Radio Energy Concerns in the Laboratory

How the various radio devices operate harmoniously within the laboratory environment without causing health issues and interference to each other.

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Animal care facilities, just like all industrial environments, are exposed to a wide spectrum of electro-magnetic radiation from many different sources. It is important to consider how these emissions could effect animal stress levels and alter their behavior as well as understand how these signals can interfere with each other.

Some of this energy is required for data communications and proper operation of the multitude of devices used within the facility and other energies are the result of man-made interference. Each of these devices emits energies at various power levels and operates on their assigned frequencies. In order for all of these devices to operate within the same environment it becomes necessary to understand the potential interference that each device can cause and realize each device's susceptibility to interference from the other devices. This aspect of radio technology is known as RFI/EMI (Radio Frequency Interference/Electro-Magnetic Interference).

Today Radio Frequency Identification (RFID) can be utilized for asset inventory, security access and rapidly tracking animal census. Animal laboratories have been utilizing RFID for the identification of animals. Subcutaneous transponders are used for smaller animals and pets while RFID ear tags, bracelets and bolus tags are used for larger animals. Passive Integrated Transponders (PIT) offering Electronic Identification (EID) meet international standards such as ISO 11784 and 11785, which describe the protocols to be used by the animal identification community. Typically these devices utilize a low-frequency (LF) air interface having emissions at 125 kHz to 135 kHz. The limitation of LF technology is its relatively short range of detection, typically from almost contact up to as much as a few feet. Another significant shortcoming of LF is its lack of anti-collision capability, limiting the reader to detect only one tag at a time.

Near Field Emissions – Low Frequency Magnetic Energy

Energy is radiated in a wave which propagates from its source and is typically intercepted by some sort of receiving device. The wavelength of these energy waves are related to the speed of light and are inversely proportional to their frequency. The wavelength is the actual measured length between consecutive peaks of the waves. The lower the frequency the longer the wavelength. Just for perspective consider that your AM car radio dial spans from 550 kHz on the bottom end up to 1700 kHz on its top end. Near its center is 1250 kHz, equal to 1.250 MHz, which is ten times the frequency of the 125 kHz Low-Frequency PIT tag. The measured wavelength of a Low Frequency 125 kHz wave is over one mile long. Since we are detecting this transponder from less than one foot away we are only seeing a very small fraction of its complete wavelength.

Actual radio waves are electro-magnetic (E-M) disturbances. The waves have an electric component and a magnetic component and these two components propagate together through space. When dealing with small fractional portions of a wavelength the electrical component becomes insignificant while the magnetic component becomes dominant. Essentially the low-frequency RFID transponder can be treated like a secondary transformer winding receiving induced power from its reader acting as a primary winding. Low frequency RFID is not a radio frequency device at all – it's a magnetically coupled device. This is the reason why the signals from low frequency transponders can penetrate body tissues and liquids. Dynasys provides thousands of these RFID devices to the natural resources departments where they implant the glass tube encapsulated transponders into the bowels of fish and they are tracked while swimming under water.

Far Field Emissions – Ultra-High Frequency Electro-Magnetics

As we move up the electro-magnetic spectrum towards Ultra-High Frequency (UHF) the expected range of a passive RFID transponder is typically 5 – 15 feet. A 900 MHz energy wave has a computed wavelength of one foot. Since you will expect to detect this device at, say 10 feet away, this represents propagation of multiple wavelengths and we experience a true electro-magnetic radio wave. Radio waves act differently than purely magnetic waves. They bounce off walls, ceilings, racks, shelving and any other metallic items. Along with the incident radio wave we may now have a number of reflected waves causing interference. This phenomenon is known as multipath interference. You may have experienced a "dead" spot in a room where your cell phone signal gets really weak but if you move a few feet over the signal gets remarkably stronger. This "can-you-hear-me-now" phenomenon is caused by multipath reflections and cancellations of the signal.

The International Telecommunications Union (ITU) based in Geneva Switzerland has allocated the Industrial, Scientific and Medical (ISM) bands for use of unlicensed radio frequency transmissions. It is within these bands that you find the frequencies for Wi-Fi computer LANS, Bluetooth devices, telemetry, cellular telephones, microwave ovens and relatively new technology known as the Electronic Product Code RFID.

There are a number of techniques used to limit the interference between devices operating on the same frequencies. One such method is known as Spread Spectrum

Communications. Bluetooth, operating at 2.4 GHz, uses Frequency-Hopping Spread Spectrum (FHSS) where power levels are kept to a minimum and both the transmitter and receiver are locked in synch as they traverse multiple channels avoiding interference for best throughput. The other method is Direct Sequence Spread Spectrum (DSSS). A simple analogy might be like talking to a colleague at a noisy cocktail party. Through the noise and conversation you pick up a juicy story being told by someone at a distance. You now focus in on the pitch and cadence of that speaker that you want to hear and while temporarily ignoring your colleague's boring story you can now tune in on the more interesting conversation. DSSS encodes the communications in a known unique sequence that both transmitter and receiver can lock in on.

Wi-Fi wireless radio Local Area Network (LAN) infrastructure uses Access Points installed in the ceilings along the hallways and rooms of the laboratory facility. These LANS typically adhere to the 802.11 standards and also operate on 2.4 GHz. Microwave ovens also share this same 2.4 GHz channel. Interference within this band causes errors in the data streams and increase the requests for retransmissions. The result is slower data throughput. One method of increasing the available bandwidth for radio communications without introducing additional channel interference is with the use of fiber optics.

