

D. J. Graham, J. A. Neasham and B. S. Sharif, "Investigation of Methods for Data Communication and Power Delivery Through Metals," in *IEEE Transactions on Industrial Electronics*, vol. 58, no. 10, pp. 4972-4980, Oct. 2011.

doi: 10.1109/TIE.2010.2103535

Abstract: When a sensor is located within a metallic housing, conveying data back to a controller or data logger is not trivial. To maintain structural integrity, or simply for ease of installation, it is often not desirable to break the wall of the vessel, preventing any hard-wired solution. The conducting nature of the structure prevents the effective use of radio communications due to skin effect. Applications involving sealed containers also have a requirement for power delivery, as the periodic changing of batteries is impractical. In this paper, a number of systems are presented for through-metal communications and power delivery. A novel noncontact electromagnetic acoustic transducer communication system is demonstrated, which is capable of data rates in excess of 1 Mb/s. Furthermore, a power transfer efficiency of approximately 4% is shown to be achievable through 20-mm-thick stainless steel using inductive coupling. These novel solutions are critically compared to previous systems based on piezoelectric transducers.

keywords: {acoustic transducers;data communication;data loggers;electromagnetic devices;inductive power transmission;packaging;piezoelectric transducers;radiocommunication;sensor placement;skin effect;stainless steel;data communication;data logger;electromagnetic acoustic transducer;inductive coupling;metallic housing;piezoelectric transducers;power delivery;power transfer efficiency;radio communications;skin effect;stainless steel;through-metal communications;Acoustics;Coils;Magnetoacoustic effects;Materials;Metals;Piezoelectric transducers;Acoustic signal processing;inductive power transfer (IPT);transducers},

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H. Zangl, A. Fuchs, T. Bretterklieber, M. Moser and G. Holler, "An Investigation on Wireless Communication and Power Supply Through Metal Tank Walls," *2008 IEEE Instrumentation and Measurement Technology Conference*, Victoria, BC, 2008, pp. 1452-1457.

doi: 10.1109/IMTC.2008.4547271

Abstract: Passive wireless sensors, i.e. sensors that do neither require wires nor external power supply/batteries, are attractive for many measurement problems. Standard approaches based on radio frequency identification technology usually have difficulties when fairly conductive matter such as steel or large amount of water is in the vicinity of the devices. This paper investigates methods for power and data transmission even through metal walls, e.g. of a tank or a pipe using super low frequency carrier signals. The feasibility is demonstrated by means of finite element analysis and laboratory experiments and validated with a prototype setup for both a steel pipe and a tin container.

keywords: {finite element analysis;radiofrequency identification;wireless sensor networks;data transmission;finite element analysis;metal tank walls;passive wireless sensor network;power supply;power transmission;radio frequency identification technology;steel pipe;tin container;wireless communication;Battery charge measurement;Data communication;Frequency;Power measurement;Power supplies;Radiofrequency identification;Steel;Wireless communication;Wireless sensor networks;Wires;Finite Element Analysis;Metal Pipe;Metal Tank;Near-Field Communication;SLF-RFID;Wireless Communication},

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S. T. Brewer, F. R. Dickinson and C. A. Von Roesgen, "Repeaters and equalizers for the SD submarine cable system," in *The Bell System Technical Journal*, vol. 43, no. 4, pp. 1243-1273, July 1964.

doi: 10.1002/j.1538-7305.1964.tb04082.x

Abstract: An equivalent four-wire repeater and an adjustable equalizer are described. The repeater incorporates a low-aging design to reduce the effect of electron tube gain changes. The equalizer contains a number of bridged-T networks, some of which can be switched in or out by a selector. The high-pressure container which houses either unit is made up of a beryllium copper cylinder with welded dome covers. Electrical connections are made through polyethylene-metal seals.

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6773524&isnumber=6773520>

M. Arsalan, M. H. Ouda, L. Marnat, T. J. Ahmad, A. Shamim and K. N. Salama, "A 5.2GHz, 0.5mW RF powered wireless sensor with dual on-chip antennas for implantable intraocular pressure monitoring," *2013 IEEE MTT-S International Microwave Symposium Digest (MTT)*, Seattle, WA, 2013, pp. 1-4.

