reader manufacturers
 - B** Label printer manufacturers
 - C** RFID inlay manufacturers
 - D** Such devices do not exist—smart labels must be pre-encoded at the factory

ANSWERS: 1-C, 2-D, 3-B

13 PRIVACY, SECURITY AND SAFETY

SCOPE

PRIVACY | RFID is the exchange of data between an item and a reader which then hands off that data to another system for processing. That data can be used to identify an individual person directly (e.g. an employee badge) or to indirectly determine a person's identity (e.g. a credit card number, which leads to the person). Such data needs to be carefully managed to comply with any regulatory requirements, and to respect the individual's right to privacy.

SECURITY | RFID data might also contain financial information, such as in contactless payment systems, or have other sensitive information. The exchange of RFID data by radio transmission could be subject to unauthorized interception of the transmission and capture of the data being exchanged. This requires sophisticated equipment and techniques, but it must be guarded against.

SAFETY | RFID equipment uses electric current to operate, and it radiates energy when seeking tags or exchanging data. As such, it is important that all RFID equipment be operated safely, in line with health and safety regulations and without any adverse impact on the surrounding environment.

This section of the exam will cover:

- Privacy
 - Give consumers notice
 - Give consumers a choice
 - Provide information on the use of RFID
 - Do not link RFID serial numbers to personally identifiable information
- Safety
 - Establish a buffer zone
 - Protect the body
 - Limit the reader's duty cycle
- RFID in hazardous environments
 - ATEX-certified tags and readers
 - Zones 0,1 and 2
 - Zones 20, 21 and 22
 - National Electric Code (NEC)
 - Classes 1, 2 and 3
 - Groups A, B, C and D
 - Groups E, F and G
 - Divisions 1 and 2
 - International Electrotechnical Commission (IECEX)
 - Class 1
 - Groups A, B and C
 - Class 2
 - Groups A, B and C
 - Divisions 1 and 2
 - Hazard of Electromagnetic Radiation to Ordnance (HERO)
- Security
 - Counterfeiting of transponders
 - Eavesdropping
 - Attacks on the system
 - Insert attack
 - Replay attack
 - Virus attack

KNOWLEDGE TESTED

Candidates are expected to know:

- The potential privacy issues that could arise during an RFID implementation
- The means of protecting data that can identify a person
- When privacy is a concern and the measures companies can take to protect privacy
- The potential health hazards RFID systems pose and how to address them
- The safety issues RFID systems present in hazardous environments and some of the regulations with which RFID hardware must comply
- Potential issues caused by cloned transponders
- Potential threats of RFID data being intercepted and how to address them
- Potential attacks on RFID systems

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Details of privacy regulations for a country or region
- Specific safety regulations for a country or region
- Specific levels of radio waves that could cause health issues
- Specific manufacturing techniques for preventing RFID systems from causing explosions
- Methods of cloning RFID tags
- Details of equipment and methods that could be used to intercept RFID signals
- Details of how hackers could attack an RFID system

SAMPLE QUESTIONS

- 1. RFID tags and readers that are ATEX-certified have undergone rigorous testing outlined by European Union directives, and have been proven safe for use in which types of environments?**
 - A** Those containing large numbers of people
 - B** Those containing hazardous liquids
 - C** Those containing munitions
 - D** Those containing explosive environments
- 2. True or false? The U.S. Occupational Safety and Health Administration (OSHA) requires equipment to be certified as intrinsically safe by a nationally recognized testing laboratory before it can be used in an environment containing hazardous gasses.**
 - A** True
 - B** False
- 3. For an RFID system to be deployed at a U.S. Army munitions depot, it must be which of the following?**
 - A** ATEX-certified
 - B** NEC-compliant
 - C** HERO-compliant
 - D** OSHA-certified

ANSWERS: 1-D, 2-A, 3-C

14 COMMON USE CASES FOR EACH TYPE OF RFID

SCOPE

Given the different performance characteristics of the different types of RFID systems, it makes sense that some types of RFID are suitable for some applications and not others. For this reason, certain types of RFID have been used in specific applications successfully throughout the past 20 years. While certain deployments are unique and might require a different technology than is commonly used, it is important for candidates to understand where and how each type of RFID is currently being deployed.

This section of the exam will cover:

- Passive low-frequency (LF) RFID (below 135 kHz) applications
 - Access control
 - Animal identification and tracking
 - Automobile immobilizers
 - Identifying, counting and tracking fish
 - Laundry management
 - Tracking tools, jigs and other metal items
- Passive high-frequency (HF) RFID (13.56 MHz) applications
 - Access control
 - Anti-counterfeiting
 - Document/file management
 - Hotel room keys
 - Inspections verification
 - Library management
 - Livestock tracking
 - Passport authenticity
 - Payment systems
 - Ski-resort management
 - Surgical sponge tracking
 - Test-tube tracking
- Near Field Communication (NFC) applications (13.56 MHz)
 - Access control
 - Authentication
 - Pairing consumer electronic devices
 - Pairing phones
 - Product interaction
 - Ticketing
- Passive ultrahigh-frequency (UHF) RFID (860 to 960 MHz) applications
 - Asset tracking
 - Automated toll collection
 - Baggage handling
 - Conference management
 - Hospitality management
 - Inventory management
 - IT asset tracking
 - Parts and raw materials management
 - Recycling and waste management
 - Store operations
 - Supply chain tracking
 - Tool tracking