RFID Census Tracking

Today another significant contender for the Ultra-High Frequency (UHF) radio space is Electronic Product Code (EPC) RFID devices. Over 30 years ago Wal-Mart conspired with the Wrigley's Gum company to print a bar code on their package. This led to the Universal Product Code (UPC) bar code being printed on every consumer item. Wal-Mart is at it again, this time attempting to mandate that every shipment of consumer goods be labeled with an RFID EPC tag. These EPC tags operate in the 900 MHz band and RFID readers can detect up to 300 tags each second without errors. These tags now find there way into the labs in applications where a large number of assets can be detected rapidly and accurately.

A remarkable RFID application currently uses EPC tags attached to the metal cage card holders of rodent cages. The University of Florida under the direction of Dr. August Battles has tagged thousands of cages with such RFID tags. Census inventory of the cages is taken by wheeling a WiFi connected mobile reader cart past the racks of cages. Within minutes they have a completely reconciled inventory of every cage in that room. These RFID EPC tags are completely passive, meaning they do not contain any internal power source. These devices utilize a technique known as "Backscatter". A simple analogy would be picturing two boy scouts signaling each other with flashlights. If one scout gained access to a power plug and would leave his powered search light on after sending his message the other scout could flash back the light beam just using a small signaling mirror rather than his self-powered flashlight and would not require a battery of his own. In essence every RFID tag scatters (reflects) back a portion of the radio energy that it receives thus transmitting its associated ID and data back to the reader that interrogated it – thus the term “backscatter”.

Animal Behavior and Radio Emissions

Consideration should be given to whether the radio energy emissions present in the laboratory environment are affecting animal behavior in any significant manner. Dr. Debbie Scheuer, PhD, Associate Professor of Physiology at the University of Florida conducted stress tests to determine whether the Dynasys RFID Animal Care System affected the rodents in her care. A PhysioTel PA series model PA-C40 small implantable transmitter manufactured by Data Sciences International provided telemetry signals indicative of the animal’s arterial blood pressure and heart rate. Additionally the animal’s relative activity was monitored. These three key parameters, systolic/diastolic arterial blood pressure, heart rate and relative activity are very strong indicators of the animal’s physical or psychological stress level. The animal’s physiology attempts to maintain a stable internal environment and any significant alterations to this environment results in the disturbance of homeostasis and the animal’s arterial blood pressure and heart rate will be affected. These key parameters showed no change when the animals were subjected to the EPC RFID readers. These readers emit relatively low power 900 MHz energy and apparently do not affect the welfare or behavior of the animal. Additionally the tests showed that the RFID emissions had no affect on the PA-C40 telemetry monitoring.

Radio Frequency Exposure

The worldwide Radio Frequency Exposure standards are designed to minimize the body’s exposure to potential heating, shocks, burns and electro-stimulation. Governing agencies stringently regulate emissions, defined as energy coming out of a device. U.S. standards are most restrictive between 30 MHz and 300 MHz. The high end of this spectrum represents the resonant frequency of a new born baby. Radiation emission levels are tested based on the Specific Absorption Rate (SAR) which is a way of measuring the amount of RF energy that is absorbed by the tissues. Radio frequency energy can be categorized into either “Non-Ionizing Radiation” or “Ionizing Radiation”.

Non-Ionizing Radiation is typically safe. The Effective Radiated Power (ERP) level is low enough to avoid tissue heating or any long term damage. This type of radiation can be found in radio waves, microwaves and within the visual light spectrum.

Ionizing Radiation contains enough electro-magnetic energy to strip atoms and molecules from the tissues of the body. This type of radiation can be experienced when exposed to X-rays or Gamma rays. It is recommended that individuals that are frequently in the proximity of X-rays wear leaded vests for protection.

Lasers in the Laboratory

There are a number of devices involving lasers found in the laboratory environment. Laser energy is “Light Amplification by Stimulated Emission of Radiation” and is in a band of the electro-magnetic spectrum that is above the frequency of microwaves. As mentioned earlier a wave of 900 MHz UHF energy has a radio wavelength of about 12 inches. Light energy has a wavelength band measured in hundreds of nanometers. Laser light is a highly coherent and monochromatic directional light. Laboratories use lasers for applications ranging from simple barcode scanning to complex surgeries. Lasers must be used carefully so that they do not cause harm to the personnel operating them or the animals that may be subjected to their emissions.

Hand held barcode scanners use semiconductor laser diodes for illumination. These lasers categorized as Class II cannot harm the retina because the human blink reflex is sufficient to provide protection. The blink reflex (aversion response) in humans will prevent eye damage, unless the person deliberately stares into the beam for an extended period. The animal's aversion response should be considered when they may be subjected to this class of light. Output power may be up to 1 mw. Class II includes only lasers that emit visible light in the range of 630-680 nm. Some laser pointers are also in this category. Class IV lasers are used for surgery and proper eye protection should be worn. Many industrial, scientific, and medical lasers are in this category

Various types of spectrometers are used in the laboratory. Sciences such as magnetic resonance spectroscopy, liquid chromatography and fluorescence spectroscopy are used for quantitative and qualitative analysis. Mass spectrometers used for quantitative analysis determine the relative abundance ratio of proteins in cancers. Spectrometers are also used for qualitative analysis to identify substances present by monitoring the reaction of the unknown to specific reagents. These instruments emit powerful photon energies and proper precautions should be taken to avoid exposure to this radiation. The Federal government's Food and Drug Administration manages the Center for Devices and Radiological Health (CDRH) that set safe guideline for the use of this type of equipment.

Conclusion

The electro-magnetic spectrum in the laboratory environment is jammed full of energy emissions supporting all kinds of communications and research instruments. Careful consideration should be given to possible RFI/EMI and potential health hazards to personnel as well as the animals that are housed within the facility when introducing devices that radiate energy. Due diligence site surveys should be performed before adding any significant instrumentation or communication devices to the laboratory infrastructure.

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