doi: 10.1109/MWSYM.2013.6697639

Abstract: For the first time a single chip implantable wireless sensor system for Intraocular Pressure Monitoring (IOPM) is presented. This system-on-chip (SoC) is battery-free and harvests energy from incoming RF signals. The chip is self-contained and does not require external components or bond wires to function. This 1.4mm³ SoC has separate 2.4GHz-transmit and 5.2GHz-receive antennas, an energy harvesting module, a temperature sensor, a 7-bit TIQ Flash ADC, a 4-bit RFID, a power management and control unit, and a VCO transmitter. The chip is fabricated in a standard 6-metal 0.18μm CMOS process and is designed to work with a post-processed MEMS pressure sensor. It consumes 513μW of peak power and when implanted inside the eye, it is designed to communicate with an external reader using on-off keying (OOK).

keywords: {biomedical telemetry;eye;patient monitoring;pressure measurement;system-on-chip;temperature sensors;CMOS process;MEMS pressure sensor;RF powered wireless sensor;RFID;TIQ Flash ADC;VCO transmitter;control unit;dual on-chip antennas;energy harvesting module;frequency 2.4 GHz;frequency 5.2 GHz;implantable intraocular pressure monitoring;power 0.5 mW;power management unit;system-on-chip;temperature sensor;Antennas;Erbium;Monitoring;System-on-chip;Temperature sensors;Wireless communication;Wireless sensor networks;Glaucoma Wireless CMOS Sensor;Intraocular Pressure Monitoring (IOPM);System on a Chip (SoC)},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6697639&isnumber=6697324>

M. Ritamäki and A. Ruhanen, "Embedded passive UHF RFID seal tag for metallic returnable transit items," *2010 IEEE International Conference on RFID (IEEE RFID 2010)*, Orlando, FL, 2010, pp. 152-157.

doi: 10.1109/RFID.2010.5467263

Abstract: In this paper the novel passive UHF RFID seal tag for metallic returnable transit items (RTI) is presented. The tag design exploits the metal structure of RTI. Enhanced security encoding based on MD5 hash and AES algorithm is also presented, which enables authentication without online network connection. Up to 9 m theoretical read distance was obtained with 19 mm $\varnothing$ 20 mm $\varnothing$ 57 mm size tag. 100% read rate was reached with the stack of ten RTI containers in a 3.5 m wide RFID portal.

keywords: {UHF antennas;cryptography;message authentication;radiofrequency identification;AES algorithm;MD5 hash;RFID}

portal;RTI containers;authentication;embedded passive UHF RFID seal tag;enhanced security encoding;metallic returnable transit items;online network connection;tag design;theoretical read distance;Authentication;Costs;Dipole antennas;Microstrip antennas;Passive RFID tags;Patch antennas;RFID tags;Radiofrequency identification;Reflector antennas;Seals},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5467263&isnumber=5467233>

A. Rida, Li Yang, R. Vyas, S. Basat, S. K. Bhattacharya and M. M. Tentzeris, "Novel Manufacturing Processes for Ultra-Low-Cost Paper-Based RFID Tags with Enhanced "Wireless Intelligence", " *2007 Proceedings 57th Electronic Components and Technology Conference*, Reno, NV, 2007, pp. 773-776.

doi: 10.1109/ECTC.2007.373885

Abstract: The objective of this study is to demonstrate ultra-low-cost paper substrates for the realization of inexpensive RFID tags that can be integrated with batteries and sensors for wireless sensing, tracking and monitoring applications. The first step toward achieving this goal is to demonstrate "conductors on paper substrates" from processing standpoint and to characterize the electrical performance of paper substrates up to 2 GHz from design standpoint. The conductors are achieved by (i) direct-write ink jet printing technology with tailored conductive ink and by (ii) conventional copper etching upon lamination of metal foils on to the paper substrates. There are several issues in optimizing the processes in either of the two approaches. For example, ink jet printing would require smooth surface finish, good adhesion, less smearing of the ink, fast curing profile, and ultimately copper-like conductivity of the printed ink and rapid prototyping for high volume manufacturing. On the other hand, metallization using copper will require bonding of copper onto paper surface, adhesion, compatibility with copper etch solutions and lithography, and moisture sealing. Both approaches have been successfully demonstrated for printing conductors on paper substrates which can be easily scaled to large-quantity manufacturing. For the electrical characterization of the paper substrates up to 2 GHz, one microstrip ring resonator was designed and fabricated for extracting dielectric constant and dielectric losses. The copper metallization of paper substrates and the dielectric characterization of paper up to 2 GHz are reported for the first time.