- Work-in-process tracking
- Battery-assisted passive (BAP) UHF RFID (860 to 960 MHz) applications
 - Cold chain management
 - Environmental conditions monitoring
 - People tracking
- Active RFID (433 MHz) applications
 - Asset tracking outdoors
 - Cargo management and shipping container tracking
 - Distribution yard management
 - Logistics and transportation management
 - Patron location
- Active RFID (2.45 GHz) applications
 - Patient management
 - Medical equipment tracking
 - Container, tool and jig tracking
- Ultrawide-band (UWB) RFID (3 to 5 GHz) applications
 - Contact tracing
 - Manufacturing execution
 - Sports performance

KNOWLEDGE TESTED

Candidates are expected to know:

- Some common applications for which passive LF RFID is used
- Some common applications for which passive HF RFID is used
- Some common applications for which passive UHF RFID is used
- Some common applications for which battery-assisted passive tags are used
- Some common applications for which active 433 MHz RFID is used
- Some common applications for which active 2.45 GHz RFID is used
- Some common applications for which ultrawide-band RFID is used

KNOWLEDGE NOT TESTED

Candidates are not expected to know:

- Details of specific applications, such as what memory is on the transponders, where readers are placed and what software is used
- The costs, benefits and return on investment of specific applications
- The number of deployments of specific applications

SAMPLE QUESTIONS

1. Which of the following types of RFID is commonly used for identifying, counting and/or tracking fish in streams or rivers?

- A Low-frequency RFID
- B High-frequency RFID
- C Ultrahigh-frequency RFID
- D Active RFID

2. Which of the following types of RFID is commonly used in credit cards and key fobs for contactless payment transactions?

- A Low-frequency RFID
- B High-frequency RFID
- C Ultrahigh-frequency RFID
- D Active RFID

3. Which of the following types of RFID is commonly used by retailers to manage store inventory?

- A** Low-frequency RFID
- B** High-frequency RFID
- C** Ultrahigh-frequency RFID
- D** Active RFID

ANSWERS: 1-A, 2-B, 3-C

PREPARING FOR YOUR EXAM

WHAT TO STUDY

You are likely to pass the exam if you have the following background:

- You've studied the subject areas set out in this curriculum
- You're familiar with RFID terms and applications, different types of RFID systems, common terms related to RFID and the components that make up an RFID solution
- You have a basic understanding of the physics for the various forms of RFID
- You have an understanding of data provided by RFID systems
- You possess good knowledge of the international standards related to RFID equipment and its use

SOME STEPS TO TAKE BEFORE UNDERGOING THE EXAM

Study the subject areas outlined in this exam guide. Remember that the exam is not focused on a specific form of RFID. Exam-takers will be tested on different aspects of all types of RFID systems, including passive LF, HF and UHF RFID, as well as active systems and hybrid systems.

If you are an experienced RFID professional, then you may feel that it's unnecessary for you to review the curriculum subject areas. But we advise you against this approach because you will likely be tested on aspects of RFID and related technologies with which you have not become familiar in your career so far, and because RFID technologies and applications are constantly changing. This curriculum provides a structured list of everything that might be on the exam.

RESOURCES

STUDY GUIDE

The RFID Professional Institute has created a detailed Study Guide that covers all of the topics that might be included on the exam, plus some related topics that are not covered but will be of use to anyone involved with RFID. The study guide can be purchased by visiting the RFID Professional Institute's website.

WEBSITES

There is a great deal of free information about RFID technology on the Internet, though not all of it is accurate or up to date. Among the best sources of information are:

- RFID Journal: www.rfidjournal.com
- AIM: www.aimglobal.org

BOOKS

There are also numerous books about RFID, including:

RFID for Everyone, A Comprehensive Guide: RFID for Technicians, Engineers, Layman [sic], Installers and Field Service Engineers

by Andre Smalling CET | Jan. 23, 2023

<https://www.amazon.com/RFID-Everyone-Comprehensive-Guide-Technicians/dp/B0BVDF534/>

RFID FM: Radio-Frequency Identification Field Manual

by Tim Bryant | Oct. 14, 2021

<https://www.amazon.com/RFID-FM-Radio-Frequency-Identification-Manual/dp/1736526731/>

The Insider's Guide to Working with RFID

by Suzanne Smiley | Jan. 1, 2020

<https://www.amazon.com/Insiders-Guide-Working-RFID/dp/0578778777/>

RFID Handbook: Technology, Applications, Security and Privacy

by Gordon Colbach | Dec. 29, 2018

<https://www.amazon.com/RFID-Handbook-Technology-Applications-Security/dp/1792824270/>

RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication

by Klaus Finkenzeller and Dörte Müller | Aug. 2, 2010

<https://www.amazon.com/RFID-Handbook-Fundamentals-Identification-Communication/dp/0470695064/>

IN-PERSON TRAINING

RFID4U is currently the only company running regular training for the RFID Professional Institute exams. The organization offers fast-track training courses at some RFID conferences, as well as more in-depth training at its facility in California, several times a year. For more information, visit www.rfid4u.com.