keywords: {adhesion;copper;dielectric losses;etching;ink jet printers;lithography;metallisation;microstrip resonators;paper making;radiofrequency identification;substrates;wireless sensor networks;RFID tags;adhesion;batteries;copper etching;dielectric constant;dielectric losses;direct-write ink jet printing technology;lithography;manufacturing process;metal foils lamination;metallization;microstrip ring resonator;moisture sealing;monitoring applications;tailored conductive ink;tracking applications;ultra-low-cost paper substrates;wireless sensors;Adhesives;Conductors;Copper;Dielectric substrates;Etching;Ink jet printing;Intelligent sensors;Manufacturing processes;RFID tags;Wireless sensor networks},

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A. D. Rittmann and T. J. Miles, "High-frequency silicon alloy transistor," in *IRE Transactions on Electron Devices*, vol. 3, no. 2, pp. 78-82, April 1956.

doi: 10.1109/T-ED.1956.14107

Abstract: The silicon alloy transistor is a high-frequency, p-n-p type transistor capable of operation at high temperatures. Its temperature characteristic, derived principally from the use of silicon as the semiconductor, permits operation from - 70°C to 150°C. It achieves its high-frequency characteristic through accurate control of the base geometry. The n-type base of silicon is accurately machined by jet electrochemical techniques. Alloy contacts of aluminum are fused into the bottoms of the etch pits without producing appreciable change in base geometry. The depth of alloy is limited by the thickness of the aluminum, by the temperature, and by the length of time for alloying. Lead wires are soldered to the aluminum contacts and the transistor hermetically sealed in glass-metal containers. The electrical characteristics of typical silicon alloy transistors include an I_{co} of 0.005 μ A, a common emitter forward current gain of 12, and an alpha-cutoff frequency of 12 mc.

keywords: {Alloying;Aluminum alloys;Contacts;Etching;Geometry;Hermetic seals;Lead;Silicon alloys;Temperature;Wires},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1472026&isnumber=31547>

A. D. Rittman and T. J. Miles, "High frequency silicon alloy transistor," *1955 International Electron Devices Meeting*, 1955, pp. 23-23.

doi: 10.1109/IEDM.1955.186936

Abstract: The silicon alloy transistor is a high-frequency, PNP-type transistor capable of operation at high temperatures. Its temperature characteristic, derived principally from the use of silicon as the semiconductor, permits operation from -70°C to 150°C. It achieves its high-frequency characteristic through accurate control of the base geometry. The N-type base of silicon is accurately machined by jet electrochemical techniques. Alloy contacts of aluminum are fused into the bottoms of the etch pits without producing appreciable change in base geometry. The depth of alloy is limited by the thickness of the aluminum, by the temperature and by the length of time for alloying. Lead wires are soldered to the aluminum contacts and the transistor hermetically sealed in glass-metal containers. The electrical characteristics of typical silicon alloy transistors include an I_{co} of 0.001 microamperes, a common emitter forward current gain of 12, and an alpha-cutoff frequency of 12 megacycles.

keywords: {Alloying;Aluminum alloys;Contacts;Etching;Frequency;Geometry;Lead;Silicon alloys;Temperature;Wires},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1471983&isnumber=31545>

W. F. Garland, "Effect of decomposition products from electrical insulation on metal and metal finishes," *1965 Sixth Electrical Insulation Conference*, New York, USA, 1965, pp. 56-60.

doi: 10.1109/EIC.1965.7461180

Abstract: The foregoing presents evidence of corrosion caused by the heat decomposition of electrical insulation materials. The temperatures used with Class O and A type materials were necessarily somewhat severe in order to include the additional heat caused by the operation of electrical or electronic systems within closed containers. The results show: 1. That extracted materials from PVC sleeveings and also vapors from PVC in inclosed areas are highly acidic and may cause corrosion due perhaps to improper stabilization. 2. That cadmium and zinc are rather easily corroded by many insulation materials, especially plastic sleeveings. 3. That sealing (potting) compounds can cause severe corroding of copper. 4. That the heat resistant molded plastics used in this report were not effectively stabilized. 5. That aluminum and anodized aluminum were relatively unaffected by contact or vapors from the insulation materials tested.

keywords: {Aging;Cadmium;Corrosion;Insulation;Plastics;Wires;Zinc},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7461180&isnumber=7461156>

A. Gagnon and R. Schmidt, "Trial results conducted by multiple Canadian government agencies of the recent covert technology developed by Tektrap to trace and track the integrity of maritime containers worldwide," *2012 IEEE International Carnahan*

Conference on Security Technology (ICCST), Boston, MA, 2012, pp. 78-82.

doi: 10.1109/CCST.2012.6393540

Abstract: iCargo is an easy-to-install miniature covert electronic device combining GPS and door lock tracking with wireless and satellite communications to remotely track the status and position of maritime containers worldwide. A system of strategically placed readers combined with satellite or cellular communications and redundant technologies ensures that security breaches are detected early and reliably anywhere along the supply chain. iCargo provides a GPS trace of where a container has travelled and where the container might have been opened. Deviations from the expected itinerary in time and/or distance are detected and the container can be flagged for physical inspection. Such a system helps borders authorities to focus their energy on suspicious cargo with the overall impact of speeding the flow of all cargo. iCargo uses a patented technique to convert the metal structure of the container into an antenna thereby allowing it to be installed behind the rubber seal of the door in a truly covert fashion. Other technologies are visible from the exterior and vulnerable to tampering and damage during container handling. The location within the door gasket is ideal for monitoring the door open/close status as well as for acting as a communications gateway to optional internal sensors. There are approximately 7 million maritime containers entering/leaving North America every year. The interiors of such containers are rarely inspected. Such containers may include contraband, hazmats, weapons or illegal items that present an economic or security risk. Despite significant security improvements since Sept-11th, only 5% of the maritime containers go through physical inspection. The use of the iCargo mounted on a container at the point of departure will assist government authorities in making better decisions about which containers to inspect thereby speeding up the overall throughput of all containers. In today's lean economy, goods in transit do not contribute to economic growth but instead are added costs to customers and shippers. With rising fuel and transportation costs, delays at borders are becoming increasingly expensive. Early detection via the iCargo system will help to reduce these costs by not only helping to shorten inspection delays but by also allowing officials to focus their energy on suspicious cargo thereby improving border security. Tektrap has been selected for the Pool of Pre-qualified Proposals for the Canadian Innovation Commercialization Program (CICP). CICP is a very competitive program that targets recent innovations, especially in the field of national security, which are ready for the beta phase of product development. Within this award, iCargo will be evaluated during spring and early summer 2012 by Canada Border Services Agency for Canadian-US border application, by Defense Research and Development Canada, DND, for land, rail and air applications in the Canada Nordic environment, and by Transport Canada for trans-Canada land/rail and Asia-Canada sea conditions. In addition to presenting the results of these multiple trial results, this paper covers the innovative engineering aspects of using the metal enclosure of a maritime container as a VHF, cellular, satellite, GPS and Wifi antenna, thereby eliminating the need to add any external antenna and achieving the goal of being 100% covert.

keywords: {containers;government;inspection;satellite communication;GPS;Tektrap;cellular communications;communications gateway;container handling;damage;door gasket;door lock tracking;easy-to-install miniature covert electronic device;iCargo;maritime containers;maritime containers worldwide;multiple Canadian government agencies;optional internal sensors;physical inspection;satellite communications;supply chain;tampering;trial results;wireless communications;Containers;Energy harvesting;Frequency modulation;Global Positioning System;Monitoring;Satellites;Security;Maritime container intrusion sensor and Active RFID;Maritime container traceability},

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H. y. Hu and Q. z. Liu, "Research on lightning sparks discharge and protection measures of large floating roof tank," *2012 International Conference on Lightning Protection (ICLP)*, Vienna, 2012, pp. 1-4.

doi: 10.1109/ICLP.2012.6344239

Abstract: In order to avoid and greatly reduce floating roof tank fire accidents caused by lightning, theoretical analysis is carried out on shunts, mechanical seal structure and guide pole spark discharge in the oil and gas space. To study the problem of shunts spark discharge, a 2m diameter tank model was made to carry out simulation lightning experiment of shunts spark discharge. Experimental results show that shunts attached to the tank shell by its own flexibility can generate sparks when the lightning current flow reaches a peak value of about 400 Amperes. If there are gaps between shunts and the tank shell during lightning high voltage stock, potential difference between the roof and shell may breakdown the gaps and cause sparks. Lightning spark discharge on large floating roof tanks is inevitable if shunts are set as an interval of 3m according to the standard. Finally, according to the actual operation of the floating roof tank, some protective measures were put forward, such as removing the shunts, making mechanical seal structure insulating from the tank shell or using soft seal structure, connecting the floating roof and the tank shell by using more equipotential bonding wires, ensure a safe distance for the metal parts in the oil gas space, bonding scraping wax with floating roof, making the guide pole insulating from the floating roof, etc.

keywords: {lightning protection;roofs;seals (stoppers);sparks;tanks (containers);floating roof tank fire accident;guide pole spark discharge;large floating roof tank;lightning current flow;lightning protection;lightning sparks discharge;mechanical seal structure;oil gas space;scraping wax;shunts spark discharge;size 2 m;Mechanical variables measurement;Retractable Grounding Assembly;equipotential bonding;floating roof tank;second seal;spark discharge},

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P. Marco, F. Lorenzo and B. Claudio, "A novel dry storage security system using UWB techniques," *2011 IEEE International Conference on Ultra-Wideband (ICUWB)*, Bologna, 2011, pp. 550-554.

doi: 10.1109/ICUWB.2011.6058907

Abstract: In this paper an overview of the dry storage facilities for nuclear waste material is presented. A security related IAEA - International Atomic Energy Agency - request for dry storage installations has been done. Solutions based on different technologies are taken into account. A comparison between GPS, RFId and UWB potential application for nuclear facilities is described. Finally the motivations for an UWB-based sealing solution are highlighted opening the research future works to an innovative multi-path communication protocol design and development.

keywords: {fuel storage;multipath channels;protocols;security of data;ultra wideband communication;UWB techniques;dry storage security system;multipath communication protocol;nuclear waste material;Concrete;Containers;Fuels;Global Positioning System;Metals;Seals;Ultra wideband technology;CANDU;Dry Storage;IAEA;Ultra Wideband},

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H. Zangl, A. Fuchs, T. Bretterkieber, M. J. Moser and G. Holler, "Wireless Communication and Power Supply Strategy for Sensor Applications Within Closed Metal Walls," in *IEEE Transactions on Instrumentation and Measurement*, vol. 59, no. 6, pp. 1686-1692, June 2010.

doi: 10.1109/TIM.2009.2026602

Abstract: Passive or semiactive wireless sensors, i.e., sensors that require neither wires nor external power supply/batteries, are attractive for many measurement problems. Standard approaches based on Radio Frequency Identification technology usually have difficulties when a fairly conductive matter such as steel or a large amount of water is in the vicinity of the devices. This paper investigates methods for power and data transmission, even through the metal walls, e.g., of a tank or a pipe using super low frequency carrier signals. The feasibility is demonstrated by means of finite-element analysis and laboratory experiments and validated with a prototype setup for both a steel pipe and a tin container. Experimental results for capacitive fill-level measurement inside a metallic container are reported.

keywords: {capacitive sensors;finite element analysis;radiofrequency identification;wireless sensor networks;capacitive fill-level measurement;closed metal walls;finite-element analysis;frequency carrier signals;metallic container;passive wireless sensors;power supply strategy;radio frequency identification technology;semiactive wireless sensors;tin container;wireless communication;Finite-element analysis (FEA);metal pipe;metal tank;near-field communication;super low (SLF)-Radio Frequency Identification (RFID);wireless communication},

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W. B. Brecht, "Structural Considerations in Lead-Acid Stationary Cell Design," *Telecommunications Energy Conference, 1986. INTELEC '86. International*, Toronto, Canada, 1986, pp. 31-34.

doi: 10.1109/INTLEC.1986.4794401

Abstract: The classical deficiencies of the lead-acid system which lead to eventual failure are examined from a structural engineering perspective. The fundamental low tensile strength of lead in conjunction with the formation of oxide films as it relates to the creep of the metal and the resultant growth of the positive electrode is discussed. The high mass of lead combined with its low tensile strength resulting in mechanical failures and creep in other structural elements (non-positive plate) is examined. The various ways in which the above mentioned problems manifest themselves in eventual failure are considered. The effects of plate growth when not accommodated result in electrical short circuits, breakage of grid members, loss of contact between the active material and the current collector, movement of the positive posts resulting in post seal failure or breakage of the cover, and breakage of the jar walls due to contact with the growing positive plate is examined. The low tensile strength of lead and its alloys as a structural material leads to susceptibility to shipping damage, gradual collapse of the element due to creep, downward movement of the post seals due to creep resulting in post seal failure or breakage of the cover, and buckling of the element. Various means of overcoming the shortcomings of both lead as a structural material and the traditional means of constructing lead-acid stationary cells are examined. Improved positive grid designs, which accommodate growth of the grid members, are discussed.

keywords: {Batteries;Contacts;Containers;Creep;Electrodes;Lead compounds;Power systems;Sealing materials;Seals;Structural engineering},

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4794401&isnumber=4794382>